PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY

VOLUME XXXVI

DUBLIN: HODGES, FIGGIS, & CO.
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1921–1924

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SECTION A.—MATHEMATICAL, ASTRONOMICAL, AND PHYSICAL SCIENCE.

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SECTION A.—MATHEMATICAL, ASTRONOMICAL, AND PHYSICAL SCIENCE.

PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY

PAPERS READ BEFORE THE ACADEMY

I.

ON POLYGONS TO GENERATE DIAGRAMS OF MAX. STRESS ON GIRDERS DUE TO LOCOMOTIVES AND DEAD LOADS,

TOGETHER WITH

AN EXTENSION OF RANKINE'S CONJUGATE LOAD AREAS TO THE DESIGN OF MASONRY ARCHES.

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AND

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Read November 14. Published December 21, 1921.

In a paper read to the Royal Irish Academy in June, 1912, and published on August 31st,* we described our new and exact treatment of the stresses on girder bridges of short span due to the transit of a locomotive. This paper is an extension in more general terms of the same subject, and explains a method of drawing the diagrams of the square roots of maximum bending moments with a template of celluloid or cardboard, which indicates on its face all the maxima of maxima and their positions on the girder. The card will correspond to one locomotive, and for spans increasing from the smallest which can accommodate the locomotive. It can also be made to include the dead load on the girder by changing the position of the tracing point.

We will begin with the following regular polygons, fig. 1. The equilateral triangle standing on its left side turns clock-wise over on to its base, and again over on to its right side; the vertex describes two circular arcs. The square turns over three times, the tracing point describing three quadrants,

* Proc. R.I.A., vol. xxx, sec. A, No. 2.

and the pentagon four times, the tracing point describing four arcs. The least polygon is the *limiting* isosceles triangle when the base is zero; its vertex describes a semicircle. The base of each diagram so generated is the perimeter of the polygon. From the one extreme of the limiting triangle with two sides we may proceed to the other extreme of a polygon with an infinite number of sides, when the tracing point will describe the cycloid.

In all these diagrams the sum of the areas of the circular sectors is *twice the area* of the circle circumscribing the generating polygon. The triangular parts, shaded on the figure, are the polygon itself split up and buried in the diagram. This makes the total area of the cycloid three times that of the generating circle. See hexagon, fig. 11.

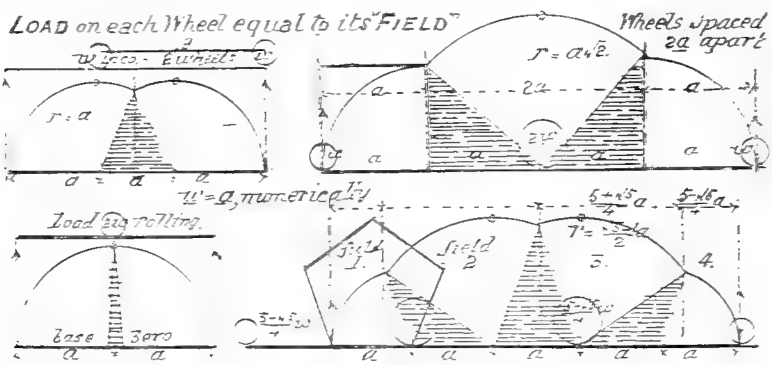

Fig. 1.

These diagrams give maxima stresses for certain dead loads as well as moving loads. The arrangements of the loads, however, are not practical, and so we pass on from these to irregular polygons, but will return to them later on, as there are interesting geometrical traits connected with them.

The Generating Triangle.

The fig. 2 shows a locomotive, the wheels 12 feet apart, and transmitting 24 and 12 half tons respectively to the 36-foot girder as it passes across. The double parabolic locus gives the max. bending moment at each point as the corresponding wheel comes over it. The larger wheel dominates two-thirds of the span, as its weight is two-thirds of the load. The dotted central parabolic segment standing on the span is the locus of maxima for the adjacent girder, upon which the whole 36 half tons is concentrated by one wheel, seen peeping over the loco. It is situated between the other pair of wheels opposite their centre of gravity, which is 4 feet from the one and 8 feet from the other.

The loads are expressed in half tons, so that the total load shall be numerically equal to the span. The three parabolic loci are segments of the same parabola, and from the above equality its modulus is unity; that is, the height of any point on the parabola above the base of a segment equals the product of the two parts into which its base is divided by a perpendicular dropped upon it. We can now replace these segments by semicircles, when we have a locus of the square roots of maximum bending moments. The locus near the ends completely changes as the wheels leave the span. For the purposes of this paper, we assume that the girder overhangs its two supports, and now the locus between the supports is complete. This is shown on fig. 3. Here the two wheels equally share the load.

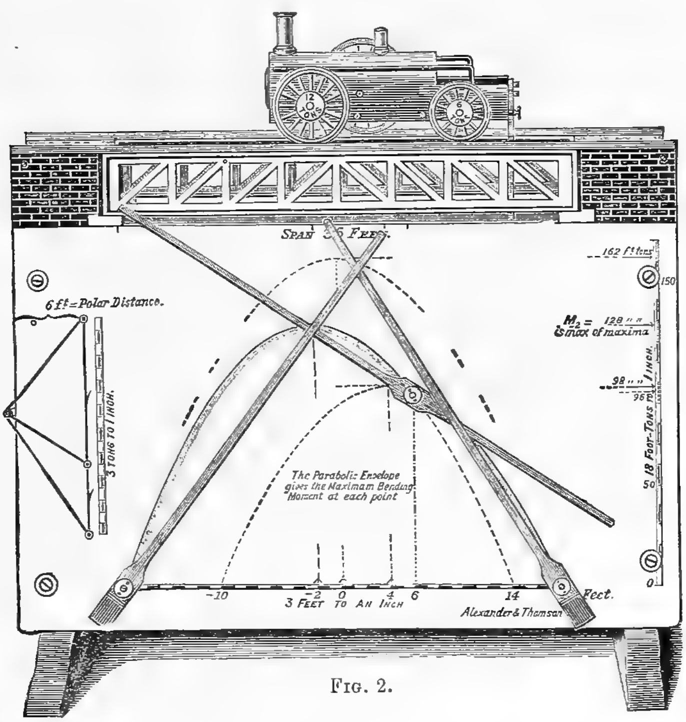

Fig. 2.

Consider BA_1L_2 and CA_2L_1 to be semicircles replacing the parabolic segments, and it is evident that the circular arcs BA_1DA_2C could be struck out by D, the vertex of the triangle S_1DS_2, lying first on its left side S_1D, then turning over on its base, and again turning over on its right side DS_2.

This triangle S_1DS_2 we call the "generating triangle" of the square roots of the maximum bending moments on a girder of span equal to the perimeter, the stress being due to a locomotive of a weight numerically equal to the span, and equally divided on two wheels at a distance apart *twice* the base of the triangle. Each side of the triangle is a max. of maxima for half the span, being the radius of a semicircle. Each super-max. occurs when a wheel is over a point, which was the end of the base of the triangle as it turned over; that is, at a point *half* as far from the centre of the span as the wheel is from the centre of gravity of the locomotive.

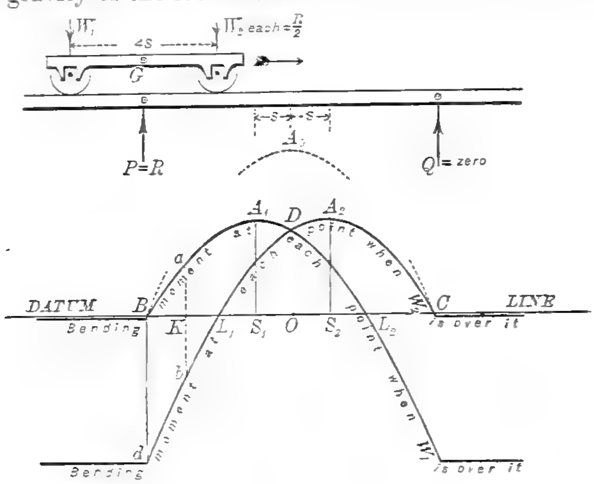

Fig. 3.

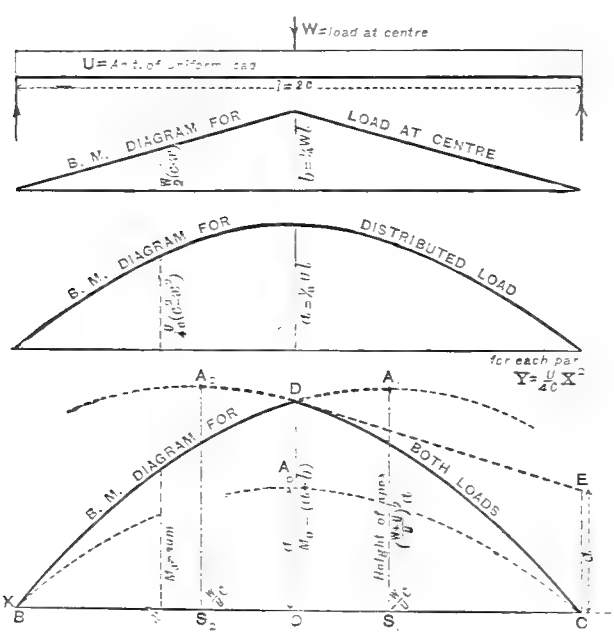

Fig. 4.

But the stress diagram thus generated by the triangle S_1DS_2 applies to another manner of loading: to a uniform dead load numerically *double* the span, together with an upward concentrated load at the centre, and numerically equal to *twice* the base of the generating triangle or to the distance between the wheels of the locomotive considered previously. Fig. 4 shows a load downward at the centre added to a uniform load, with the B. M. diagrams separate. If we suppose there are two parabolic segments coincident for the distributed load alone, then the addition of the central load makes them *rise up* and cross each other, with D the highest point of the joint locus. Had W been upward, the two segments would have sunk down and receded, with A_1 and A_2 the highest points of the joint locus, and D a lower point between these, as on fig. 3. Then with the values of the loads already stated, the stress diagrams of figs. 3 and 4 would be identical.

ROLLING TRIANGLES GENERATING DIAGRAMS OF THE SQ. ROOTS OF MAX. BENDING MOMENTS.

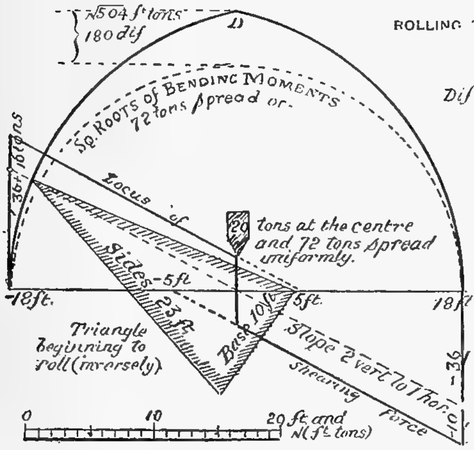

FIG. 5.

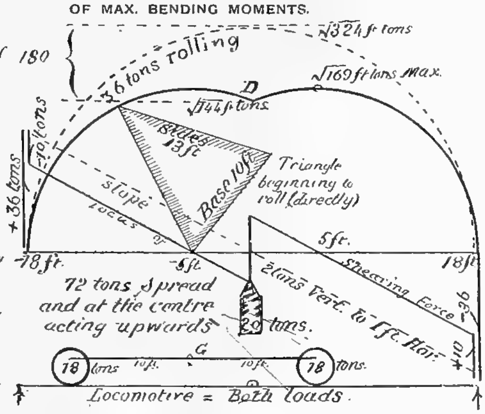

FIG. 6.

Direct and Inverse Rolling.

It will now be readily understood from figs. 5 and 6 the complementary nature of the stress diagrams generated by the direct and inverse rolling of the generating triangle. Two triangles are used in order that the two diagrams generated may have a common span of 36 feet. The triangles have a common base of 10 feet, but have different side values—13 feet in the one rolling clockwise directly, and 23 feet in the other; and the span is twice 13 plus 10, and twice 23 minus 10. In the figs. 5 and 6 the triangles are shown turned through a small angle from their first position.

In fig. 5 the two circular arcs, less than quadrants, meet at D, the highest point of the locus. Its height is $\sqrt{(23^2 - 5^2)}$, the height of the generating triangle. The square of this height is 504 foot-tons, and is the bending moment at the centre due to a uniform load of 72 tons, numerically twice the span, together with a concentrated load at the centre of 20 tons, numerically twice the base of the triangle.

The shearing force locus begins at the left support with 36 + 10 tons, falls at the rate of two tons vertical to one foot horizontal, and would pass through zero at 5 feet *past* the centre, so that here is the centre of the circular locus; but it falls suddenly 20 tons at the centre of the span.

On fig. 6 the shearing force locus begins with 36 – 10 tons at the left end, crosses the base at 5 feet before reaching the centre of the span, continues to fall, but suddenly passes up through the centre, due to the 20 tons *upwards* there. It again crosses the base at 5 feet beyond the centre. For every crossing there is a corresponding max. or min. of bending. In this case a min. at the centre and two equal max. of maxima at 5 feet, half the base of the triangle, on each side of the centre of the girder. These super-max., $M_5 = M_{-5} = 169$ foot-tons, are squares of 13, the sides of the generating triangle, and are the radii of the two circular arcs, greater than quadrants, meeting at D over the centre at a height less by $5^2 = 25$ foot-tons than the max., giving 144 foot-tons.

The dotted semicircle standing on the base of each fig. 5 and fig. 6 gives square roots of the B. M. for the uniform load alone, the height at the centre being $18^2 = 324$ foot-tons, an average of the values for D and D on the two figures.

The case, fig. 6, for direct rolling is of importance because it also is the bending stress diagram for a 36-ton locomotive, with the load equally divided between two wheels spaced 20 feet apart.

The Irregular Generating Polygon.

Two reciprocal generating polygons are shown on figs. 7 and 8. Each has begun to roll clockwise, the vertex A having traced the first part of the arc AB. The base of one polygon is a *convex* polygon $2\frac{1}{2}$, 4, 5, $3\frac{1}{2}$, and the base of the other is a *concave* polygon $3\frac{1}{2}$, 5, 4, $2\frac{1}{2}$. In each case the girder is 42 feet in span; the uniform load 84 tons, or numerically double the span. There are also four concentrated loads of 3, 8, 10, and 7 tons dividing the span of the girder into five parts of 5, 5, 11, 12, 9 feet. On one figure these four loads are downward, an every-day thing, but on the other they are *upward*—an arrangement leading to a locomotive equivalent to the uniform load, numerically twice the span, together with the four upward forces. The magnitudes of these four forces are numerically the four *intervals* between the five wheels of the loco., while the five intervals on the girder are numerically the same as the weights of the wheels.

On each diagram the slope of the shearing force locus is 42 tons vertical to 21 feet horizontal, or 2 to 1. On fig. 7 the downward loads add 17 tons to the shear (support) at the left end. The locus slopes in five parts, which are produced to meet the base. The first slope meets the base at half of 59 feet from the left end, or at $8\frac{1}{2}$ feet past the centre. This, then, is the highest point of the bending-moment diagram for the first 5-foot interval of the span, and is therefore the centre of the first arc up to *B*. The centres for the other arcs are *half* of 5, 8, 10, and 7, nearer the left end, one after another.

On the other diagram, fig. 8, the shear at the left end of the girder begins with 25 tons, being 17 less than 42, so that now the first slope meets the base $12\frac{1}{2}$ feet from the left end, or $8\frac{1}{2}$ feet to the left of the centre. The other four slopes meet the base at points further from the left end by *half of* 5, 8, 10, and 7, and so give the centres for the arcs, as shown on the diagram below.

On fig. 7 the locus of shearing force crosses the base once, so that the height of *D* is the max. of maxima. Its value is $M_0 = 630$ ft.-tons, so that the height of *D* should scale off at $\sqrt{630} = 25{\cdot}1$ on the scale, common to feet and sq. roots of foot-tons.

But on fig. 8 the locus of shearing crosses the base *three times*: at the centre, at 2 feet left, and at 3 feet right of the centre of the span. The height of *D* is a min. of maxima, lying between the two super-maxima, whose values are given by the heights of $a_2 = 16$ and $a_1 = 16{\cdot}1$, these being the radii of the arcs *CD* and *DE*. Hence $M_2 = 16^2 = 256$ and $M_3 = 261$, while the height of *D* squared gives $261 - 3^2$ or $256 - 2^2 = 252$ ft.-tons.

On the two loci of figs. 7 and 8, formed by the arcs of semicircles interlacing at *B*, *C*, *D*, and *E*, the average of the squares of the heights, at a pair of corresponding points, equals the square of the height to a semicircle standing on the span.

If the four intermediate loads be halved, the shearing force locus shows that the distances apart of the centres of the semicircles are halved also. As the loads are further and further decreased, the semicircles come closer and closer together; and when the four loads are altogether removed, they all coincide with the semicircle standing on the span. It is the diagram of square roots of the bending moments due to the spread load of 84 tons alone.

Consider the locomotive. If its wheels come closer and closer together proportionately, the centres of the semicircles do the same, and the modified locus suits the shortened locomotive. If the loco. be further shortened till all its wheels coincide, we then again have the semicircle standing on the span as the square roots of the max. bending moments, due to a single rolling load of 42 tons.

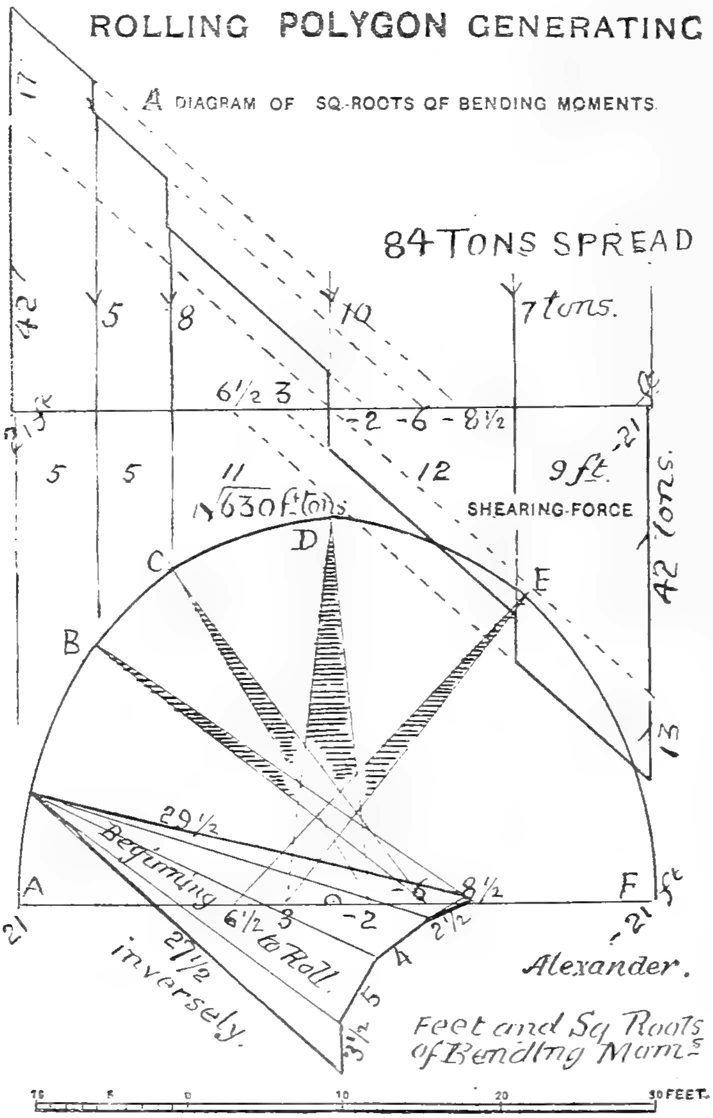

FIG. 7.

Generating Polygon, including a dead load with a locomotive.

To include a uniform dead load with a locomotive. Add it to the uniform load, fig. 8, numerically double the span; say 28 tons added to the 84 tons, and adopt $1\frac{1}{3}$ tons as a new unit of load, when the load will again be numerically double the span, but the four upward forces will be shortened in the ratio of 3 : 4. The shearing locus shows that the centres of the circles come

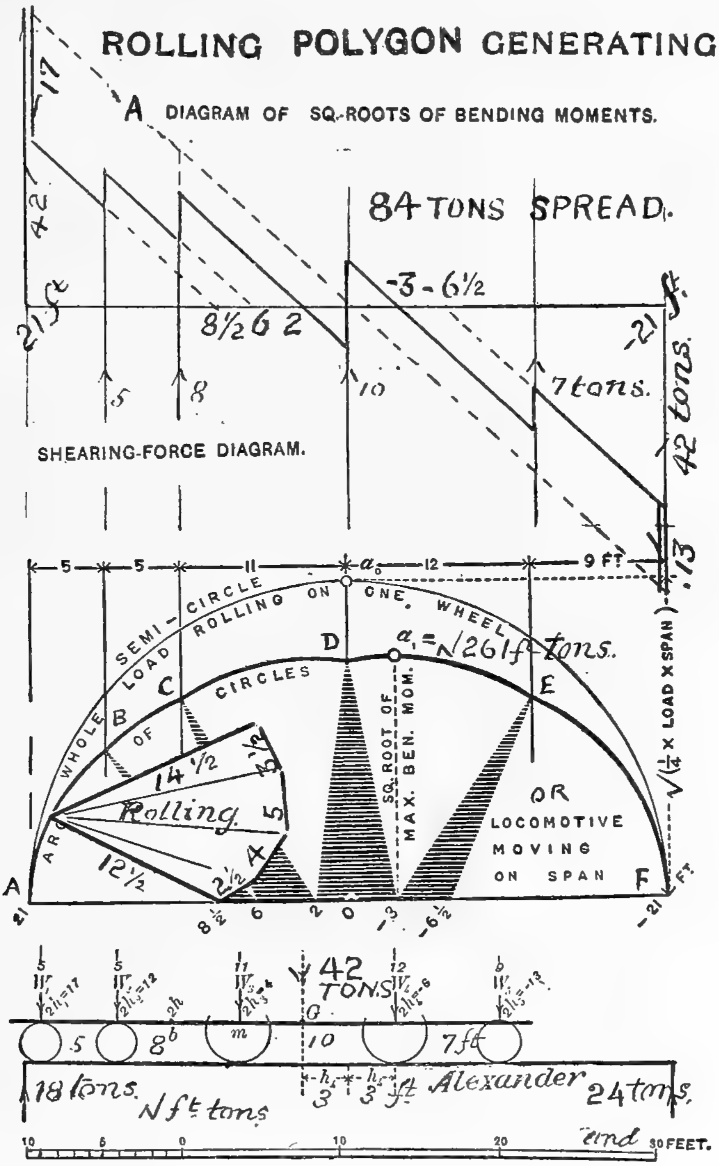

FIG. 8.

closer in that ratio, but intersect on the same verticals as before. We have then a diagram of the square roots of max. bendings for a new ideal locomotive heavier than the real one in the ratio 4 : 3, wheel for wheel, but the wheels closer together in the ratio 3 : 4. A vertical scaled from the diagram with the scale of feet, when squared, is the bending moment in ft.-$1\frac{1}{3}$-tons, and becomes ft.-tons when multiplied by the ratio 4 : 3.

Another way of considering the diagram, fig. 8, is to consider the loco. to have been closed up to 42 tons rolling on one wheel, and the 28 tons of spread load closed up to be 14 tons on one wheel. Those then become 56 tons, which is extended into the ideal heavier, shorter loco.

A SHORTER, HEAVIER IDEAL LOCOMOTIVE, EQUIVALENT TO

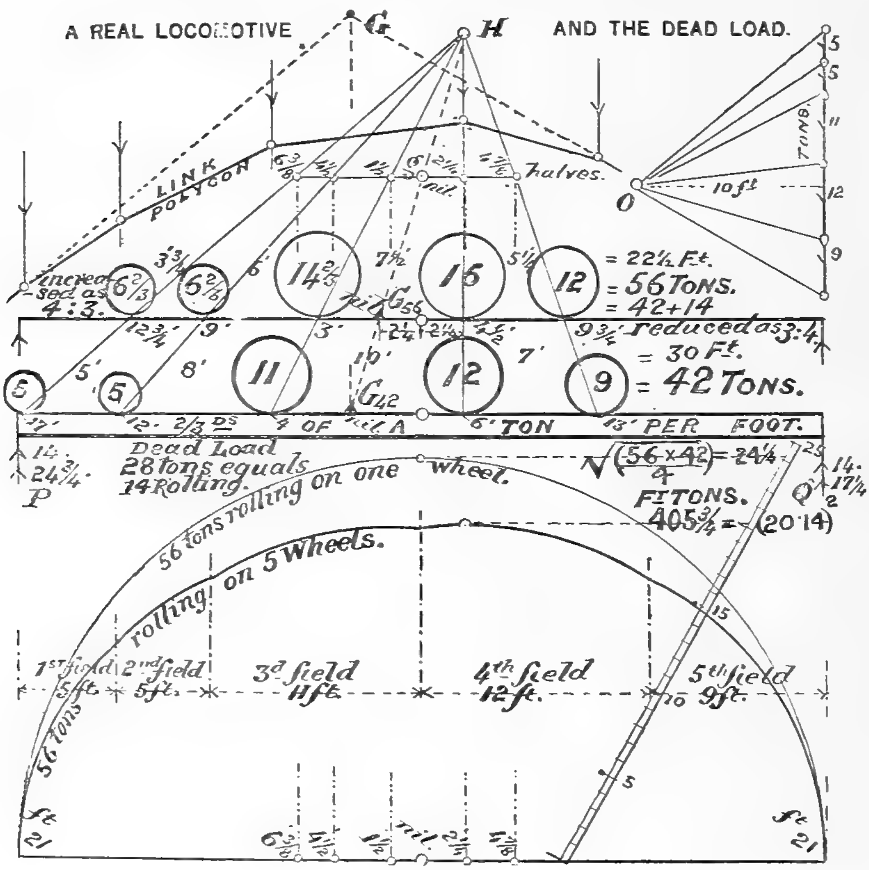

FIG. 9.

A heavy uniform moving load shorter than the span was used to test some long bridges in America. It is the limit of a loco. with equal loads on a great number of wheels, and can in a like manner absorb a uniform dead load, becoming itself heavier and shorter.

On fig. 9 a special oblique scale is used to read directly the verticals. It is a standard scale sloped till the height (21) of the semicircle standing on the span shall read sq. root of $\frac{1}{4} \times 42 \times 56$, and on it the height at $2\frac{1}{4}$ feet scales 20·14, and squaring we get $405\frac{3}{4}$ foot-tons, the super-max. stress for the combined loads.

But, by compelling the load to be numerically equal to the span, we may scale the height at $2\frac{1}{4}$ directly as 17·44 on the feet scale; this squared gives the super-max. = 304·15 foot – $1\frac{1}{3}$ tons = $405\frac{3}{4}$ foot-tons.

The product 56×42 suggests a third way of scaling the diagram. Using a finer scale for feet, the 56 becomes the span of a longer girder, the ideal loco. regains its original length, and to make the uniform load numerically double the new span, the unit of load must now be three-quarters of a ton, and this again makes the wheels of the loco. return to their original weight, so that the 16-ton wheel returns to 12 tons, the $2\frac{1}{2}$ feet returns to 3 feet, and we have the scaled height there on the finer scale to be 23·26, and this squared gives 540·9 foot – $\frac{3}{4}$ tons = $405\frac{3}{4}$ foot-tons.

The fig. 9 is a diagram of the sq. roots of bending moments due to the 42-ton loco. alone, on a 56-foot girder, or of 28 tons of dead load, together with the loco. on a 42-foot girder, according as we use a scale that makes the span 56 feet or 42 feet; in each case the unit of force must be changed so as to make the weight of the loco. numerically equal to the span.

The 42-foot span is chosen as the *shortest* non-overhanging girder that will accommodate all the wheels when the 12-ton wheel stands 3 feet to the right of the centre, its most trying position. With any given loco. this shortest span is chosen as a beginning, and the unit of load taken so as to make the load numerically equal to that span. A template can then be prepared for rolling out the stress diagram on a bold scale. Then by shifting the tracing point it will roll the stress diagrams for increasing spans with or without an included dead load.

Lesser spans formed the subject-matter of our former paper, already referred to; they can only accommodate a few wheels of the locomotive.

The template for practically generating the stress diagram due to a locomotive with or without a dead load.

We now give, on fig. 10, the template for generating the diagram of square roots of maxima bending moments on a 42-foot girder, due to the transit of a 42-ton loco. with five wheels, among which the load is distributed, and the wheels themselves spaced thus—

Loads	5		5		11		12		9	=	42 tons.
Feet		5		8		10		7		=	30 feet.

The polygon *Abcdef* is to be pricked through on cardboard, drawn, and its sides produced to the edges of the card. The points *b*, *c*, *d*, *e*, and *f* are to be pricked through the card itself, from the face, making a slight burr

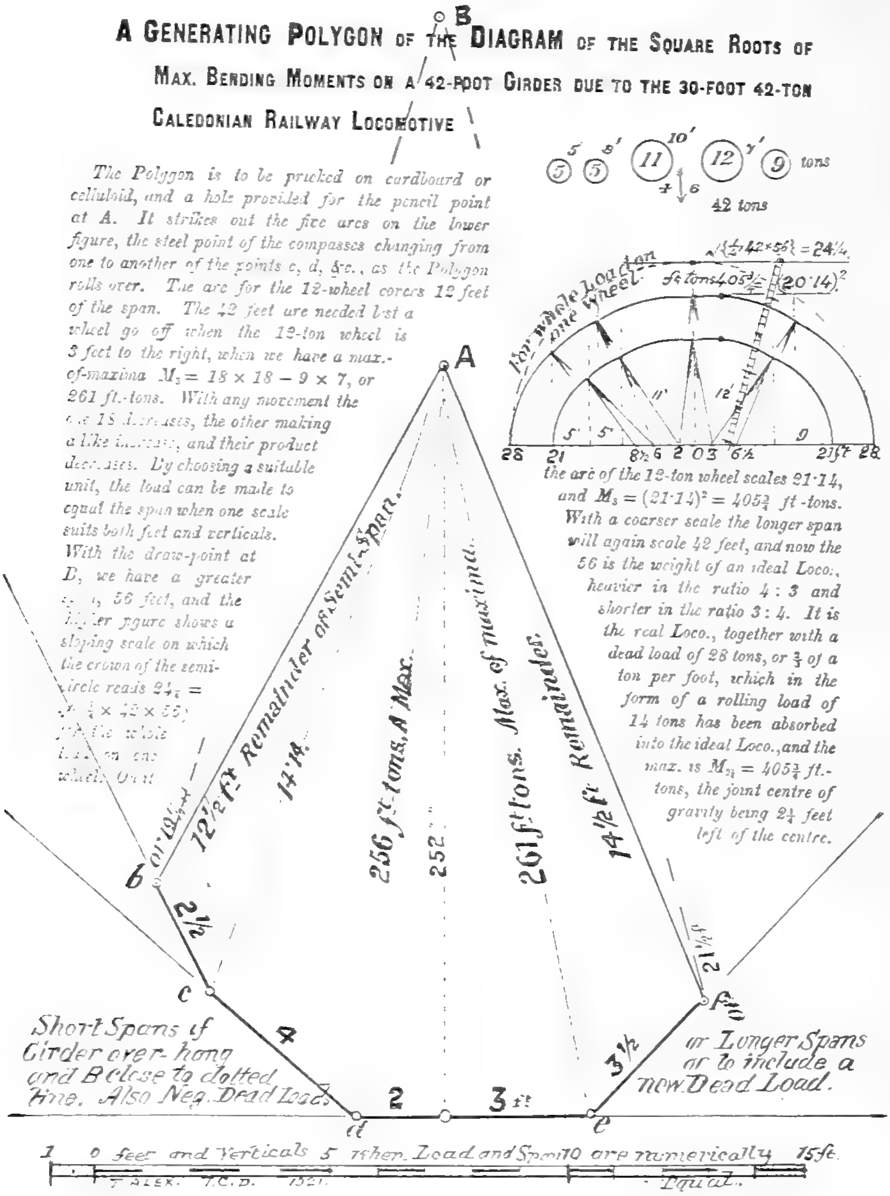

FIG. 10.

on the back, which allows the card to turn more freely. The draw-point *A* should be pricked through from the back with a thick needle, to accommodate the pencil point, and leave the back smooth. The card will lie along the base, with bA produced each way. The steel point of the dividers will go through b, and the pencil point through A, and the first arc drawn till bc, produced both ways, comes on the base, when the steel point shifts to c. In this way the five arcs are drawn. For good definition of the junction of the arcs, each arc should be drawn a bit both back and forward. A pin and a pencil, or syphon ink-pen, may be used instead of the dividers. The tracing point A will generate the smaller diagram, *inset* on fig. 10. See also fig. 8. The two super-maxima, equal to the two central radii, will scale $(16)^2$ and $(16{\cdot}1)^2$, giving $M = 256$ ft.-tons and $M = 261$ ft.-tons, at 2 feet left and 3 feet right of the centre of the girder. The scale for feet and verticals is 4 feet to an inch. The arcs will cross on verticals, dividing the span into *fields* numerically equal to the weights of the wheels.

Another tracing point B is plotted by arcs from b and f of radii $19\frac{1}{2}$ and $21\frac{1}{2}$. It generates the larger *inset* on fig. 10, almost mathematically the corresponding diagram for a girder 56 feet in span. The angles should have been slightly changed, but as B is sensibly on the dotted vertical through A, the two super-maxima dB, eB will scale with great accuracy. The crossings of the other arcs will not lie so closely on the junctions of their fields. The locus of the points such as B, which should be the dotted vertical line, will, when plotted as above, be a hyperbola with foci at b and f, as bB and fB constantly differ by two feet. The part AB will be sensibly straight.

By using a scale of 3 feet to an inch, that is, coarser in the ratio 56 to 42, the higher *inset* on fig. 10 returns to the initial span of 42 feet, while the loco. is replaced by the heavier, shorter ideal loco. described at fig. 9. The super-max., now $2\frac{1}{4}$ to the right of the centre of the girder, will scale 17·44. Squaring this, we have 304·31 ft.-$1\frac{1}{3}$ tons, as the unit of load is now $1\frac{1}{3}$ tons to make the load and span equal numerically. So we have the position $2\frac{1}{4}$ feet, and the value $405\frac{3}{4}$ foot-tons of the super-max. on the 42-foot span for the 42-ton loco. together with a dead load of 28 tons.

At the junction of two "fields" the bending-moment remains constant as long as the pair of commanding wheels straddle across it, or one of them arrives at it. Their values on fig. 8 are 100, 175, 256, and 180 foot-tons. If we complete the circle of which CD is an arc, complete the chords CC', DD', and the diameter DC', then the tangent of $CC'D$ is 11 divided by $13{\cdot}2 + 16$, and we have the half angle subtended at the centre of the chord CD. This is the extern angle at the point d on the polygon (fig. 10), and for the others:—

$$\cos b = {\cdot}6, \quad \tan\frac{c}{2} = {\cdot}215, \quad \tan\frac{d}{2} = {\cdot}37, \quad \tan\frac{e}{2} = {\cdot}41, \quad \cos f = {\cdot}4.$$

The template (fig. 10) is quite accurately constructed by plotting the diagram on a large scale and compounding the triangles by lineal measurements alone.

Using a third scale, the upper *inset* would yield results for the real loco. on spans between 42 and 56, including dead loads less than 28 tons. This, with other positions of *B*, enables the template, fig. 10, to generate diagrams giving general results for various spans upwards of 42 feet, and to include any desired dead loads, but not for spans much smaller, as the hyperbola would curve rapidly.

A large wooden model polygon turning on a lath pinned to the black-board and guided by a steel strap jointed at *b*, *c*, *d*, *e*, and *f*, and having a chalk holder that can pull out from *A* to *B*, is made for demonstrating purposes by *Dixon and Hempenstall*, Dublin; also a celluloid polygon.

The Regular Polygon.

On fig. 1 are shown the diagrams generated by the regular polygons of two sides (base zero), three, four, and five sides, with the corresponding locos. The super-max. is given numerically by the radius of the arc nearest the centre, and occurs either at the centre or distant half a side from it, according as the number of sides of the polygon is even or odd.

That the area of the circular sectors is twice that of the circle circumscribing the polygon follows from the theorem. If from one of a number of points dividing a circle into n equal arcs chords be drawn to the others, the sum of the squares of the $n-1$ chords equals the area of the circle multiplied by $2n : \pi$.

As the two isosceles triangles, one with the base zero and the other with the base equal to the sides, both sweep out the area indicated, it follows that some isosceles triangle lying between them will sweep out the minimum area lying between those two equal maxima. It is readily proved by differentiating that 2θ the vertical angle is given by $2\theta + \cot\theta = \pi$.

On fig. 11 are shown the diagrams swept out, one by the corner *A* of the regular hexagon, and two, above and below the base, by a point *B* carried by the hexagon at a distance twice its side from the centre out through *A*.

For the hexagon the corresponding loco. has its five wheels spaced $2a$ apart, and their weights are as follows, being the same as the *fields* into which the span is divided, but having a replaced by w:—

$$\frac{w}{2}, \quad \frac{3w}{2}, \quad 2w, \quad \frac{3w}{2}, \quad \frac{w}{2}.$$

The radii of the arcs covering the fields are $a, \; a\sqrt{3}, \; 2a, \; a\sqrt{3}, \; a.$

The diagram generated above the base by B, the carried point, corresponds to a loco. with loads on its five wheels thus—

$$w(\sqrt{3} - 3/2), \quad 2w, \quad 3w, \quad 2w, \quad w(\sqrt{3} - 3/2).$$

They are spaced $2a$ apart, giving an extreme length $8a$, which is more than $(4a + 2a\sqrt{3}) = 7{\cdot}564a$, the span. With the carried point B a little further out from the centre of the hexagon, the girder would be slightly over $8a$ in span, and would give the $8a$–loco. space to move and bring its wheels into their most trying positions without any wheel leaving the span.

It will be seen that this is like the practical problem by comparing it with fig. 10 ; only the shuttle loco. above with the weight mostly in the centre and trifling at its ends is not usual. If its circumscribed circle replace the hexagon, the carried point B describes *a trochoid.*

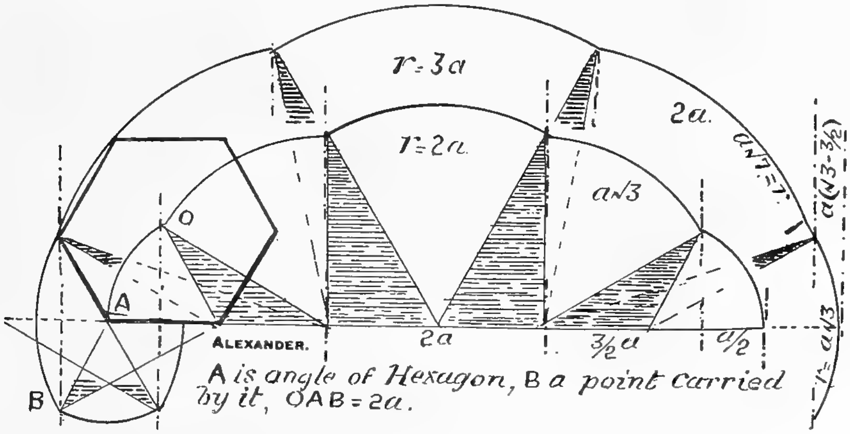

FIG. 11.

The part of the diagram below the base on fig. 11, if turned upside down, corresponds to a girder with a uniform load double its span, together with two downward loads $2a$ each at the two points where the arcs cross. See fig. 7, which, like it, is produced by a polygon rolling *inversely.*

To return to the upper diagram on fig. 11 produced by direct rolling besides loco. just described, it also corresponds to a uniform load numerically twice the span, with *upward* loads numerically $2a$ each acting at the junctions of the *fields.* See fig. 8.

If the hexagon turn over inside a duodecagon with the same sides, the arcs will only have half the areas shown on fig. 11, and their sum equal once the area of the circumscribing circle. If it turn over outside the duodecagon, the area will increase to three times that of the circle. In the limit, when both polygons become circles, we have, adding the area of the rolling circle itself inside, twice the area of the rolling circle, or half the area of the larger circle, but outside four times the area of the rolling circle. So that if a circle make a complete excursion on a *semicircle* of double its radius, rolling inside as it advances and outside on its return, the tracing-point will draw a closed curve with an area six times that of the rolling circle. One part will be straight and equal to the diameter. It is evident that the area thus enclosed is the same if the path be any plane curve, provided the curvature be nowhere sharper than that of the rolling circle.

For the diagram generated by A, a corner of the hexagon, the measure of the downward uniform load is $12a$, and four upward forces $2a$ each, at the junctions of the *fields*. In the circumscribed circle, suppose the hexagon replaced by a 12-sided polygon, there would be ten upward forces, each measured by twice the side of the new polygon. In the limit, when a circle was reached, the sum of the equal upward forces would be the same as the downward uniform load, but they would be spread sparsely at the centre of the girder, and closely at the ends.

The Cycloid.

If we consider the inverse problem—namely, what is the manner of loading a girder so that the diagram of the square roots of the bending moments shall be the cycloid—we see that the total load is zero, that the locus of the load is a curve, convex upwards, lying above the base for a large central part of the base, crossing it near the ends, and reaching far down at each end. The areas of the two parts below the base are the two supports.

Now, as the areas for load, shearing, and bending for fixed loads are derived by successive integration, we propose to determine the shape of the load by differentiation from the cycloid.

With a the radius of the rolling circle, we have

$$x = a\,(\theta - \sin\theta), \quad y = a\,(1 - \cos\theta),$$

$$\frac{dx}{d\theta} = y, \quad \frac{dy}{d\theta} = a\sin\theta, \quad \frac{d}{d\theta}\,(y^2) = 2ya\sin\theta,$$

$$\frac{d}{dx}\,(y^2) = 2a\sin\theta \quad \text{and} \quad \frac{d^2}{dx^2}\,(y^2) = \frac{2\,(a - y)}{y}\,.$$

With k to determine the scale, the equation of the load-locus is

$$\eta = k\,\frac{2\,(a - y)}{y}\,.$$

With $k = a$, the equation takes the form $(2a - \eta)\,y = 2a^2$, which leads to the neat construction of the load-locus shown on fig. 12. The locus is seen, by inspection, to cross the base when $\theta = 90°$ $y = a$; and so divide the half-base into segments, the arc of a quadrant plus and minus a radius respectively

$$\tan \psi = \frac{d\eta}{dx} = \frac{2a^3}{y^3} \sin \theta.$$

And the locus crosses the base at a slope of 2 to 1, corresponding to the 1 to 1 slope of the cycloid. Further, the areas below the semi-base and above it, the limits being

$$x_1 = \left(\frac{\pi}{2} - 1\right) a \quad \text{and} \quad x_2 = \pi a,$$

are

$$\int_0^{x_1} \eta dx = - 2a^2 \int_0^{\frac{\pi}{2}} \cos \theta . d\theta = - 2a^2,$$

$$\int_{x_1}^{x_2} \eta dx = - 2a^2 \int_{\frac{\pi}{2}}^{\pi} \cos \theta . d\theta = 2a^2.$$

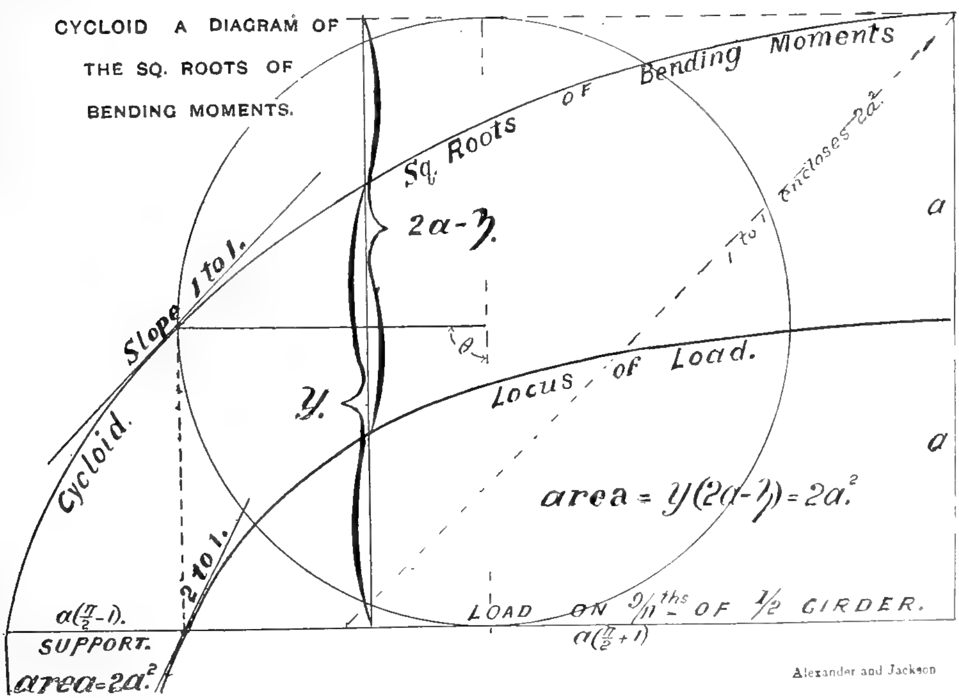

FIG. 12.

A girder loaded in this manner over a middle *nine-elevenths* of its span and supported on the end segments would have the cycloid as its diagram of the square roots of the bending-moments.

The diagram rolled by a regular polygon of many sides, as on fig. 13, can be constructed with great accuracy. For the half diagram the first stroke is upward at θ to the vertical, then down vertically, then up at plus 2θ, down at minus θ, and so on, like writing, plus 2θ up, θ down; ever making an equal advance on the base with the further check, point by point, that each up stroke equals the last one down.

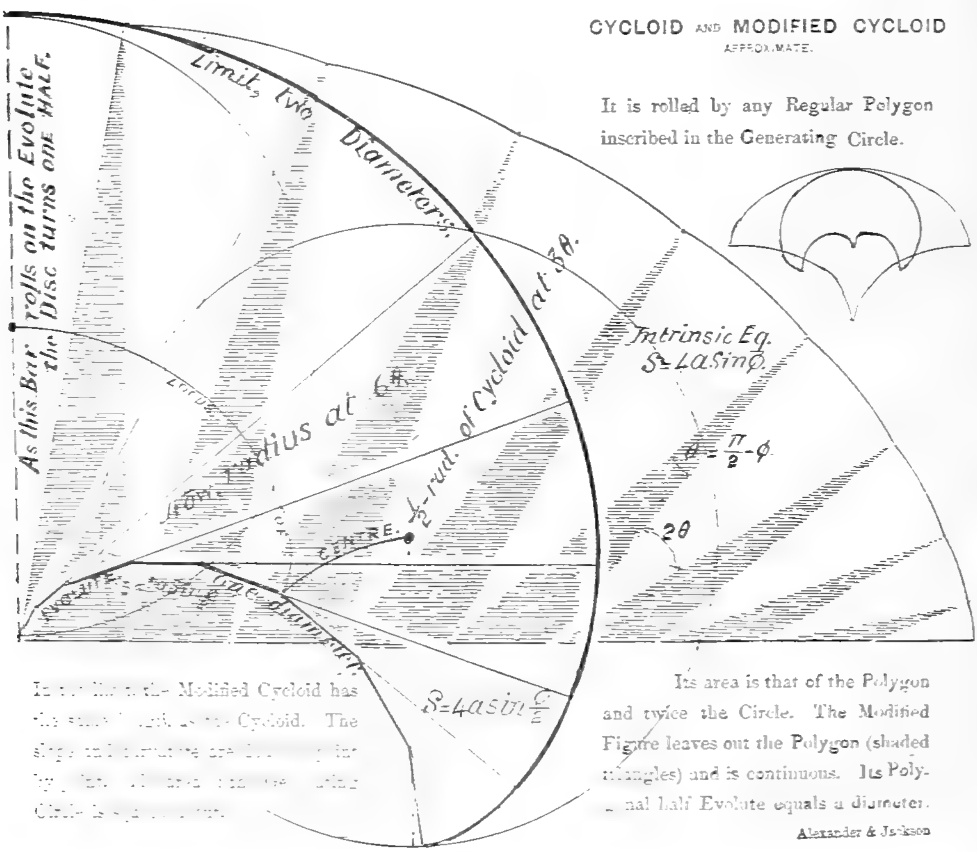

Fig. 13.

When the black triangles are taken out (that is, the generating polygon) and the white sectors closed up, we have a modified continuous curve, which in the limit is equal in length to the cycloid, and the area inclosed between it and its polygonal evolute is that of twice the rolling circle.

By inspection of the diagram it will be seen that this *modified cycloid* has, from point to point, [illegible] the slope and curvature of the cycloid.

The *intrinsic* equations of the cycloid, modified cycloid, and its evolute are

$$s = 4a \sin \phi, \quad s = 4a \sin \frac{\phi}{2}, \quad \text{and} \quad s = 2a \sin \frac{\phi}{2}.$$

In this way we have the cycloid with the generating circle squeezed out.

The inset figure shows the area of 4 circles inclosed by the cycloid and its evolute, with a joint perimeter of 8 diameters; and as modified into an epicycloid with its evolute, inclosing the area of 2 circles, with a joint perimeter of 6 diameters.

This epicycloid can be generated either by the disc, fig. 13, having a vertical bar that wraps round the evolute, or independently by a circle of diameter *two-thirds* that of the disc rolling outside another circle of *double* its own diameter.

If we contrast the figs. 7 and 8 we see that as the direct rolling polygon of the one becomes regular, so also does the concave base of the inverse rolling polygon on the other. When the sides increase indefinitely and the one polygon becomes a circle, and the locus *ABCDEF* a cycloid, then the other polygon becomes *equilateral*, its two long sides equal to the span *AF* and its concave base as well. In form the base is like a parabola. The limit of the locus *ABCDEF*, fig. 7, is like half of an ellipse, its area being the same. The semi-axes are πa equal to half of *AF*, and the height of *D* equal to the sq. root of $2\pi^2a^2 - 4a^2$, derived from the relationship of the depth and height of *D*, below and above the semicircle on figs. 7 and 8, respectively, and shown also on figs. 5 and 6.

From this relationship among the cycloid, semicircle, and limiting value of the locus *ABCDEF* on fig. 7, all on the same base *AF*, the origin being at *A*, with $x = a(\theta - \sin\theta)$, we find

$$\frac{Y^2}{a^2} = 2\theta(2\pi - \theta) - 4(\pi - \theta)\sin\theta + (1 + \cos^2\theta) - 4.$$

CONJUGATE LOAD AREAS.

In a former paper read to the Royal Irish Academy* on two-nosed catenaries, we developed their application to the design of segmental masonry arches. It was adopted later by Professor Howe in the chapters of his elegant treatise† that dealt with masonry arches in general. To meet

* "On Two-Nosed Catenaries and their Application to the Design of Segmental Arches," by T. Alexander, C.E., Professor of Engineering, Trinity College, Dublin; and A. W. Thomson, B.SC., Lecturer in the Glasgow and West of Scotland Technical College. Trans. of the R.I.A., vol. xxix, part iii, 1888.

† "A Treatise on Arches," by Malverd A. Howe, C.E., Professor of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Indiana. New York: John Wiley & Son. London: Chapman & Hall, Ltd., 1897.

his criticism, that the catenary method neglected horizontal loads, we made a graphical development of Rankine's conjugate loads, printed for private use in the Engineering School of Trinity College, Dublin. In this we were allowed by the Academy the use of the blocks and part of the scientific work of our paper.

In this paper we will give our latest development of conjugate load areas, and use the blocks of the privately printed paper, but only to aid the scientific discussion. Still these blocks have sufficient information on their faces to express their practical use to the engineer.

Rankine's Stereostatic Arch.

This refers to a linear rib, generally having two quadrants, which he calls a complete arch, horizontal at the crown and vertical at the springings. It is balanced by two conjugate loads—a vertical load varying in a symmetrical definite way horizontally outward from the crown in each direction, and resisted as a whole by the two upward supports at the springings, and also bearing a pair of horizontal loads, which are distributed in a definite vertical way so as to prevent the arch from spreading or collapsing at any point; so that if the rib be supposed to have a plenum of hinges, there is no bending, but only thrust (or tension), at each point due to the total load. Rankine's theorem is, that of the three things—the shape of the curve, the distribution of the vertical load, the distribution of the horizontal load; given any two, the third is determinate.

We shall deal principally with the semicircular rib, and suppose the vertical load spread in some definite manner on a horizontal platform equal to the span; these two given, we shall find the necessary distribution of the horizontal load upon two vertical platforms equal to the rise of the rib. In this diagrammatic way we have two sets of conjugate load areas.

The Balanced Circular Horizontal Rib.

For the circular rib, fig. 1*a*, the given north-south load areas are a pair of parallelograms representing a uniform stress p, spread on the barricades, of which ab is one base for the north-west quadrant. They tend to make the rib collapse. By symmetry the conjugate load areas, east-west, that resist the collapse is the uniform stress, *equal and like*, $q = p$, in part shown on the base (or barricade) cd. These Rankine calls *equal like principal stresses*, or, more shortly, *a fluid stress*, and this correctly describes the *state of stress* of the fluid surrounding the cylinder, or of the granular mass of earth in level layers surrounding it, and means that cubes of the surrounding mass, oriented north-south, mutually press normally on each other with p, or $q = p$, in those directions, or on the barricades ab, cd, or, finally, on the back of the rib everywhere normally with $r = p = q$. These are passive stresses, the active stress being the vertical column of water $h = p = q$, or $h = 3p = 3q$ for the column of earth, where the friction among the grains is usually in this ratio of 3 to 1 in favour of the passive resistance. The state of strain in the mass of earth itself is *prolate spheroidal*, since the rib, being circular if balanced, compels q to be equal to p.

For the earth (geostatic) load the cylindrical shaft might be elliptical to a slight degree, that is, till $q = h = 3p$ (oblate spheroidal stress). We may suppose the circular rib to become rigid, and the four parallelograms concentrated into four forces acting on it. And now let the figure be pulled out east-west till the circle becomes an ellipse, with diameters in the ratio $\sqrt{3} : 1$. The east-west force for equilibrium will be increased; and when spread on the same barricade cd it gives the new value of q greater in the ratio $\sqrt{3} : 1$. The north-south force is unaltered by the pull out; but when spread out on the elongated barricade ab, the new value of p is reduced in the ratio $1 : \sqrt{3}$. The ellipse of stress (trace of the spheroid) for the earth itself has its axis in the duplicate ratio 3 : 1, the greatest safe ratio that the earth may not "run" and gradually allow the shaft to flatten. A fine example is the ventilating shaft of the Hoosac Tunnel, Massachusetts (Simm's "Tunnelling"), elliptical in form, the axes being 27 by 15 feet, which are sensibly in the ratio $\sqrt{3} : 1$.

This is Rankine's linear transformation of a structure. If one of the conjugate stresses be a datum that cannot be supposed to decrease in intensity, then the other must increase by the duplicate ratio, just as if we multiplied *both* our resultant new stresses by $\sqrt{3}$.

For a formal proof of the rib of radius R, fig. 1a, being balanced, we consider the north-west quadrant AS as rigid and hinged only at A and B; then $T_0 = qc$, the whole of the Q area, and is tangential, and $T_1 = pc$ in the same way, and each of these equals rc, the normal resultant stress at A and S, and, indeed, at all points. But for all (*complete*) ribs, with any conjugate loads, the hoop thrust at A equals p_0c, where p_0 is the normal *component* stress at A, and c the radius of curvature of the rib at A, for the reason that at A, as on fig. 1a, there is *complete exposure* to the stress p_0 at a, while the exposure to q at d is *nil*. Hence, if we know p_0 at the a end of the barricade, and the radius of curvature at A, their product gives us the algebraic sum of the whole conjugate load Q on the other base cd, and also, if we know q at c and the radius at S, their product is the algebraic total area of the load P.

Next suppose that the rigid arc *AS* has a hinge at any point *B*; let us consider the equilibrium of the upper rigid part *AB*. At *B* introduce the horizontal force *H* equal to the shaded part of the *Q* parallelogram, and the vertical force *V* equal to the shaded part of the *P* parallelogram. The three forces *T*, *H*, and *V* balance the rigid arc *BA*. But these shaded areas are proportional to *cf* and *ae* respectively, or to cos θ and sin θ, therefore the resultant of *H* and *V* equals *T*, and is tangential to the rib at *B*, so that there is no bending stress at the hinge *B*. But *B* was any point, and so the whole arc *AS* may be a *plenum* of hinges, that is, it need not be rigid, but free to change its shape. These resultant stresses (loads) on the back of the rib are not *necessarily* due to the requirements of a surrounding mass that its own equilibrium be assured. They can be produced artificially, as we shall see when dealing with the vertical arch.

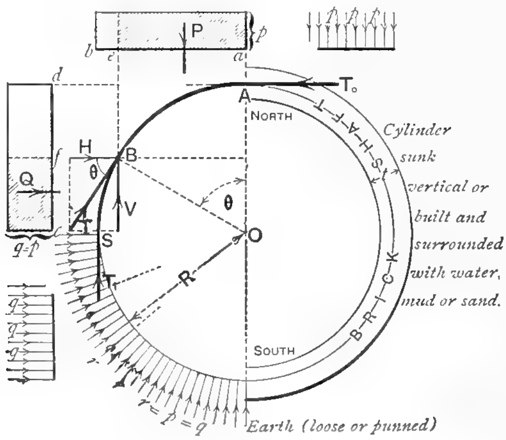

FIG. 1*a*.

The result of our latest investigation points at *two pairs* of symmetrical conjugate loads which balance a "complete arch." Indeed, their number may be indefinite, with only two of them real. The pair already discussed are *like*, wholly positive and uniform.

It is most remarkable that there is another pair for the circular rib. They are *unlike*, but symmetrical, in that each has a central smaller part of opposite sense from the end parts. The corresponding geometrical diagrams are parabolic in form, a *sixth* of the depth at the vertex being on the opposite side of the base.

They are shown on fig. 2*a*. The *linear unit* is taken as *r*, the radius of the rib, to simplify the arithmetic; it makes the parabolic segment isosceles, as the two co-ordinates from its vertex to any point x and x^2 are equal.

They are thus lettered on fig. 2*a*, though drawn flatter to save space. The north-south pair acts *towards* the rib, their algebraic value being $\frac{r^3}{3}$, so that at S and S' we have a *hoop thrust* $\frac{r^3}{6}$. The east-west pair acts *away* from the rib, so that at A and A' there is a *hoop tension* of $\frac{r^3}{6}$.

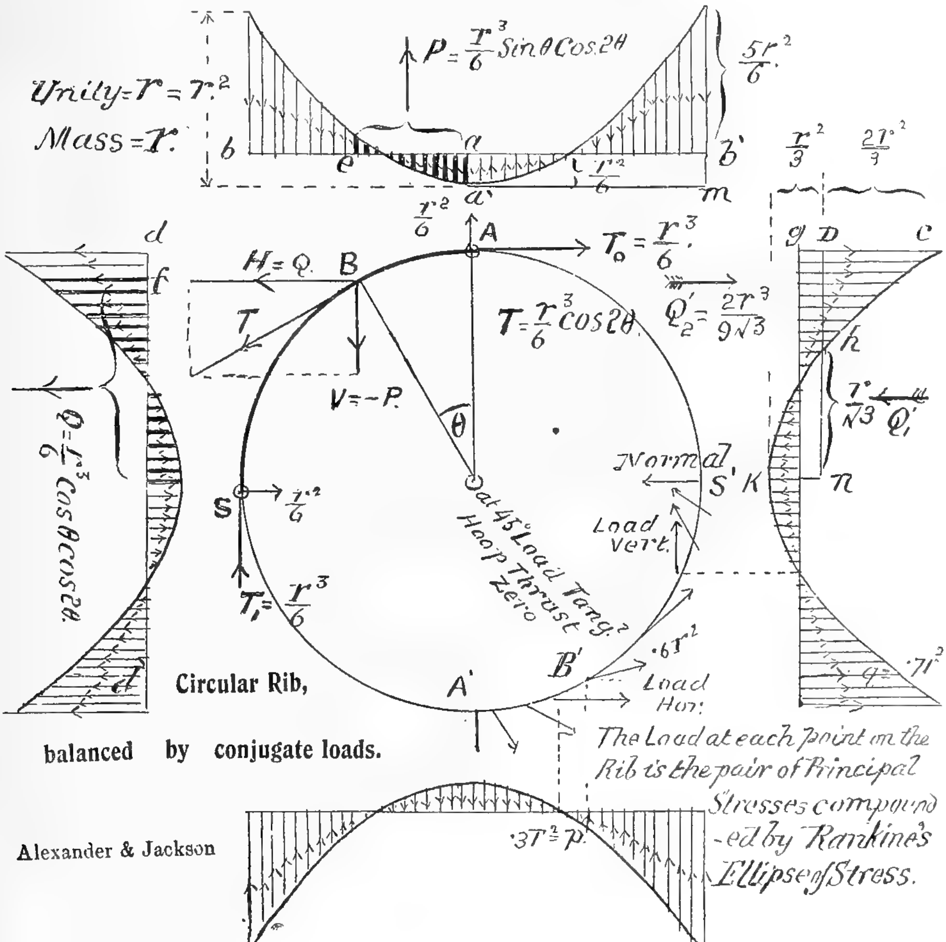

FIG. 2*a*.

It is readily proved that the shaded portions of the stress areas P and Q on the arc AB, just as in the former case, are proportional to sin θ and cos θ, where θ is the slope of the curve at B. Thus $-V = P = \frac{r^3}{6}\sin\theta\cos 2\theta$, and $H = Q = \frac{r^3}{6}\cos\theta\cos 2\theta$, giving the hoop tension at $B = \frac{r^3}{6}\cos 2\theta$. With successive values of θ, we have hoop tension on the rib from A to the middle of the quadrant, where it is *nil*, then hoop thrust. There can be no *normal* component load at $\theta = 45°$. The state of stress at B' or 30° from south is given by the pair of unlike principal stresses $p = \cdot 3r^2$ and $q = \cdot 7r^2$, advanced to touch the back of the rib, one from each of the two load areas, and there compounded by Rankine's ellipse of stress, thus giving an outward oblique load of $\cdot 6r^2$ at B' at east by north. At A' it is $\frac{r^2}{6}$ south, soon it is east, still outward. At $\theta = 45$ it is wholly tangential, then due north, then west, and so at S' it is again $\frac{r^2}{6}$ and normal, but inward. The whole load is two equal and opposite couples taken in pairs of opposite quadrants.

The Balanced Vertical Circular Rib.

Now we are considering the semicircular masonry arched bridge, its stability developed from the linear rib. Only a small part of the vertical load is uniform along the span, the superstructure up to the level of the rails and the live load, a row of locomotives covering or half-covering the span. By far the greatest part of the load is the weight of the arch-ring, generally uniform along the curve, or assumed to be so in the first instance. It cannot be pictured by an area spread on a horizontal straight platform, as the heights at the ends reach up indefinitely. We have devised a simpler way. Again, there is what Rankine calls the *spandril-area*, mapped out by a quadrant of the linear arch, and tangents from its crown and springing point. For this load alone there is no normal load at the crown, so that the horizontal hoop-thrust at the crown is *nil*, and so the shape of the corresponding horizontal load area is necessarily like a figure-eight, with the lower positive thrust-area equal to the upper negative pull-area. When built upon a vertical straight base equal to the rise (radius) of the linear rib, the locus (q) crosses the base. The point on the rib, at the height of the crossing-point, is Rankine's point of rupture, or joint of rupture; and its slope, the angle of rupture, he finds to be $\phi = 56° =$ limiting value of θ. His construction to build the *area* fails to give any idea of its correct shape. The horizontal upper outward part of this load cannot be practically applied to masonry arches. Its absence compels the linear circular rib in the midst of the upper segmental, elastic, and important part of the arch to become a modified catenary. Now, as the *total depth* of the load at the crown is always, in railway bridges, a much smaller fraction of the radius than 1 : 3, the line of stress is a *two-nosed catenary*, a basket-handle-shaped curve. The confining of this altered linear rib within the *middle-third* of the masonry arch ring was the subject of our former paper. When this is secured the depths of the keystone and springing stone are determined with the hoop-thrusts and factors of safety against crushing. It is an advantage to this segmental part of the semicircular arch not to be hampered by rigid backing as it yields elastically as the load moves. Of course, rubble spandrils acting by their weight chiefly may be necessary to check the upward swing of the half-arch when the locomotives are on the other half-arch only. Note, too, there is another *joint of rupture* where the slope $\theta = 30°$; this is where the *noses* of the line of stress (or elbows of the basket-handle) touch the upper limit of the middle third. The joint here is inclined to gape at its *lower end*; the joint of the keystone at its upper end. At the springing the stress is nearly at the centre of the joint, and this springing joint is closer to $\theta = 60°$ than $= 45°$. These two, θ_2 about 60° and $\theta_1 = 30$, our *pair of joints* of rupture, replace scientifically Rankine's joint of rupture, which he roughly estimates to be about $\theta = 45°$.

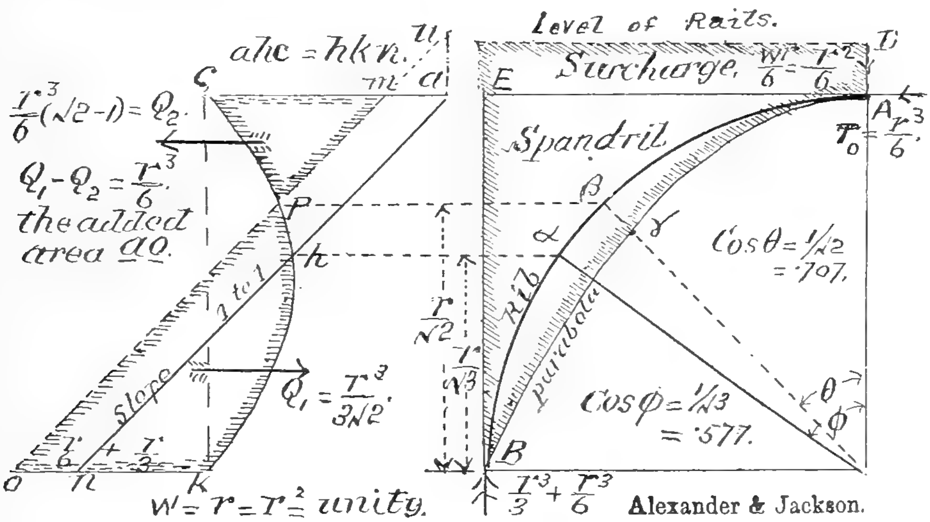

FIG. 3*a*.

The horizontal conjugate load is the passive resistance of the heavy square-dressed backing to resist the spreading of the arch even in the slightest degree. The shape of the conjugate load area enables the stability of the arch to be secured economically, and there is great economy in the arch-ring, whose "kernel" just accommodates the line of stress.

Approximate Solution of the Semicircular Arch.

On fig. 3*a*, *DE* is the surcharge (parallelogram), and *EAβB* the spandril-area, whose density is much less than that of the arch-ring, due to the voids, and may be taken as the *average*; and later on the ring-area is increased by

(50, 40, or 30 p. c.) a percentage for granite, sandstone, or brick rings. As these voids alter the true shape of the spandril-area, it might be taken as having the parabolic shape $EA\gamma B$, which is the north-south load on the AS_1, quadrant of fig. 2*a*, with a parallelogram *am* added of depth $\frac{r^2}{6}$ acting towards the rib, and raises the thrust at *B*, fig. 3*a*, the springing, to $\frac{r^3}{3}$, doubling its value. A like parallelogram *gn*, fig. 2*a*, acting towards the rib, is added there to the horizontal load-area, and now the thrust at the crown is *nil.* This value is verified, as the normal load at the crown is now *zero.* For the parabolic spandril-load on the quadrant AS' we have the horizontal conjugate load-area, shaped figure-eight-wise, mapped out by the two boundaries—a parabolic quadrant *chk* and a vertical line *Dhn,* the lower part acting towards the rib and the upper away from it, their common area being $Q_1' = Q_2' = \cdot 128r^3$, or $\frac{2r^3}{9\sqrt{3}}$. It is convenient on fig. 3*a* to replace that vertical boundary by *an* at 45° to the horizon, when the other boundary *chk* becomes a right parabolic segment. They cross at *h* on the same level $\frac{r}{\sqrt{3}}$ as before, and the point *a* on the rib is Rankine's point of rupture; and the limiting position of θ is ϕ, given by

$$\cos\phi = \frac{\sqrt{3}}{3} = \cdot 577.$$

If a parallelogram *DE* for the superstructure be added to the load, say, *AD* or *au* = a sixth of the radius $= \frac{r^2}{6}$, it is at once added also to the conjugate load-area by the draughtsman placing his set-square at the point *u*, and drawing the one-to-one dotted boundary *uo* to supersede *an.* The thrust at the crown is now $Q_1 - Q_2 = T_0 = \frac{r^3}{6}$, and at the springing $T_1 = \frac{r^3}{2}$. Part of the added parallelogram may allow for the excess density of the masonry ring. The boundaries of the new figure-eight-like area cross at *p*, so that β is now the point of rupture, and $\cos\theta = \frac{\sqrt{2}}{2} = \cdot 707$. The solid backing required by the arch $Q_1 = phko = \frac{r^3}{3\sqrt{2}}$, and the leaving out of Q_2, the negative part of the backing, makes T_0 increase by $\frac{r^3}{6}(\sqrt{2}-1)$; and since the normal load at *A*, the crown, remains $\frac{r^2}{6}$, the *radius of curvature* of the modified line of stress must be *greater* than *r* in the ratio $\sqrt{2}:1$. The modified curve from *A* to β is a modified catenary, flatter at *A* than the circle, and sharper in curvature at about 30° near β.

As the square-dressed heavy backing is built up from *ok*, its power of resisting the spreading of the arch from point to point as it rises is determined by the *shape* of *phko.* This is a good approximation, taking the shape of the spandril-area parabolic, and the *excess load* along the rib as if it were along the span.

Exact Solution of the Masonry Semicircular Arch.

The quadrant *ABS* has three loads a parallelogram of height *AD*, the spandril area and a load spread uniformly along the arc *ABS* on fig. 4*a*, where it is shown like a collar *MHA*, of a depth one-half of the radius. Such might be the actual case in a brick sewer, whose ring was deep, and heavier than the surrounding mass. We have chosen this extreme depth $\frac{1}{2}r$ so that the area of the collar bit by bit of the arc shall correspond to the

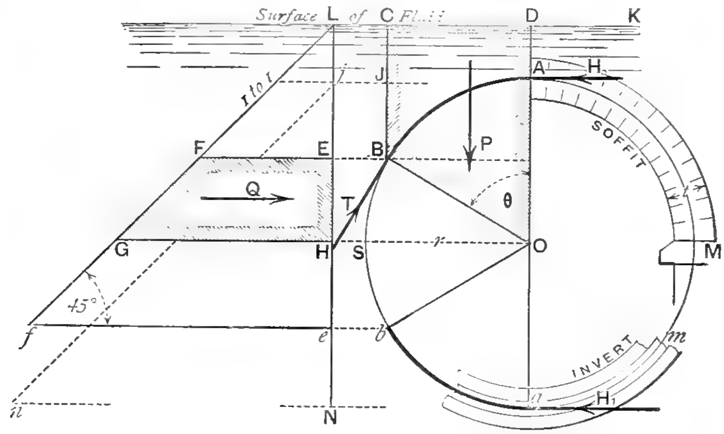

FIG. 4*a*.

sectors subtended at *O* by those arcs. So now the whole load on the arc *AB* is the trapezoid *OBCD.* It at once becomes evident that the horizontal conjugate load-area is an isosceles right-angled triangle *LHG*, mapped out by the vertical *LH*, and a 45° or 1-to-1 slope *LEG.* The horizontal load on the arc *SB* is the trapezoid *GFEH.* Now, the two trapezoids *P* and *Q* have their parallel sides equal each to each, and so $P : Q = CD : EH = \sin\theta : \cos\theta$, and *T* is tangential to the rib, and the rib is balanced.* Although there is always

* It will be seen that if the shell *ABSaM* have the same weight as the water (or fluid as mercury) it will be balanced by the external fluid at any depth, the fluid supplying the two conjugate loads simultaneously, and sinking, merely adding equal parallelograms to each.

This elegant theorem of the equilibrium of the thin horizontal empty circular cylinder displacing its own weight of fluid was given by the authors in a letter to "Nature" of 18th February, 1897. From some private correspondence about it, with an additional load along the rib, a fifteenth or lesser fraction of r, it is better to get rid of the $\frac{1}{2}r$ load along the rib altogether, and restore such fraction of it as may be necessary later on.

To find the conjugate load for a vertical load uniform along a circular quadrantal rib, we proceed by the calculus, as Rankine does for the spandril area. In doing so for load $\frac{1}{2}r$ it has only to be done once and for all, and can be adjusted by simple proportion for lesser thicknesses. We have always $Q = P \cot \theta$, and Q is split up into thin horizontal strips $q.dy$, where y is measured from H up to L; and P is divided into thin vertical strips $p.dx$, where x is measured from A towards E. We then have fig. 5a—

$$q = \frac{dQ}{dy} = \frac{d}{dy}(P \cot i); \quad P = \frac{r}{2} \cdot s = \frac{r}{2} \cdot ri = \frac{r^2}{2} i; \quad P \cot i = \frac{r^2}{2} i \cot i;$$

$$\frac{d}{di}(P \cot i) = \frac{r^2}{2}(\cot i - i \operatorname{cosec}^2 i); \quad y = r \cos i; \quad \frac{dy}{di} = -r \sin i;$$

and $$\frac{di}{dy} = \frac{-1}{r \sin i}. \text{ So that the value of } fv \text{ is } \quad q = \frac{d}{dy}(P \cot i)$$

$$= \frac{d}{di}(P \cot i)\frac{di}{dy} = \frac{r^2}{2}(\cot i - i \operatorname{cosec}^2 i)\frac{1}{r \sin i} = r\frac{\sin i \cos i - i}{2 \sin^3 i},$$

a part of Rankine's expression. He failed to notice that the other part was the right-angled isosceles triangle we have described, or he would not have proposed to build the conjugate area in the unsatisfactory way he does.

From the modified form $\quad q = fv = \dfrac{2i - \sin 2i}{3 \sin i - \sin 3i} r \quad$ the ten breadths of *abkd*, fig. 5a, are calculated and plotted; the top value is found to be $\frac{1}{3}r$ when i = zero, in the usual way, by differentiation of the numerator and denominator of q separately. The upward thrust at the springing B is the area of the collar or the quadrant, and equals $\frac{1}{4}\pi r^2$; and this divided by the radius gives the value of the normal load at B as $kd = \frac{1}{4}\pi r = \cdot 7854 r$. Again, the normal load at the crown is $\frac{1}{2}r$, the depth of the collar. Multiplying this by r, we have the horizon area $abkd = \frac{1}{2}r^2$, just as for a load $\frac{1}{2}r$ spread along the span; but now, instead of being also $\frac{1}{2}r$ spread along ad the rise, it begins by $ab = \frac{1}{3}r$, and ends with dk, a trifle greater than $\frac{3}{4}r$, and as the average is $\frac{1}{2}r$ the boundary from b to k is slightly curved. The curve we replace by the *treble-batter boundary*, where bg batters at 1 in 4 for four-ninths

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two scientific men interested in it, it appears as if the theorem were new to hydrostatics. From criticism of the method of conjugate load-areas employed, it seems as if this elegant method, especially lending itself to graphical construction, were little known or understood. The theorem can be proved by the strict but laborious methods of the integral calculus.

of the depth r, then gl batters at 1 in 2 for the next four-ninths of the depth, and lk at 1 to 1 for the last ninth. This boundary encloses the exact area $\frac{1}{2}r^2$, just as the curve does. And, further, the triangular area and also includes the area $\frac{1}{2}r^2$, and acts towards the rib to resist the spreading due to the weight of both the spandril and the collar; see the triangle with a dotted hypotenuse on fig. 4a. Removing the collar *away* requires that and be removed *away* from acting on the rib. The two figures and and $abgkd$ standing on the same base ad, and the same side of it, the one, when thus substracted from the other, leaves the figure-eight-like area $abgkn$ of algebraical area zero to resist the weight of the spandril-area alone. The area is mapped out by the 1-to-1 boundary an and 1-to-4, 1-to-2, 1-to-1 treble-batter boundary $bglk$. This figure is readily drawn on *squared paper*, represented by *dots* on fig. 5a, all the points b, g, l, k lying on a *dot*. The radius of the linear semicircle is to be *nine intervals* of the distance between the ruled lines, so that each *square* on the paper has an *area* of $\frac{r^2}{81}$. By counting the squares, the area $glkng$ of the lower part acting towards the rib is found to be the same as that of the upper area acting away from the rib; each holds six squares, and $gab = glkn = \frac{2r^2}{27}$. And the height of g = five intervals determines the limiting value of i_0 to be such that $\cos i_0 = \frac{4}{9}$, and $i_0 = 56·15$, a sufficiently close approximation to 57·04°, the exact (Rankine's) value determined by the height of h where the curve crosses an. Both the linear semicircle AGB and $abgkn$ might be engraved on the squared paper; for the superstructure $\frac{r}{10}$ above A the corresponding parallelogram is added, uo being drawn through u with the set-square, and p gives a higher point of rupure. Now there is hoop-thrust at A, the crown, equal to that parallelogram $\frac{wr^2}{10}$. Further, to allow for the extra density of the ring, the dotted treble boundary with $bb' = \frac{ba}{15}$ and $kk' = \frac{kd}{15}$, and a like receding at l and g gives the increased thrust at the crown as measured by squares, or by a planimeter from $pok'p'$, and the joint of rupture is 43·15°. If the arch-ring widen out from AC, an allowance, always very slight, can be made by moving to the right *both* the boundaries, as shown inside the arch. The line of stress has to be moved into the middle of the arch-ring by a pair of equal and opposite couples at the *joints* A and p', and then modified by having a longer radius of curvature at the A joint, due to the negative outward area $p'ab'$ being left out, which causes the thrust at A to be greater by that amount.

As the normal load at the crown is no greater, the radius of the line of stress must increase at *A*, and begin at a point lower down in that joint. The sharpest point on the modified line of stress will be at the 30° joint, and high up in that joint, and that 30° joint, together with the 43·15° joint, are the *two* joints of rupture. That the masonry ring has been chosen of a thick-

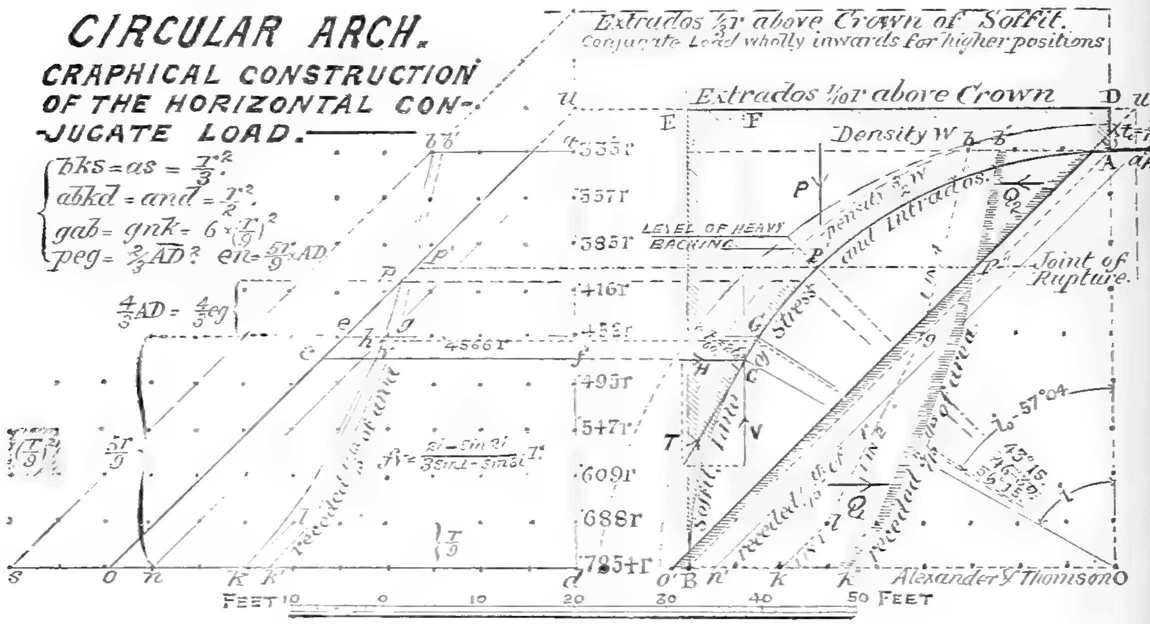

Fig. 7a.

ness sufficient for equilibrium is determined if the modified line of stress lie within the *middle* third of the three joints, the crown, and these two joints of rupture. To be of the most economical thickness the centre of stress at the crown (cheeks of the keystone) should be at the *upper limit* of the middle third, and at the lower limit in the 30° joint.

II.

IONISATION IN MOIST AND DRY AIR.

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In a previous paper[1] an account has been given of an examination by one of us of the ionisation produced in moist air by a radio-active source. The method employed was of high resolving power, and served to show that the ordinary small ions consist for the greater part of four distinct groups, each group having a definite mobility, the values being roughly 2, 1·8, 1·5, and 1·35 cm./sec. in a field of 1 volt/cm. In addition, other groups present in small quantities were detected, the most mobile of these having a mobility value of about 12. Ions of this type had been already discovered in the ionisation produced by breaking up water.[2] The present paper gives the results of a more complete examination by the same method of the ionisation in moist air and of a brief examination of the ionisation in carbon dioxide. It also deals with the examination of moist and very dry air by the method of Rutherford and Franck. It is convenient to distinguish the two methods as the "air-current method" and the "alternating field method."

Examination of the Ionisation in Moist Air by the Air-Current Method.

This method has been already described, and for fuller details of the apparatus, etc., the reader is referred to the previous paper already cited. Air is drawn between two parallel plates, close to one of which is a small space exposed to a fairly intense ionising radiation. The source of the radiation is a number of thin glass tubes containing the decay products of radium emanation. The plate close to which the ions are produced is charged up to various potentials, and the corresponding currents to the other

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[1] J. J. Nolan, Proc. Royal Irish Academy, Sect. A, vol. xxxv, 1920.
[2] J. J. Nolan, Proc. Royal Society, Sect. A, vol. xciv, 1918.

plate are observed. The current in general is made up of two parts—(1) that due to ions produced throughout the space between the plates by the unscreened part of the radiation, and (2) that due to ions produced by the intense radiation at what we may regard as the "point-source," close to one plate and captured on the other plate before they had been carried away by the air-current. If a current-voltage curve is plotted, (1) in the absence of (2) would give a smooth curve something like an ordinary saturation curve. The ions, however, from the "point-source" will show up (if they are all of one kind) as an abrupt upward step on the curve at a certain voltage. If there is more than one class of ion present, each class will show up as a distinct step on the curve. The mobilities are readily calculated from the formula $Vu = Qa/Lb$, where V is the "critical voltage," u the mobility, Q the volume of air passing per second through the apparatus, a the distance between the plates, L the length of the receiving plate, and b the breadth of the apparatus. As in the work previously described, the air was passed through the apparatus from one gasometer into another. These gasometers were of identical dimensions, and were connected together so as to move at the same rate. The greatest care was taken to secure steady working conditions, as the special object of these particular experiments was to determine accurately the form of the current-voltage curve, and to obtain exact values for the mobilities of the different types of ions already recognized.

Results.

In fig. 1 a number of the current-voltage curves indicating the ions of high mobility are shown. The curves selected for reproduction are such that the value of the product Vu, (critical voltage × mobility) is very approximately the same for all. The current values are plotted to the same scale, but to various arbitrary zeros in order to show all the curves without overlapping. These curves illustrate the method that has been adopted in this work, i.e., to work over a limited range with small voltage-steps and great attention to accurate electrometer readings. The agreement between the curves is very satisfactory. In ordinary circumstances the most mobile ion found produces a peak or step at about 2 volts, and has therefore a mobility value of 12 approximately. This ion is found both with positive and negative charges. On two occasions, however, distinct evidence was obtained of a negative ion having twice this mobility. The curves in question have been reproduced. Apart from this ion of mobility, approximately 24, no difference between positive and negative ionisation has been noticed. The mobility values deduced from all reliable observations are given below. These mobilities have been corrected to correspond with normal atmospheric pressure. The general effect of the correction is to improve the agreement.

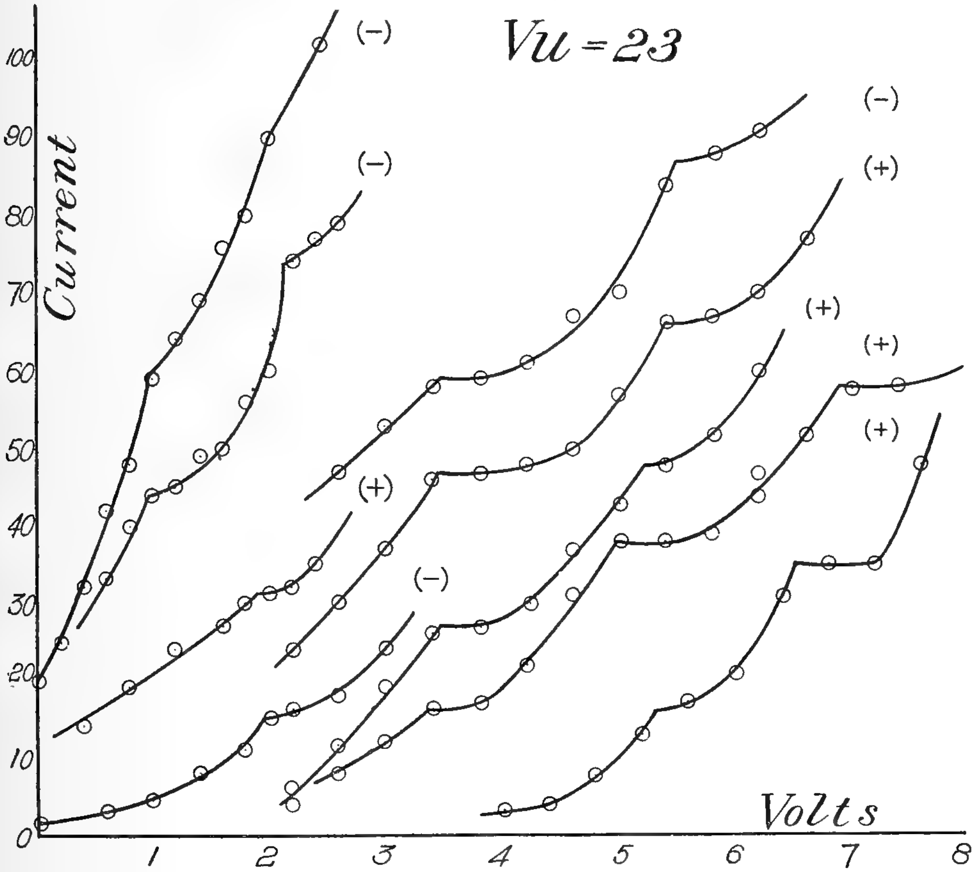

FIG. 1.

Ionisation curves in saturated air, air-current method, showing ions, positive and negative, of mobilities 12·2, 6·62, 4·23, and 3·00, and negative ions of mobility 24.

TABLE OF MORE MOBILE IONS.

(Mobilities in cm./sec. per volt/cm.)

Negative.					Positive.			
24	12·2	6·58	4·24	3·03	12·5	6·61	4·14	2·92
24	12·2	6·57	4·21		12·3	6·60	4·21	2·95
	12·3	6·66	4·26		12·3	6·65	4·24	3·11
	12·0	6·70	4·28		12·25	6·83	4·36	
	12·0		4·30					
			4·26					

A weighted mean (making no distinction between positive and negative) gives the values :

12·2, **6·62**, **4·23**, and **3·00**.

In fig. 2 some of the curves corresponding to the slower ions have been reproduced. The ions indicated are those of mobilities approximately 2, 1·8, 1·5, and 1·35. The agreement is again very good. In one practically unique instance one of the four ions failed to appear. This curve has been reproduced. Even in this case more observations taken about the range 14–15 volts would probably have shown up the missing ion. In general with

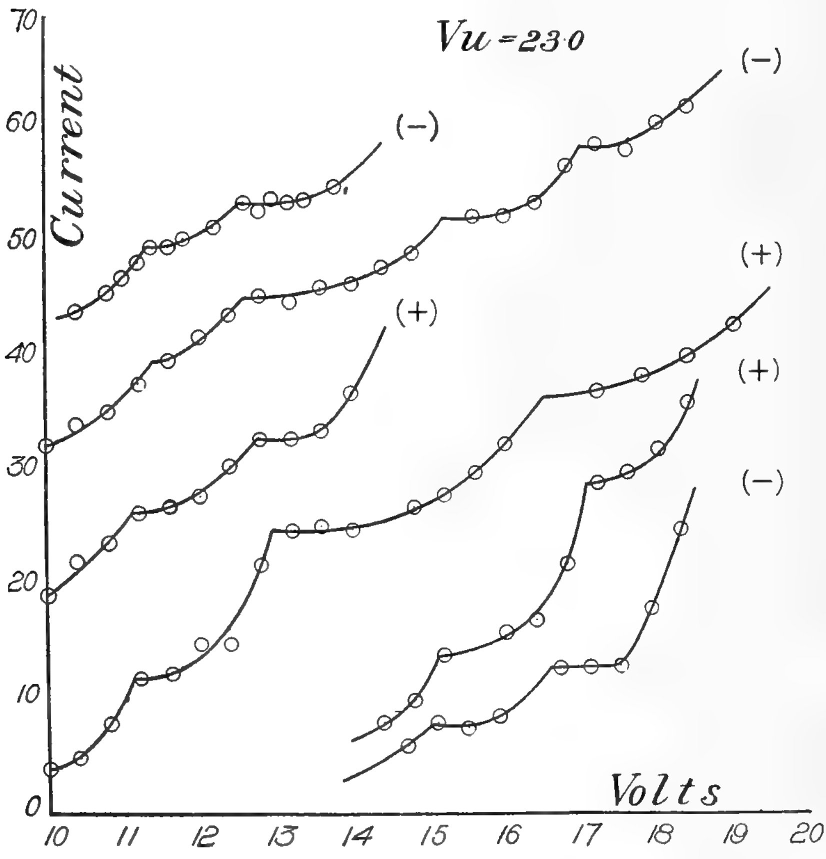

Fig. 2.

Ionisation curves in saturated air, air-current method, showing positive and negative ions of mobilities 2·04, 1·79, 1·52, and 1·37.

these ions the steps in the curve are more pronounced than in the case of the more mobile groups, indicating the presence of greater quantities. There is a certain gap between the regions dealt with by the two sets of curves given, say, between voltages 8 and 10. This region has been carefully examined; but on only two occasions were any indications of an ion found. On both occasions the ion was negative and not very well marked. The mobilities calculated were 2·24 and 2·13.

The following table gives the values deduced from all good determinations of the slower groups :—

TABLE OF SLOWER IONS.

(Corrected to 76 cm. pressure.)

Negative.					Positive.			
(2·24)	1·92	1·72	1·52	1·37	2·07	1·79	1·60	1·37
(2·13)	2·07	1·80	1·51	1·37	2·07	1·79	1·54	1·35
	2·09	1·70	1·50	1·36	1·95	1·79		1·38
	2·00		1·50		2·01			
	2·07							

Weighted means: **2·04, 1·79, 1·52,** and **1·37.**

In the previous paper some uncertainty was expressed as to whether the mobility of the slowest of these ions was the same for positive as for negative. The present work shows a very exact agreement for this ion as for the others. The best agreement between repeated observations and the most distinct indications are obtained as far as the negative ions are concerned for the ion of mobility 1·51, and for the positive for the ions of mobilities 1·79 and 1.37. It is interesting to note that Zeleny's values for moist air are 1·51 for negative and 1·37 for positive.

Examination of the Ionisation in CO_2 *by the Air-Current Method.*

Having completed the examination of moist air, we decided to undertake the examination of other gases. Hydrogen would obviously be of the greatest interest, but we were unable to obtain this gas in the large volumes demanded by our method. Carbon dioxide was available, and was submitted to the test. The greatest difficulty was experienced in keeping the gas even moderately pure. It was necessary that the whole system, including two gasometers, connecting pipes, and the ionisation chamber, should be air-tight. After much trouble this was approximately secured; but very minute leaks were still present, and after the lapse of a few days much air had found its way into the system. All the results obtained therefore apply to CO_2 mixed with various quantities of air. The percentage of CO_2 in the gas was determined before and after each experiment, so that in each case we know the degree of contamination. The results obtained apply only to positive ions.

As will be seen from the table which follows, the general character of the ionisation resembles very much that found in the case of air. For each ion found in air we find a corresponding ion in CO_2. The mobilities of the ions in CO_2 are, of course, smaller. The percentage of CO_2 present is given for each determination, and the mobilities have been corrected to correspond with pure CO_2 on the assumption that the mobility varies inversely as the square root of the density. The error involved in this calculation will not be very great as long as the percentage of CO_2 is not unduly small.

MOBILITIES OF POSITIVE IONS IN MOIST CO_2.

Per cent. CO_2.	Mobility.	Mobility in 100 per cent. CO_2.	Corresponding value in air.	Ratio.
92	10·2	10·1	12·2	1·21
{ 92	5·86	5·78 }	6·62	1·14
{ 92	5·90	5·82 }		
92	3·60	3·55	4·23	1·19
92	2·64	2·60	3·00	1·15
97	1·85	1·83	2·04	1·12
{ 97	1·60	1·58 }	1·79	1·16
{ 87	1·55	1·51 }		
{ 96	1·39	1·37 }	1·52	1·11
{ 87	1·40	1·37 }		
80	1·21	1·17	1·37	1·17
80	·89	·86	1·06	1·23

Only a moderate degree of accuracy can be claimed for the mobility values given in this table, as we were unable, for the reasons already explained, to make a thorough examination. It is clear, however, that the ionisation in CO_2 is of the same general character as that in air. The ratio between the mobilities of the ions in air and of the corresponding ions (or, at least, the ions which seem to correspond in CO_2 has a mean value of 1·16. The ratio of the square root of the densities of these gases is 1·24. The mobility of the last ion (·86) seems to correspond to the value reported for CO_2 by other observers. The corresponding ion in air (mobility = 1·06) has not been investigated in the course of the present work, but has been found by one of us previously, both in air ionised by a radio-active source and in the air from a water-spray.

About the relative proportions of the different ions present, it is difficult to make a definite statement. The last-mentioned ion is certainly present in considerable quantities; but the faster ions are also present in quantities which seem large in view of the low mobility value generally attributed to ionisation in this gas. This question takes on a different aspect, however, in the light of further information.

Examination of Undried Air by the Alternating Field Method.

Our experience with CO_2 showed clearly that the air-stream method was not suitable, without extensive alterations in our apparatus, for dealing with ionisation in gases other than air. To deal with various gases, to examine dry gases, and especially to obtain by an independent method confirmation of the results already obtained, it was desirable to use some such method as

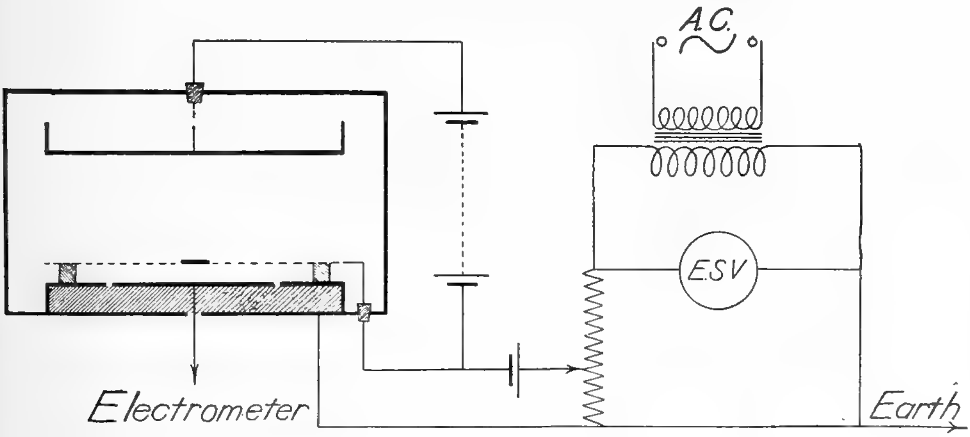

FIG. 3.

Diagram of apparatus used in alternating-field method of measuring mobilities.

that of Rutherford, as modified by Franck. Various forms of this method were tried, and finally the very simple method described below was found satisfactory. A diagram of the apparatus is given in fig. 3. It is not drawn strictly to scale.

The alternating field is applied between a sheet of perforated zinc and a brass plate, distant exactly 1 cm. below it. This plate is furnished with an earth-connected guard-ring, and the perforated plate is supported by three ebonite pillars, which rest on the guard-ring. The ionisation is produced by a thin layer of polonium on the upper surface of a small disc of bismuth, which rests on the perforated plate. Ions of one sign are driven into the lower space by a field applied between the perforated plate and a plate 4 cms.

above it. In most of our experiments the potential difference between these plates was 20 volts. The apparatus is contained in a metal box, which can be rendered air-tight. The alternating E.M.F. was obtained from a transformer, the primary of which was connected to the city supply. An Ayrton and Mather electrostatic voltmeter was connected across the secondary of the transformer. In order to obtain small potentials, a potentiometer arrangement was used, as shown in the diagram. The E.M.F. obtained in this way was remarkably steady. Except on very rare occasions the voltmeter showed no fluctuations. Electrometer readings of great accuracy and consistency were possible.

The theory of the method is well known. Ions of one sign diffuse through the perforated plate, move downwards under the influence of the field, and give up their charge to the lower plate if they have reached it before the field is reversed. If they have not reached it, they are carried upwards and are discharged at the perforated plate, the lower plate being unaffected. It is clear, therefore, that if we keep the frequency of alternation constant and gradually increase the field, no charging of the lower plate will occur until the field is reached, which is just sufficient to carry the fastest ion across the space during half the periodic time. For higher voltages the current will increase rapidly. If more than one class of ion is present, each class will show itself by a sharp upward inclination of the current-voltage curve at a voltage inversely proportional to its mobility. The relation between this critical voltage and the other quantities, assuming that the E.M.F. is of sine form, is given by the expression

$$Vu = \frac{\pi}{\sqrt{2}} \cdot nd^2,$$

V being the voltage reading on the electrostatic voltmeter, *u* the mobility, *n* the frequency, and *d* the distance between the plates. In order to make sure that ions which just escape capture at the lower plate are discharged at the end of their upward journey, it is necessary to make the alternating field slightly asymmetric, so that the upward field is greater than the downward. This was effected in our case by introducing a small steady voltage between the alternating voltage terminal and the apparatus. This is represented in our diagram as a single cell, but it was more often a fraction of the voltage of a cell.

In the first set of experiments the apparatus was not rendered air-tight. The air was, therefore, the ordinary moist air of the atmosphere, and the results are consequently in some degree comparable with those obtained for saturated air by the other method. Some examples of the current-voltage curves obtained are given in fig. 4. For voltages less than about 50 the current is zero. Then it begins to rise, the slope increasing sharply at four points, indicating the existence of ions of four mobilities. These four mobilities correspond, within the limits of experimental error, to the four ions present in greatest quantity in saturated air, as determined by the other method. The fact that the curves begin to rise at about 50 volts (the exact

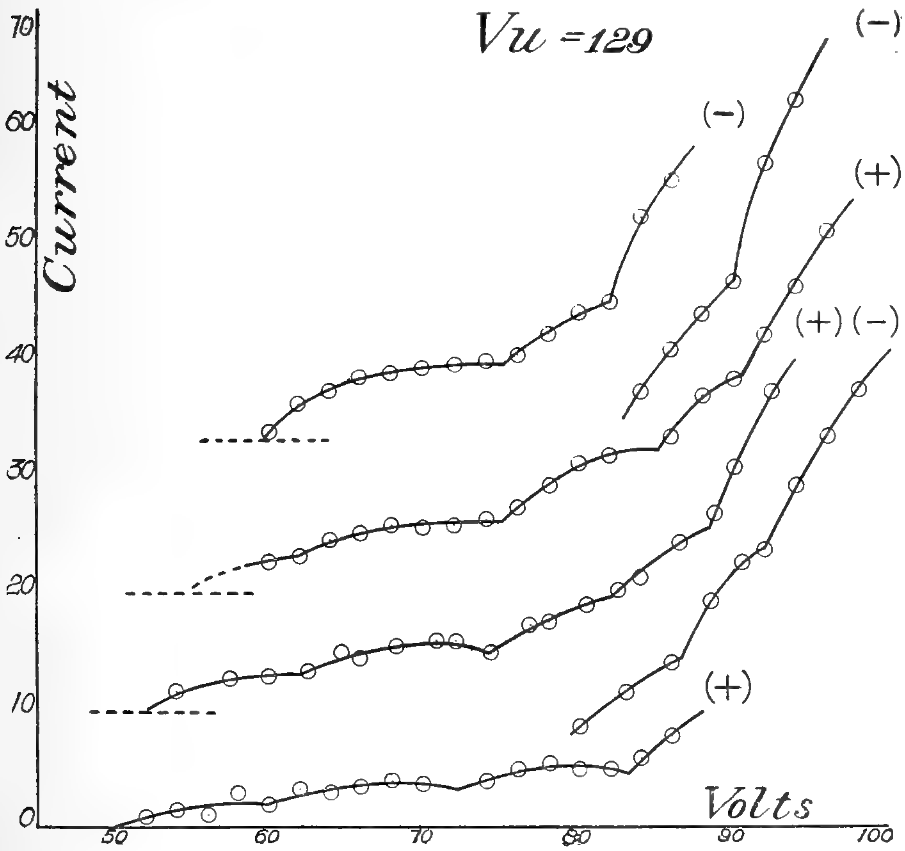

FIG. 4.
Ionisation curves in undried atmospheric air, alternating-field method, showing positive and negative ions of mobilities 2·5, 2·04, 1·73, 1·54, and 1·42. Upper curve (negative) for *saturated* air does not show ion of mobility 2·5.

determination of this voltage is somewhat difficult) shows that there are also present ions of mobility about 2·5 or 2·6. The fact that no current is obtained at lower voltages shows that the faster ions found by the other method are absent, or perhaps present only in very small quantities. The negative curves rise much more steeply than the positive. The agreement between the different curves is fairly good.

In examining curves in this connexion it must be remembered that the correction for pressure has to be applied, and also that a variation of 1 volt in the critical voltage corresponds to a variation of less than 2 per cent. in the mobility deduced. One curve is given which shows no current until a voltage of 60 is reached. The ion of mobility about 2·5 shown by the other curves and not found in the air-stream method is here absent. This one curve was plotted with saturated air, a vessel containing water having been introduced into the box. The values found from the best curves are tabulated below.

IONISATION IN UNDRIED AIR. Alternating Field Method.

(Corrected to 76 cm. pressure.)

Positive.					Negative.			
2·56	2·13	1·81	1·59	1·46	2·15	1·71	1·52	1·43
2·50	2·10	1·79	1·58	1·46		1·60	1·49	1·40
2·41	2·07	1·75	1·58	1·46		1·57	1·50	1·41
	1·93	1·74	1·57	1·44			1·49	1·39
		1·72	1·52	1·44				
		1·70	1·50	1·44				
			1·50	1·43				
			1·49	1·40				

Weighted means: **2·5, 2·04, 1·73, 1·54,** and **1·42.**

In addition to the values given above, a number of positive curves have been found showing an ion of mobility about 1·30; in some cases this ion has shown up on curves which also showed the ion of mobility a little greater than 1·40. We hope to re-examine this point later. These observations serve to demonstrate the existence of the four principal groups which we have already found by the other method. They indicate the existence of an ion which we had not previously found, and they show no trace of the ions of higher mobility clearly shown by the other method. We decided to proceed at once to the examination of dry air.

Examination of Dry Air by the Alternating Field Method.

There is no doubt that the best way to dry a gas is to leave the drying agent in continuous contact with it. With this in view, we fitted a rim to the upper plate of our apparatus (as shown in fig. 3), and spread a layer of phosphorus pentoxide over it. The apparatus was immediately closed up, all joints being carefully sealed. The effect of drying was at once noticeable. A progressive increase in the ionisation immediately set in. We were examining the negative ionisation, and we found that the curves were increasing in steepness. The ion of mobility 2·5 was present, and that of mobility 3 had appeared. The ion of mobility 2 was found, but on the fifth day of drying no slower ion could be found with certainty. At this stage the work was interrupted for eleven days. On resuming, it was at once evident that a great increase in the ionisation had occurred. An effect appeared also which had not been noticed before. With the accelerating voltage on the upper system, and no field between the perforated plate and the electrometer plate, a considerable current passed down to the latter. We spent a

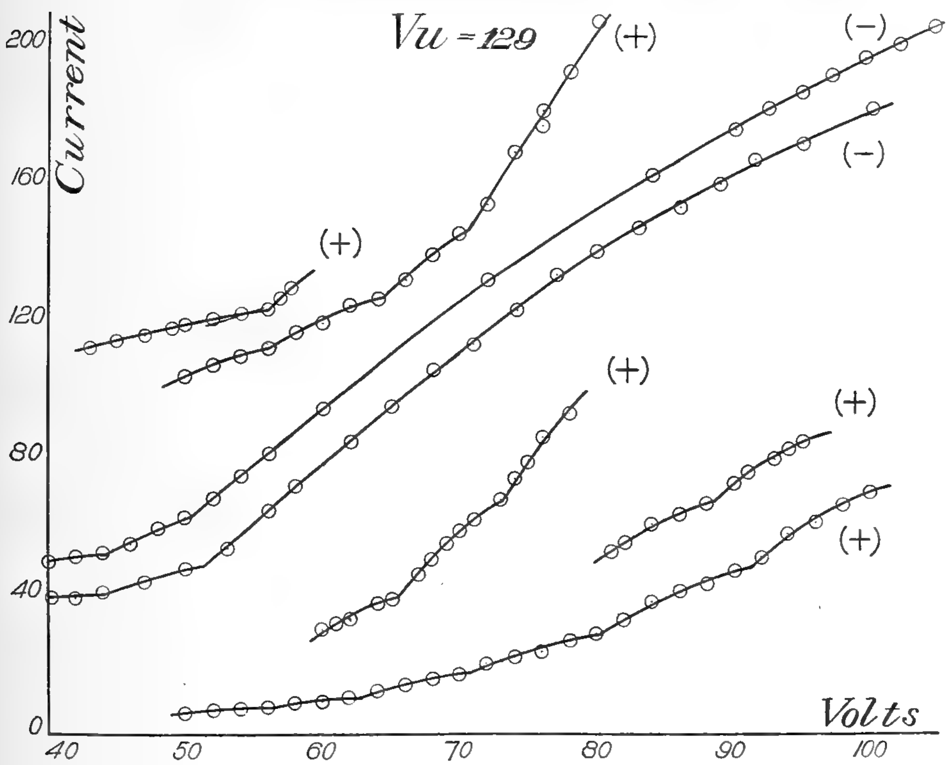

FIG. 5.

Ionisation curves in dry air, alternating-field method. Two negative curves show no ion of mobility less than 2·5. Positive curves show normal ions.

good deal of time in satisfying ourselves that this current was due to the diffusion downward under their mutual repulsion of ions which had come through the perforated plate. Some samples of the curves now obtained are given in figs. 5 and 6. It may be said at once that they differ very materially from the curves obtained with moist air. Fig. 5 covers roughly the same range as fig. 4, and fig. 6 includes the range corresponding to the fast ions which have now made their appearance. Fig. 5 gives two curves for negative ionisation. These curves were obtained thirty-two and thirty-five days after drying had begun, and they show quite clearly that no negative ion is present of mobility less than 2·5. These curves run quite smoothly through the region where curves obtained previously had shown discontinuities corresponding to the four common types of ions found in moist air. On the other hand, the familiar ions all show up on the positive curves. As usual, these are plotted to various arbitrary zeros of current in order to exhibit them apart; but in addition it has here been found necessary to plot them to different scales of current, as the negative current values are much greater than the positive, and as the positive currents increase very rapidly as the voltage increases. The ions of mobility roughly 2·5, 2, 1·8, 1·5, and 1·35 are easily recognized. Two observations give an ion of mobility 2·3, corresponding to an ion found twice before only faintly marked in the negative ionisation in moist air.

Turning now to fig. 6 for the curves obtained at lower voltage, and considering the negative curves first, we have no difficulty in recognizing the ion of mobility 12, which shows up as a discontinuity at about 10 volts. Instead of the ion of mobility 6·6, which we had found in moist air by the air-current method, we now find two ions of mobility 8 and 5·6 approximately. In addition, we find the ions of mobility 4·2 and 3·0 already found by the air-stream method. It is readily seen also that the current begins to rise at about 5 volts, corresponding to the ion of mobility 24. It is not always easy to determine this voltage accurately.

If we examine the positive curves, we find that they do not differ much from the negative either as to the quantity or the character of the ionisation. The ions of mobility 12, 8, 5·6, 4·2, and 3·0 are all present. The first positive curves we obtained started sharply from about 10 volts, corresponding to the mobility 12. After forty-two days' drying, however, we obtained a curve starting quite as definitely at a voltage of 5, and thus indicating the existence of an ion of mobility 24. Two curves of this character were obtained, of which one is reproduced. A later curve under conditions exactly similar as far as our knowledge goes failed to show this ion. The conditions for the appearance of this ion are at present under investigation.

It should be stated that in deducing mobility values from these curves, we have applied certain small corrections to the critical voltages in order to allow for the asymmetry of the field.

Some hesitation might be felt in accepting as correct mobility values deduced from discontinuities occurring at small values of the alternating field. With this in mind, we constructed another apparatus, practically identical with that shown in the diagram, except that the distance between the perforated plate and the electrometer plate was now 5 cms. instead of 1 cm. The constant *Vu* for the new apparatus has therefore the value $129 \times 5^2 = 3{,}225$. With this apparatus, after twenty-five days' drying, we obtained discontinuities in the negative curve at voltages of 132, 260, 407, and 568, corresponding to ions of mobilities 24·4, 12·4, 7·9, and 5·6. In addition we observed indications of ions of mobilities roughly 16 and 11. Similar results were obtained with the positive. These results are satis-

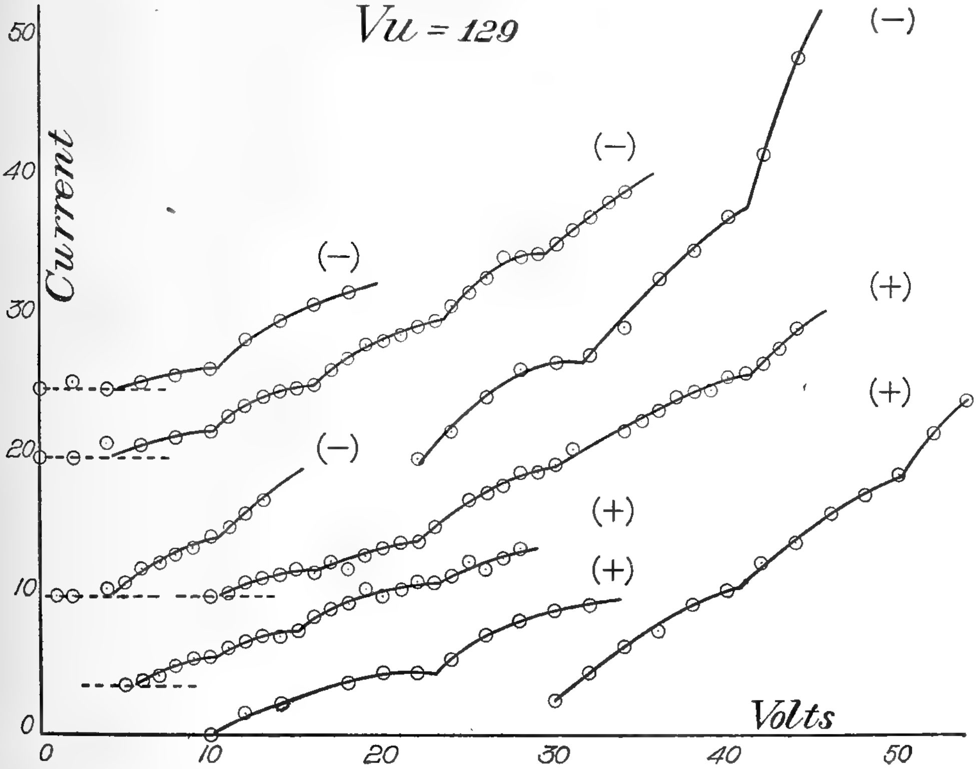

FIG. 6.

Ionisation curves in dry air, alternating-field method. Negative and positive curves show ions of mobilities 12·3, 8·2, 5·61, 4·39, 3·04, and 2·53. All negatives show an ion of mobility 24·6, and one positive curve shows the same ion.

factory, as they show that no serious error was made in calculating mobilities from the curves got by the other apparatus. The appearance of two new ions of mobilities 16 and 11 has to be explained. There is no doubt that the second apparatus is superior in resolving power to the first; but this we think is not the sole reason for the appearance of these new ions. In the first apparatus the accelerating field was of the order of 5 volts/cm.; with the second apparatus we used an accelerating field of ten times this value. This we think is the real cause of the difference. Experiments on this point are now proceeding.

We give below a table of all the mobility values in dry air. We have not included any of the results got by the second apparatus; but, as will be seen from the figures quoted above, they are in very good agreement, as far as they go, with the results got by the first apparatus. On examining the table it will be seen that there is some disagreement as to the correct value for one of the ions. The positive values are 8·0, 8·32, and 8·6. A negative value is 8·11, and the second apparatus gave 7·9. Some of our observations suggest that there are really two ions here, one of mobility about 8, and the other having a value between 8·5 and 9.

MOBILITIES IN DRY AIR.

					Positive.						
24·6	12·3	8·0	5·56	4·45	2·91	2·53	2·26	2·0	1·82	1·60	1·40
24·8	12·3	8·32	5·61	4·30	3·11	2·60	2·28	2·05	1·82	1·50	1·39
	12·4	8·6	5·73		3·14		2·32	2·02	1·78		
					Negative.						
24·8	12·1	8·11	5·56	4·42	3·0	2·5	—	—	—	—	—
24·1	12·1				3·02	2·5	—	—	—	—	—
	12·3				3·09						
	12·6										

Mean values, Positive and Negative: **24·6, 12·3, 8·2, 5·61, 4·39, 3·04, 2·53**
Positive only: **2·29, 2·02, 1·81, 1·55,** and **1·39**

Possibility of the Presence of Free Electrons.

In view of the great changes produced by long drying, it seemed to us possible that free electrons might be present in the dry gas. We have therefore endeavoured to determine the exact voltage at which the current begins to rise from zero values, using the second apparatus. At low voltages the current values are very small, and it is difficult to obtain consistent readings. From observations made on a number of occasions, when conditions were fairly steady, we believe that the current begins to rise at some voltage between 25 and 30. Two specially good observations give 27·5 and 28 volts. As the constant Vu for this apparatus is 3,225, this would indicate a mobility of about 115. We consider it probable then that free electrons are present in *very small quantities.* The mobility value which we find is, however, much smaller than that usually quoted for gases such as nitrogen. As the free electron in this apparatus, after passing through the perforated plate, would have to pass through 5 cms. of air, and would therefore be very liable to capture by a molecule, it is possible that what we measure is only a mean velocity, and that we are not dealing with electrons free for the whole of their path.

Consideration of Results.

The results obtained so far may be briefly reviewed as follows:—

I. In saturated air by the air-current method we find positive and negative ions of mobilities 12·2, 6·62, 4·23, 3·0, 2·04, 1·79, 1·52, and 1·37, the last four being present in large quantities. Amongst the negative ions we sometimes find the mobilities 24 and (faintly marked) 2·2.

II. In saturated CO_2 by the same method we find a corresponding set of ions, the fastest having a mobility of 10.

III. In the ordinary undried air of the atmosphere we find by the alternating field method five ions. One of these is new (2·5); the others are the four ions disclosed in large quantity by the air-current method. In one observation made with *saturated* air these four only were present.

IV. In well-dried air we find by the alternating field method negative ions of mobilities 24·6, 12·3, 8·2, 5·6, 4·4, 3·0, and 2·5. The four groups previously so prominent have disappeared. The positive ionisation contains the same groups as the negative from 12 to 2·5, and in addition shows the four groups from 2 to 1·3. An ion of mobility 2·3 (corresponding to 2·2 noted above) has also appeared. In some cases a positive ion of mobility 24 is found. There are some indications of the presence of free electrons.

Now, the first question that arises on considering these results is this: Why does the alternating field method not show up the faster ions in moist air when the other method shows them so clearly? We think that the explanation of this lies in the one radical difference between the two methods. In the air-current method the ions of one sign are almost immediately separated from the others, and for practically all their path in the measuring vessel are moving through air free from other ions. In the alternating field method the ions are in contact with one another for some time in the space above the perforated plate. The time that an ion spends in this space will depend upon the value of the field there, the distance from the place where it was formed to the perforated plate, and its mobility. Results obtained by Erikson[1] and by J. Cabrera Felipe[2] seem to support this view. Erikson finds with positive ions an "ageing" effect, that is,

[1] Erikson, "Physical Review," xvii, p. 400, 1921, and viii, p. 100, 1921.
[2] J. Cabrera Felipe, R. Acad. de Ciencias, xviii, 1920.

observing the ions at various short intervals of time after their formation he finds the mobility value to decrease with time. Now, in his case the "ageing" is produced by keeping ions of both signs in contact with one another for various times before exposing them to the field in his measuring vessel. J. Cabrera Felipe, using an alternating field method, finds that the measured mobility of positive and negative ions is increased by increasing the value of the accelerating field. On our view this means that the average time spent by an ion in contact with ions of the opposite sign has been diminished, and that therefore mobile ions in greater proportion come into the measuring part of the apparatus.

It seems to us then reasonable to suggest that the alternating field method fails to reveal the faster ions, because they have disappeared by recombination. The other method does reveal them, because the chances of recombination have been reduced to a minimum. This does not necessarily mean that the ions in the air-current method do not change. It is possible that they do. A moderate amount of change could occur in their passage through the apparatus without obliterating the peaks in the current-voltage curve.

The remarkable effects produced by drying had now to be considered. The common negative ions have all disappeared, and in both positive and negative, mobile ions are present in considerable numbers, some of these being identical with those found in moist air, while some are quite different. The causes which rendered the alternating-current method ineffective for showing up the mobile ions in damp air are still operative. A very great increase in the proportion of the faster ions must therefore have been produced by the drying. Something necessary for the production of the slower or more common type of ion must have been withdrawn; and this fits in with the view put forward by one of us previously:[1] that the common ion is a cluster of water-molecules.

The work of Aitken and Barus on condensation has shown that a moist gas contains a number of particles of graded sizes, the number of these particles increasing as the size decreases towards the molecular size as a limit. It is natural to suppose that these nuclei are water. It is possible that the four common ions are four of these water-nuclei of different sizes. These four ions, or ions closely resembling them in mobility, were found in the ionisation produced by a water-spray. A calculation showed that their mobility values would agree with the supposition that they were groups of water-molecules containing numbers of molecules ranging roughly from

[1] J. J. Nolan, Proc. Royal Society, Sec. A, vol. xciv, 1918.

eighteen to thirty-six. From this point of view we could explain the disappearance of the common types of negative ion by saying that drying had removed the water-nuclei of those sizes, were it not for the fact that the same ions are still found with a positive charge. In whatever way this difficulty is to be surmounted, the importance of water as an element in the formation of the ordinary ion is quite clear. It must, however, be remembered that the rôle of the water-molecule might possibly be that of an intermediary for the grouping of other molecules.

Turning to the more rapid ions, the most prominent is the ion of mobility about 12·3. There is hardly any doubt that this is a single molecule—a molecule of oxygen or nitrogen. On the hypothesis of elastic collisions, a molecule of oxygen or nitrogen with a single electronic charge should have a mobility of 12 approximately. This ion is therefore, if positive, a molecule of oxygen or nitrogen from which a negative electron has been removed; if negative, a molecule of oxygen or nitrogen to which an electron has become attached. With regard to the slower ions, a possible view is that, in the presence of sufficient water-vapour, the original molecular ion passes rapidly through various stages of growth to one or other of the four stable sizes, which correspond to the ordinary ion. On this view the intermediate ions (6·6, 4·2, etc.) would represent simply stages in growth. A more probable view which fits in better with the experimental facts is this: that stable water-nuclei of different sizes are always present in air, the numbers of each size present depending on the degree of humidity; that the original molecular ion becomes attached to one or other of these, and that no further change occurs except loss by recombination, which will remove all the faster ones first. The advantage of this view is that it explains why the original ion (mobility 12) is so readily found even in saturated air by the air-current method. The appearance of two new ions in very dry air, 8 and 5·6 in place of 6·6 found in moist air, remains to be explained. We hope to be in a better position to put forward an explanation when we have acquired more accurate numerical data.

Regarding the ion of mobility 12 as a molecule of oxygen or nitrogen with a single charge, we were not surprised to find negative ions of mobility 24. These are clearly doubly charged molecules. The appearance of a positive ion of this mobility was more surprising. This ion has been found four times—twice with the first alternating field apparatus and twice with the second apparatus. As already mentioned, there is something haphazard about its appearance in the first apparatus; but we believe that this is simply a question of the magnitude of the accelerating field. It has appeared with the other apparatus on the two occasions on which it was investigated under suitable conditions. It is very likely that this is the gas-molecule with two positive charges. The ion of mobility 16, that appears with the second apparatus, is possibly the ion of mobility 8 with a double charge, while the uncertainty as to the correct value for the latter ion may be due to the fact that doubly charged ions of original mobility 4·2 are present. Whatever uncertainty may be felt as to these latter points—and the clearing up of these depends upon accurate observations of the mobilities and of the conditions under which they occur—the positive ion of mobility 24 remains well established; and we can find no reasonable explanation for it other than that of a double positive charge. This would mean that the α-particle can in the process of ionisation detach two electrons from the molecule. This agrees with the results claimed by Townsend[1] and by Franck and Westphal[2] from measurements on diffusion and mobility. Millikan, however, claims that his oil-drop experiments show conclusively that doubly charged ions, if they occur at all, occur very rarely. The question of ionisation by α-rays is dealt with specially in a recent paper,[3] and this conclusion is reaffirmed. Millikan and his collaborators state that singly charged positive ions are produced in certainly more than 99 per cent. of the cases of α-particle ionisation. The ions which we consider to be doubly charged positives appeared only with extreme drying. Millikan's oil-drop experiment would be decisive on the point if repeated under similar conditions as to drying.

In view of the results given in this paper, it is difficult to see how the mono-molecular theory of the ordinary small ion, so ably urged by such workers as Wellisch[4] and Loeb,[5] can be maintained. Much yet remains doubtful, but the composite nature of ionisation in air and the general nature of the changes produced by drying are quite clear. Reference has been made in a previous paper[6] to the work of Haines,[7] who found separate groups of negative ions of high mobility in freshly prepared and very pure hydrogen. With the lapse of time these ions disappeared. It was suggested by one of us that the impurity which found its way into the hydrogen and caused the disappearance of the mobile ions was water. This explanation is rendered very probable by the work now reported. In fact, there is a very close resemblance between Haines' results and ours. Haines' work has been

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[1] Townsend, Proc. Royal Soc., Sec. A, lxxx, 1908.

[2] Franck and Westphal, Verh. d. deutsch. phys. Ges., xi, 1909.

[3] Millikan, Gottschalk, and Kelly, "Physical Review," xv, 1920.

[4] Wellisch, "Phil. Mag.," July, 1917, and other papers.

[5] Loeb, "Phys. Rev.," viii, 1916, and xvii, 1921.

[6] P.R.S., *loc. cit.*

[7] Haines, "Phil. Mag.," Oct., 1915, and July, 1916.

criticized by Kia-Lok Yen,[1] who found that on repeating Haines' experiments he was unable to find clear indications of any ion of abnormal mobility other than the free electron. It is possible that an initial condition of very good drying was present in Haines' experiments and was not attained by Yen.

BRIEF SUMMARY.

1. The composite nature of the ionisation in moist air has been demonstrated by two methods.

2. The effect of extreme drying has been investigated. The effect on negative ionisation is to increase the numbers of ions of the more mobile type, and to cause the disappearance of the ordinary ions. With positive ionisation the more mobile ions are also found in greater numbers, but the ordinary ions are still present.

3. Doubly charged positive ions are found in very dry air.

4. Some indications are obtained of the presence of free electrons.

NOTE ADDED IN PROOF.

We have since found a paper by W. Altberg, Ann. de Phys. 37, p. 849, 1912, "Über monomolekulare Elektrizitätsträger . . ." Altberg finds in air and CO_2 negative ions of mobilities 10·1 and 5·8 respectively.

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[1] Kia-Lok Yen, "Phys. Rev.," xi, 1918.

III.

ON THE ELECTRIFICATION OF PHOSPHORUS SMOKE NUCLEI.

By JOHN J. DOWLING, M.A., F.Inst.P.;

and

C. J. HAUGHEY, M.Sc.

Read December 12, 1921. Published February 24, 1922.

I.—In the course of other work on the ionisation due to phosphorus, one of us (H.) observed the following phenomenon:—

A fragment of phosphorus, mounted between two vertical metal plates under a bell-jar, gave rise to a fine vertical thread of smoke. On establishing an electric field between the metal plates, it was observed that the smoke thread divided into two; each starting from a separate little smoke cap on opposite ends of the phosphorus, and curving over towards the nearer plate.

This clearly indicated that the smoke particles were electrically charged; some positively, others negatively. We were struck by the remarkable fineness of both smoke threads, having rather expected that a diffuse, fan-like structure should have resulted. We concluded that the smoke nuclei must be of very uniform size, and that each carried the same electric charge.

II.—A wire gauze cage was now placed over the phosphorus, and the observations repeated. Even with the largest available field (300 volts per cm.) there was no noticeable sub-division of the original vertical smoke thread. It appeared that the particles became charged in the previous case by what we may style a "water-dropper" action, without insisting on the exact *modus operandi*. It seemed likely that interesting results might be forthcoming from a detailed examination of the phenomenon, and the following is an account of the investigations carried out.

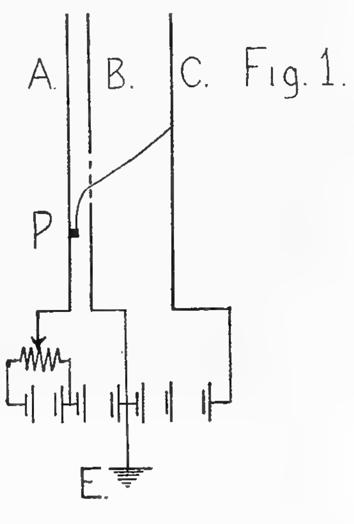
III.—In the experiments just described the smoke thread is carried upwards by a slight vertical convection current, maintained probably by the heat of the smouldering phosphorus. At the same time the charged smoke particles are urged in a horizontal direction by the electric field. The height (h) reached before the smoke strikes the plate varies inversely with the horizontal velocity (v) : thus $1/h$ is a measure of v. Since the velocity v is probably proportional to the force acting, which, in turn, is proportional to the product of the charge (q) and the electric field, it follows that—

$$1/h \propto qV,$$

where V is the potential difference between the plates. Hence, observations of h should afford us information as to the charge q, corresponding to different values of V.

We found, however, that accurate observations were possible over only a limited range of potentials, since, by reason of the dependence of q on V, h varied rapidly with V.

IV.—To evade this difficulty we planned the apparatus shown in fig. 1. In this the charge on the smoke is due to the field between the phosphorus (P) and the centre plate (B); while the rise h observed takes place with the smoke exposed to the field between the plates B and C. The central partition (B) was furnished with a wire gauze window through which the smoke stream passed. This central plate was earthed. The plate A, in front of which the phosphorus was supported on a little shelf, was connected to a suitable potential dividing device which enabled the "charging" potential V_1 to be varied as desired. The plate C was connected to a steady source of potential of the opposite sign.



The plates, about 60 cms. high, were contained in a box 13 cms. deep, the front and back being of plate-glass fitting close to the edges of the plates. A and C were about 10 cms. apart, and B was usually about 1 cm. from A. An intense parallel beam of light was directed into the top of the apparatus from the front, and then cast vertically downwards by a right-angle prism within. The consequent slight heating of the glass front at the top was found to set up a convection air-current inside of about the right intensity, and this became sufficiently steady an hour or so after lighting the lamp. The glass back of the apparatus was kept cool by a constant stream of cold water. The interior was painted dead black. Two fine silk fibres were stretched vertically between B and C, close to the smoke stream. The difference in vertical height where the smoke passed these was observed from a distance by a cathetometer. The whole apparatus was mounted in a room of equable temperature into which direct sunlight never entered, and most of the observations were made in the late afternoon.

V.—Observations of h (the rise of the smoke crossing between the fibres) were made for increasing potential differences between A and B (V_1); that between B and C (V_2) being kept at a constant, rather high value (about 400 volts). In this case $1/h$ is proportional to the charge on the particles. The curve (fig. 2) represents the type of results so obtained.

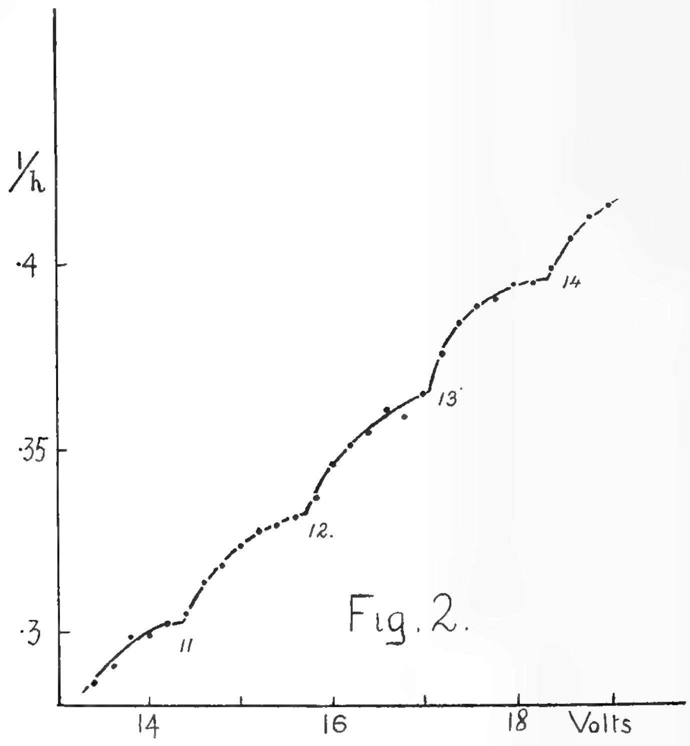


Fig. 2.

All the curves display a step-like form, the explanation of which is as follows:—The particles of uniform, minute size take up their charges as single electrons, the number of electron charges attaching themselves to each particle being dependent on the field applied. Consequently the velocities, as measured by $1/h$, should undergo sudden increases periodically, corresponding to the accession of an additional electron according as the potential V_1 attains suitable values. Between the steps the curve should, theoretically, be horizontal; practically a certain amount of rounding-off is found, due to want of uniformity of the field and other causes. The "lengths" of the steps (*i.e.*, the voltage increments) on the curves are equal—a result which we might perhaps have expected; while, of course, the "rises" (*i.e.* the charge increments) are also equal.[1]

VI.—As we have said, the voltage "step," and also the "rise" in $1/h$ at each completed step, are nearly constant in any one curve. On division of the total voltage at the commencement of any step by the (average) value of the "step" of voltage, we find that the quotient is nearly a whole number. These numbers are quite small, rarely exceeding 20, and increase by unity at each step. This is just what we would expect from our theory, and, in fact, the numbers are to be identified with the numbers of electron charges at each stage. Furthermore, the average increment in $1/h$ (the "rise") when divided into the corresponding value of the ordinate $(1/h)$ yields the same number. We feel very confident, therefore, that the explanation put forward is correct, but it is desirable to subject the matter to experimental test in another and more fundamental way, viz., to investigate the actual variation of the charges by direct measurement.

VII.—To achieve this we directed our attention to devising methods in which the periodic alteration in the individual charges showed itself in corresponding variations of the electric "transport" current, carried by the smoke stream. It was found, rather unexpectedly, that the effect was noticeable even with the very simple and direct method shown in fig. 3. This arrangement, however, only enabled us to demonstrate the periodic character of the current over about the same range as in the "visual" method just described.[2]

VIII.—In the apparatus shown in fig. 3 there is, of course, a large admixture of ordinary ions. To avoid this, the apparatus (fig. 1) was modified as follows:—The central partition was removed, and the plate C divided into two parts. The upper part, C_1 (fig. 4), was carefully insulated and connected to a sensitive electroscope (10 divisions per volt) similar to that shown in fig. 3. The lower part, C_2, was earthed. The plate A, to which the phosphorus was attached, was connected to a suitable potential dividing arrangement, so as to enable the field between A and C to be varied as desired. Some of the observations thus obtained are given in fig. 5.

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[1] It was found necessary to introduce a correction for a gradual variation in the upward air-current. This was done by repeating a measurement of h at intervals for a chosen value of V_1.

[2] The phosphorus P is here placed on a small table connected to the fibre of the "Bumstead" electroscope, and is exposed to a field of any desired intensity by means of the upper plate.

IX.—It will be seen that the step-like form of the curves is again well defined. In this, as in all the "charge" methods, the "rounding off"

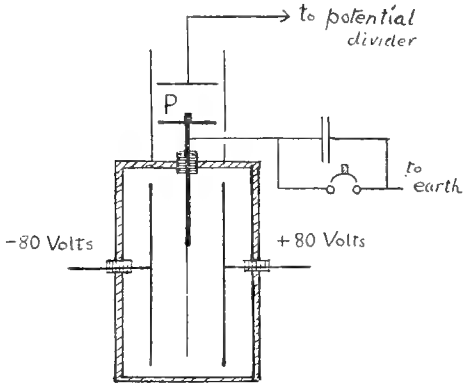


Fig. 3

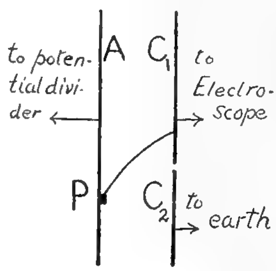
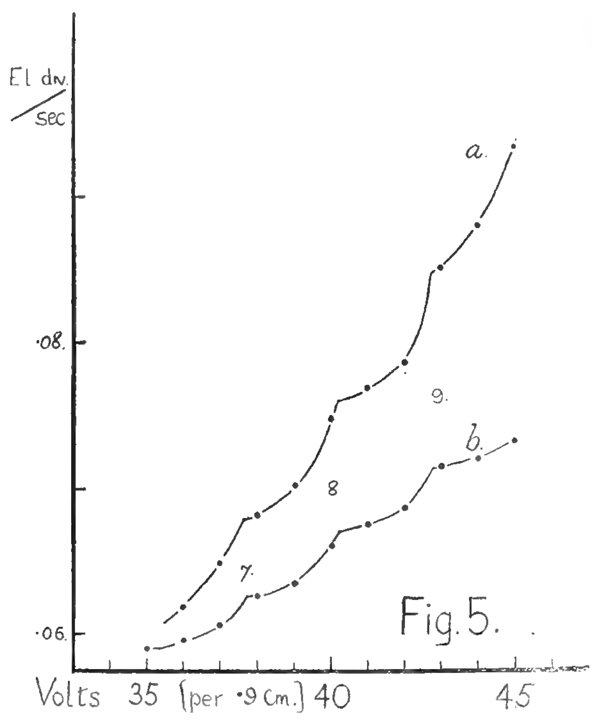


Fig. 4.

of the steps is such as to make them concave upwards, unlike the convex form exhibited in the "visual" experiments. It was not possible to push



the observations below the fourth or fifth step, and for that reason a third "charge" method was devised, which enabled us to trace the curve right back to the origin. Before considering the observations, we will describe this final apparatus.

X.—A small bell-jar (*J*, fig. 6) was cemented to a disc (*A*) of Acheson graphite, which rested on a ring of hard paraffin. Beneath this wax ring a disc of sheet metal (*B*), furnished with a hole, about 2 cms. diameter, rather to one side, was sealed. Below this was another wax ring, which in turn rested on a second metal plate (*C*), furnished with a large excentric hole. The joints were made air-tight. The holes in the discs being on opposite sides, the phosphorus rested on the lower plate on the inner side of the hole. Air was drawn through by suction applied to the bell-jar, and the smoke yielded up its charge to the graphite plate, while the ions were withdrawn by the electric field between *B* and *C*. *A* was connected to the electroscope, *B* to earth, and *C* to a potential divider. It was found that

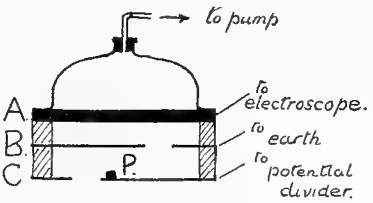
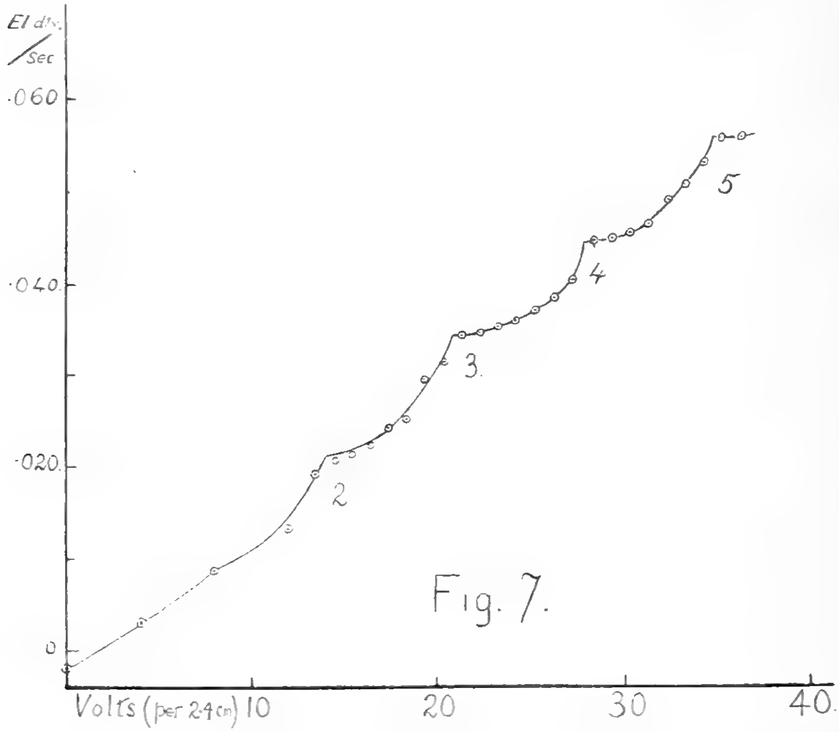


Fig. 6.

the greater part of the ions were removed, except with the lowest field strengths. To investigate the effect of the ions, a piece of metal foil was placed over the phosphorus, so as to permit the air-stream to pass while protecting it from the electric field. The curves, fig. 7 and fig. 8, show some of the results obtained: the former refer to the smoke-charging experiments, while the latter represent the effect of the ions alone.

XI.—We now proceed to the consideration of the results obtained. In the first place, it may be pointed out that all the four methods are in agreement in one important respect. The same average increment in field strength (2·9 volts per cm.) corresponds to a "step," whether the field is, on the whole, large or small, or whether the phosphorus is smoking vigorously or only feebly. This is in keeping with our assumption of the uniformity of size of the particles, for we may well suppose that the step in field strength is determined by the extra work required to attach an additional electron. This would require equal increments of field in a given case; but if the field increment is found to be always the same, the particles must always be of the same size.

XII.—Just as we have found (Section VI) in respect to the visual method, so with the "charge" method; the quotient of the potential by the "step" voltage, or that of the total charge by the average step "rise," each give the same number. We have already identified this number with the number of electron charges on the nuclei. It is difficult to suggest any reason why groups of two or more electrons should attach themselves at once; in fact, throughout many thousands of observations of an analogous case, Millikan found only one doubtful case where more than a single electron charge was taken up at one time. We, therefore, feel particularly confident in attributing the "steps" to successive electrons, and that we may thus determine the charges on the nuclei under any given field.



XIII.—This, however, leads to a serious difficulty. In experiments of the Millikan type, fields of thousands of volts per centimetre are used, and the resulting velocity attained by the charged drops is only of the order of a millimetre per second at most. In our work, although a measurement of the velocity was difficult, it was certainly, at least, a centimetre per second, and the field was only forty volts per centimetre. Thus, with charges of about the same magnitude the *mobility* in our case is about *one thousand times* that of one of Millikan's drops.

No possible difference in size between the smoke particles and Millikan's oil-drops could account for this discrepancy.

Fortunately, there is a very satisfactory explanation forthcoming, and it is, at the same time, very interesting, introducing, as it does, a conception of some novelty.

XIV.—In Millikan's experiments a single isolated drop is under observations and the velocity measured is the actual "limiting" velocity through stagnant air. In our present work, on the contrary, we are concerned with a host of particles, of nearly equal sizes, charged equally, and exposed to the same electric field. By the action of the electric field these

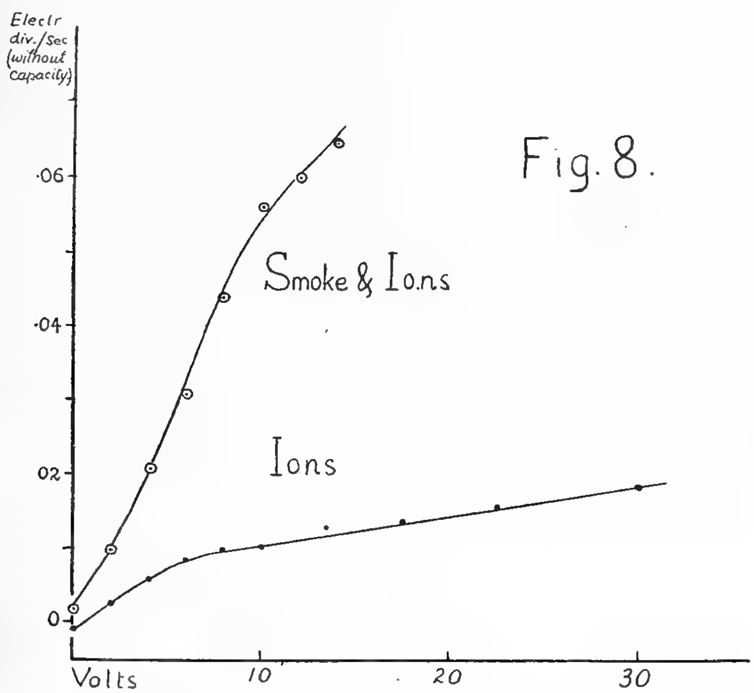


Fig. 8.

particles are dragged along a narrow laneway through the air, and *they carry the air therein along with them.* Relatively to the (moving) air-stream they do actually travel with a velocity approximating to the limiting velocity of Stokes' law; but the air-stream, in which they are situated, is itself maintained in rapid motion, being urged along by the viscous drag of these particles. In fact, due to the presence of the charged nuclei in the air-stream, we may think of it as being subjected throughout its whole extent to a force per unit volume equal to $\frac{nqV}{l}$, where n is the number of nuclei per c.c. in the smoke filament, and q the charge on each. That such a uniformly distributed force would maintain the filament of air in question in quite rapid motion can be easily shown.

XV.—Suppose u is the estimated speed of the air-current in the smoke filament, and i is the electric "transport" current measured by the electroscope, clearly

$$(anu)\, q = i,$$

where a is the cross-section of the smoke filament.

In an actual case, for example, this equation gave a value $(nau) = 5 \times 10^6$.

Considering a cylinder 1 cm. long of the smoke filament, exposed to a field $\frac{V}{l} = 40$ volts per cm., we have, if $q = 10\varepsilon$:—

$$f = \frac{a \,.\, n \,.\, q \,.\, V}{l} \doteqdot \frac{5 \times 10^6 \times 10 \times 4{\cdot}8 \times 10^{-10} \times 40}{u \times 300} \text{ dynes}$$

$$\doteqdot 3 \times 10^{-3} \text{ dynes, if } u = 1 \text{ cm. per sec.}$$

This is equivalent in its effect to a pressure difference p between the ends of the cylinder if $ap = f$. Comparing the actual case to that of a tube of section a, in which air is kept in motion by a pressure slope p per unit length,

$$U = \text{average velocity of air} = \frac{ap}{8\eta\pi}$$

$$= \frac{3 \times 10^{-3}}{8 \times 180 \times 10^{-6} \times 3{\cdot}14} \doteqdot {\cdot}7 \text{ cm. per sec.}$$

Thus u and U are of the same order, and it is clear that the force f is sufficient to maintain the whole air-stream in motion with the actual velocity observed.[1]

XVI.—Our supposition finds support from the observed behaviour of these smoke filaments. Their sharpness and obvious tendency to resist rupture indicates some internal structure conferring a sort of cohesion; the tendency of the particles to remain in the moving air-stream as affording a path of least resistance is in keeping with these properties. Again, in the "visual" experiments, where the smoke filament had to traverse a wire gauze screen, it invariably made for the centre of an opening, and never showed a tendency to strike the wires or spread out. When, in making a change in the fields, the voltage V_2 was removed, the smoke rose in the space *BC* (fig. 1) vertically. On reapplying the field this vertical thread did not move transversely to a noticeable extent. The conditions in this case would be more in keeping with Millikan's experiment, and the velocity would be of a very small order.

[1] The possibility of this process occurring in the atmosphere raises an interesting question, which might be worth consideration. It also suggests a possible source of error in Wilson's original determination of ϵ.

XVII.—We now turn to the consideration of the observations carried out under the lowest fields, as described in section 10. It will be noticed that the first "step" is completely missing, and that the second is considerably modified. There is not any good reason why the simple "whole number" progression should not hold right down to the commencement, so it was necessary to find some explanation for this obliteration of the preliminary steps. It is natural to expect that the ionisation effect should be important under low fields. Although the apparatus (fig. 6) was designed with a view to the ions being removed by the field before the smoke stream yielded up its charge, nevertheless under the weaker fields this process is probably incomplete. To ascertain how this "ion" current would affect our results, we covered the phosphorus pellet with a bridge of metal foil, so that the air could pass across as before, while the phosphorus was practically shielded from the electric field. Fig. 8 shows the form of curve obtained (to a different scale to fig. 7). Little, if any, charge can be now carried by the smoke, and the curve indicates that the ionisation current reaches a saturation value at about six volts. The magnitude of the ion-current is then probably greater than that due to the singly charged smoke, and the bend at saturation would occur about the middle part of the first "step." The result would clearly be to flatten out the curve (fig. 7) along the first and part of the second step, which is exactly what is usually found.

Summary and Conclusions.

XVIII.—It has been shown that, when smouldering phosphorus is exposed to an electric field, the smoke particles take up electric charges, of which the magnitude is determined by the field intensity. Reasons are given for the assumption that the particles approximate to a uniform size.

The periodic increase of the charge, due to successive electrons, is displayed in the observations, and enables us to determine the number of electrons assumed by each smoke particle under given conditions.

All values of this number have been observed from unity to twenty-five, and no doubt the range could be extended.

If an accurate "count" of the smoke particles could be made, it would be possible to base a determination of ϵ on the principles of this work.

An explanation is put forward for the apparent stability and cohesion of the smoke filament, and an apparent discrepancy between this work and Millikan's is accounted for.

IV.

ON THE SIMPLEST MODE OF REPRESENTING A REAL CONTINUOUS LINEAR ORTHOGONAL TRANSFORMATION (WITH CONSTANTS ADDED) BY MEANS OF ROTATION AND TRANSLATION OF A RIGID SCHEMA IN A EUCLIDEAN MANIFOLD OF n DIMENSIONS.*

By REGINALD A. P. ROGERS.

[Read December 12, 1921. Published April 6, 1922.]

CONTENTS.

I.—Theorem and Preliminary Analysis.

1. In a plane the motion of a rigid schema from one position to another can be effected by a single rotation round a point in space of three dimensions by rotation round a straight line, together with an independent uniform translation along the line (a screw).

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* The principal feature in this paper which I believe to be original is the co-ordinate method of argument used in §§ 7–16. The other sections are for the most part explanatory and verificative, and are included for the purpose of making the paper more intelligible and perhaps more interesting than it would be otherwise. See Note, p. 73.

Before entering on preliminary explanations, I will at once state that for n dimensions the corresponding general principles are :—

If n is even, a rigid schema can be moved from one given position to another by $\frac{n}{2}$ independent rotations round $\frac{n}{2}$ uniquely determinable mutually plane-normal $(n-2)$-flats; if n is odd, by $\frac{n-1}{2}$ such rotations, together with an independent uniform translation along the common line of intersection of the $(n-2)$-flats.* The "independence" means that the order of the processes is indifferent.

2. A Euclidean manifold of n dimensions is the same as a *flat* or space of zero curvature, and is called Euclidean because the axioms of congruence and Euclid's axiom of parallels are obeyed in all its geodesic surfaces (planes). The element of distance may be expressed in n co-ordinates x, y, z, u, v, w, etc., in the form

$$ds^2 = \Sigma dx^2;$$

and hence by the calculus of variations the shortest distance or *the* distance between two points P_1, P_2 is given by

$$P_1P_2^2 = \Sigma (x_1 - x_2)^2.$$

The manifold will be described as an "n-flat" or S_n, and it will be assumed that all other flats are within S_n.

An m-flat S_m is defined by $n-m$ independent linear equations among the co-ordinates, and is determined by $m+1$ points.

Every m-flat consists of a singly infinite series of $(m-1)$-flats. Thus the straight line S_1 is the fundamental flat.

3. *Orientation of flats.*—A straight line is determined by two points (P_1, P_2) by n equations

$$x - x_1 = \lambda(x_1 - x_2), \quad y - y_1 = \lambda(y_1 - y_2), \text{ etc.},$$

where λ is arbitrary. The "*direction cosines*" of a straight line are n quantities l, m, n, p, q, etc., which satisfy

$$\Sigma l^2 = 1,$$

and are proportional to $x_1 - x_2$, $y_1 - y_2$, etc. Thus a line is determined by a point P, and its orientation (l, m, etc.) by

$$\frac{x - x_1}{l} = \frac{y - y_1}{m} = \text{etc.}$$

* See, however, Note, p. 73.

The angle between two lines is θ, where

$$\cos\theta = \Sigma ll'.^*$$

An S_m is likewise determined by a point P_1 and its *orientation*, which may be taken as composed of the orientation (l_r, m_r, n_r, etc.) of any m mutually perpendicular lines lying in the flat. The direction cosines ($\alpha, \beta, \gamma \ldots$) of any line in S_m are given by n equations

$$\alpha = \lambda l_1 + \mu m_1 + \nu n_1 + \ldots$$
$$\beta = \lambda l_2 + \mu m_2 + \nu n_2 + \ldots$$
$$\gamma, \delta \ldots = \text{etc.},$$

where $\Sigma\lambda^2 = 1$.

A flat with given orientation through P_1 is given by

$$\frac{x - x_1}{\alpha} = \frac{y - y_1}{\beta} = \frac{z - z_1}{\gamma} = \text{etc.}$$

Flats with the same orientation may be described as *parallel*. Parallel flats do not meet, but the converse is not true.

4. *Mutually normal flats.*—Two flats S_m and S_m' are said to be "*normal*" or "mutually normal" when each consists of all the right lines which can be drawn through a point perpendicular to all the right lines of the other. If S_m is given, then the orientation of S_m' is found by expressing that

$$\alpha\alpha' + \beta\beta' + \gamma\gamma' + \ldots = 0$$

for all values of the variables $\lambda, \mu, \nu, \ldots \lambda', \mu', \nu', \ldots$ We have m equations of the type

$$l'_r l_s + m'_r m_s + \ldots = 0.$$

Hence $m' = n - m$. Thus *the flats normal to an m-flat are* $(n - m)$-flats, *and one passes through each point of* S_m. The two flats intersect in only one point.

For example, if $n = 5$, the 3-flat $x = 0$, $y = 0$ is normal at the origin to the 2-flat $z = 0$, $u = 0$, $v = 0$.

5. *Co-ordinates of a flat.*—S_m is defined by $n - m$ linear equations $L = 0$, $M = 0$, $N = 0$, etc. There are here $n(n - m)$ constants. But we can choose $n - m$ groups of multipliers such that in each group the coefficients of $n - m - 1$ of the variables disappear in $\lambda_r L + \mu_r M + \nu_r N + \ldots$ Thus S_m is defined by $n - m$ equations, involving constants in number $n(n - m) - (n - m - 1)$.

Thus the number of independent co-ordinates of an S_m is $(n - m)(m + 1)$.

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* Hence the n co-ordinate axes are mutually perpendicular.

6. *Plane-normal flats.*—This conception is important in what follows. If the normal flat to S_m is a plane S_2 lying in S_m', and the normal flat to S_m' is a plane S'_2 lying in S_m, then S_m and S_m' are said to be *mutually plane-normal.* Evidently $m = m' = n - 2$. Each of the flats is termed *plane-normal.* Thus the two flats $(x = 0,\ y = 0)$ and $(v = 0,\ w = 0)$ are mutually plane-normal, and if $n = 5$ (for example) the correspondiug normal planes are $(z = u = v = w = 0)$ and $(x = y = z = u = 0)$.

A plane-normal flat S_{n-2} has $2(n - 1)$ co-ordinates.

7. A *complete system* of mutually plane-normal flats is one containing the greatest possible number. Now let ^2S be plane-normal to a given ^1S, say $x = 0,\ y = 0$. Then the coefficients of x and y in the two equations for ^2S must vanish, and this reduces the number of its free co-ordinates by 4. And if it is plane-normal to N given flats the number of its free co-ordinates is reduced to

$$2(n - 1) - 4N.$$

Hence, if n is even, *a complete system contains* $\frac{n}{2}$ *mutually plane-normal flats* ; *if n is odd, the number is* $\frac{n-1}{2}$. Thus if $n = 6$, the flats $(x = 0,\ y = 0)$, $(z = 0,\ u = 0)$, $(v = 0,\ w = 0)$ form a complete system ; if $n = 5$, then $(x = 0,\ y = 0)$, $(z = 0,\ u = 0)$ form a complete system.

8. This leads to a principle which is the keystone of the argument :—*A complete system of mutually plane-normal flats has* $\frac{n^2}{2}$ or $\frac{n^2-1}{2}$ *free co-ordinates, according as n is even or odd.** Let ^1S_m, ^2S_m, ^3S_m, etc., be such a system. ^1S_m has $2(n - 1)$ co-ordinates ; when ^1S_m is fixed, ^2S_m has only $2(n - 1) - 4$ free co-ordinates; when both are fixed, ^3S_m has $2(n - 1) - 8$ free co-ordinates. Thus the total number of co-ordinates of the system is the sum of the series

$$2(n - 1) + 2(n - 1) - 4 + 2(n - 1) - 8 + 2(n - 1) - 12 + \dots .$$

o $\frac{n}{2}$ or $\frac{n-1}{2}$ terms, according as n is even or odd, and is therefore

$$\frac{n^2}{2} \text{ or } \frac{n^2-1}{2}.$$

* When $n = 3$ this is replaced by the principle that a right line has four co-ordinates

II.—Displacement and Rotation.

9. The displacement of a rigid schema in n dimensions is evidently expressed by an orthogonal transformation with constants added:—

$$x' = a + l_1x + m_1y + n_1z + p_1u + \dots$$
$$y' = b + l_2x + m_2y + n_2z + p_2u + \dots$$
$$z' = c + l_3x + m_3y + n_3z + p_3u + \dots$$
$$u' = d + l_4x + m_4y + n_4z + p_4u + \dots$$
etc.,

where a, b, c, d, etc., are constants. Also

$$\Sigma l^2 = 1 \text{ and } \Sigma l_r l_s = 0 \text{ horizontally, and (the equivalent)}$$
$$\Sigma l^2 = 1 \text{ and } \Sigma l_r m_r = 0, \text{ etc., vertically.}$$

Evidently distance is preserved in this transformation. Note also that it involves $\frac{n(n+1)}{2}$ independent constants.

10. *Condition of continuity.*—If Δ denote the determinant

$$\begin{vmatrix} l_1 & m_1 & n_1 & p_1 & . \\ l_2 & m_2 & n_2 & p_2 & . \\ l_3 & m_3 & n_3 & p_3 & . \\ l_4 & m_4 & n_4 & p_4 & . \\ . & . & . & . & . \end{vmatrix}$$

then $\Delta^2 = 1$.

The condition that the transformation be continuous and therefore capable of being precisely represented by a displacement of a rigid schema is

$$\Delta = +1.$$

For if the transformation is identical ($x' = x$, etc.), $\Delta = +1$, and Δ cannot suddenly jump from $+1$ to -1. Discontinuous transformation is exemplified by *reflexion* with regard to an S_{n-1}, e.g. if $n = 3$,

$$x' = -x, \quad y' = y, \quad z' = z$$

is discontinuous, as it would turn a right-hand glove into a left-hand.

11. *Rotation and rotatory flats.*—A rotation round an S_m is defined as a rigid-schema movement in which the points of S_m are kept fixed, while the other points in S_n move with one degree of freedom. The possibility of a rotation round $x = 0$, $y = 0$ is shown by the transformation

$$x' = x\cos\theta + y\sin\theta, \quad y' = -x\sin\theta + y\cos\theta,$$

the other co-ordinates being unaltered.

A *rotatory flat* is one round which rotation is possible.

A *rotatory flat must be an* S_{n-2}. For S_m has $(n-m)(m+1)$ co-ordinates which fix it geometrically, and there are $\frac{m(m+1)}{2}$ degrees of freedom of motion within S_m. Hence if S_m is kept *rigid*, the number of restrictions is the sum of these numbers, viz.:

$$\frac{(2n-m)(m+1)}{2}.$$

But by definition this is one less than the number of degrees of freedom in S_m, viz. $\frac{m(m+1)}{2}$. Hence $m = n - 2$.

12. *Co-ordinates of a rotation.*—A rotatory flat S_{n-2} has $2(n-1)$ co-ordinates. Hence *a rotation has* $2n-1$ *co-ordinates,* or *independent parameters which specify it.*

13. In a rotation round S_{n-2} the other points in S_n must move in circles whose centres lie in S_{n-2} and whose planes are normal to S_{n-2}. For, let S_{n-2} be $(x = y = 0)$. When $x = 0$, $y = 0$, there is no change in any of the co-ordinates, hence

$$x' = l_1 x + m_1 y, \quad y' = l_2 x + m_2 y;$$

and applying the conditions of orthogonality the transformation must be expressible in the form

$$\begin{aligned} x' &= x \cos\theta + y \sin\theta, \\ y' &= -x \sin\theta + y \cos\theta, \\ z' &= z, \\ u' &= u, \end{aligned}$$

etc.

Thus any point (P), $x, y, z, u, v \ldots.$ describes a circle round the foot (M), $0, 0, y, z, u, v$, of the single perpendicular line through P to S_{n-2}. Also if P moves to P' the angle $PMP' = \theta$, and is the same for all points.

14. A rotation may equally well be described as being *in* an $(n-2)$ ply infinite series of parallel planes, the planes normal to S_{n-2}. These planes are fixed, but not rigid. One point O is fixed in each plane, the centre of rotation for the motion in that plane, and S_{n-2} is the locus of these points. Thus in the rotation of § 13, the parallel planes are all of the form $z = c$, $v = d$, $w = e$, etc., where c, d, e are constants.

15. *General formula for rotation round* S_{n-2}.—Let S_{n-2} be a flat through the origin containing the $n-2$ mutually orthogonal directions

$$(l_r, m_r, n_r, p_r \ldots.).$$

The orientation of S_{n-2} is therefore (§ 3)

$$l = l_1\lambda + m_1\mu + \dots .$$
$$m = l_2\lambda + m_2\mu + \dots .$$
etc.

Then a rotation through an angle θ is expressed by

$$x' = \xi + (x - \xi)\cos\theta \pm A \sin\theta.$$
$$y' = \eta + (y - \eta)\cos\theta \pm B \sin\theta,$$
$$z' = \zeta + (z - \zeta)\cos\theta \pm C \sin\theta.$$
$$v' = \omega + (v - \omega)\cos\theta \pm D \sin\theta.$$
etc.

where

$$\xi = \Sigma_1^{n-2}\, l_r(l_r x + m_r y + n_r z + p_r u + \dots .),$$
$$\eta = \Sigma_1^{n-2}\, m_r(l_r x + m_r y + n_r z + p_r u + \dots .),$$
etc.,

and

$$A = \begin{vmatrix} y & z & u & v & . \\ m_1 & n_1 & p_1 & q_1 & . \\ m_2 & n_2 & p_2 & q_2 & . \\ m_3 & n_3 & p_3 & q_3 & . \\ . & . & . & . & . \end{vmatrix}$$

with similar forms for B, C, D, etc.*

This rotation formula may be verified almost as if n were equal to 3. Note that $(\xi, \eta, \zeta, \omega, \dots .)$ is the foot M of the (single) perpendicular from $P(x, y, z, \dots .)$, and if P' is the new position of P we have only to prove that M is also the foot of the perpendicular from P', and

$$PM^2 = \Sigma(x - \xi)^2 = \Sigma(x' - \xi)^2 = P'M^2,$$
$$\Sigma x^2 = \Sigma x'^2 = r^2,$$
$$\cos PMP' = \frac{\Sigma x x'}{r^2} = \cos\theta.$$

16. *Co-ordinates of a complete system of rotations.*—Let us call the system R_n. Then R_n means a series of rotations round the flats of a "complete system" (F_n) of mutually plane-normal flats (§ 7). The independent co-ordinates of R_n are therefore those of F_n together with the angles of rotation.

---

* The sign to be placed before A, B, etc., must be fixed by some arbitrary convention, which need not delay us.

When n is even, the number of flats in F_n is $\frac{n}{2}$, and this is also the number of angles in R_n. But the number of co-ordinates of F_n is $\frac{n^2}{2}$; hence the number of free co-ordinates of R_n is

$$\frac{n^2}{2} + \frac{n}{2} = \frac{n(n+1)}{2}.$$

Now this is the number of degrees of freedom of motion in S_n (§ 9). Hence:—

When n is even, any displacement of a rigid schema can be effected by $\frac{n}{2}$ determinate rotations round $\frac{n}{2}$ mutually plane-normal $(n-2)$-flats.

When n is odd, the number of co-ordinates (§ 8) of F_n is $\frac{n^2-1}{2}$. But there are $\frac{n-1}{2}$ flats in R_n and the same number of angles of rotation. Hence the number of free co-ordinates of an R_n is

$$\frac{n^2-1}{2} + \frac{n-1}{2} = \frac{n(n+1)}{2} - 1.$$

Now this is one less than the number of degrees of freedom of motion in S_n. Hence:—

When n is odd, any displacement of a rigid schema can be effected by $\frac{n-1}{2}$ determinate rotations round $\frac{n-1}{2}$ mutually plane-normal flats, combined with a uniform translation along the common line of intersection of all of these flats.

17. *Canonical form of the transformation.*—The preceding amounts to proving that the transformation of § 9 may, by referring the system to a new set of mutually orthogonal axes, be reduced to the canonical form:—

$$\begin{aligned}
X' &= X\cos\theta + Y\sin\theta, \\
Y' &= -X\sin\theta + Y\cos\theta, \\
Z' &= \qquad\qquad Z\cos\phi + U\sin\phi, \\
U' &= \qquad\qquad -Z\sin\phi + U\cos\phi, \\
V' &= \qquad\qquad\qquad\qquad V\cos\psi + W\sin\psi, \\
W' &= \qquad\qquad\qquad\qquad -V\sin\psi + W\cos\psi, \\
&\qquad\qquad \text{etc.}
\end{aligned}$$

When n is even, we have $\frac{n}{2}$ such pairs of rotations. But when n is odd, the last equation, if T is the last co-ordinate, is

$$T' = \qquad\qquad\qquad\qquad T + t,$$

where t is the uniform translation.

III.—Reduction to Canonical Form.

18. A proof based on equality of numbers of independent co-ordinates (such as in § 16) is not always reliable, though it produces a high degree of conviction. It is necessary, therefore, to show how the reduction to the canonical form may be effected directly, and further that it is *unique*, provided there are no singularities.*

Let $f(\lambda)$ represent the determinant

$$\begin{vmatrix} l_1 - \lambda & m_1 & n_1 & p_1 & . \\ l_2 & m_2 - \lambda & n_2 & p_2 & . \\ l_3 & m_3 & n_3 - \lambda & p_3 & . \\ l_4 & m_4 & n_4 & p_4 - \lambda & . \\ . & . & . & . & . \end{vmatrix}$$

The *coefficients of* λ *in this equation of the* n^{th} *degree are invariants for all orthogonal axes.* For, let $P\ (x, y, z, u, v, \ldots)$ be a point which becomes transformed to $P'\ (\lambda x, \lambda y, \lambda z, \lambda u, \lambda v, \ldots)$; then†

$$\lambda x = l_1 x + m_1 y + \text{etc.},$$
$$\lambda y = l_2 x + m_2 y + \text{etc.},$$
$$\text{etc.}$$

If we transform to other orthogonal axes through the point, it is clear that if $X, Y, Z, U, \ldots$ are the new co-ordinates of P, then $\lambda X, \lambda Y, \lambda Z, \ldots$ are the new co-ordinates of P'. Hence the equation $f(\lambda) = 0$ formed from the new coefficients must have the same roots; and since the absolute term in $f(\lambda)$ is the same in both cases ($\Delta = 1$), all the coefficients of λ are absolute invariants. Now, if we take the canonical form of § 17, it is easily seen that $f(\lambda)$ vanishes when $\lambda = e^{\pm i\theta}$. For the left-hand top small minor becomes

$$\begin{vmatrix} \cos\theta - \lambda & \sin\theta \\ -\sin\theta & \cos\theta - \lambda \end{vmatrix} = (\lambda - e^{i\theta})(\lambda - e^{-i\theta}),$$

and if this vanishes $f(\lambda) = 0$, since the determinant is simply the product of these small diagonal minors.

Thus, *when n is even, the roots of $f(\lambda) = 0$ are the n quantities* $e^{\pm i\theta}$, $e^{\pm i\phi}$, etc., whereby the $\frac{n}{2}$ angles of rotation are determined. *When n is odd, the corresponding roots of $f(\lambda) = 0$ are $n - 1$ quantities* $e^{\pm i\theta}$ and *unity*.‡

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* See Note, p. 73, and footnote p. 70.

† Constants $a, b, c, \ldots$ may be added, but it makes no difference.

‡ Because when n is odd $f(1) = 0$ always (see § 18).

We must show now that when n is even $f(\lambda) = 0$ is a reciprocal equation, and therefore may be reduced to one of degree $\frac{n}{2}$.

19. *Independent invariants of a motion.*—(1) Let n be even, and suppose

$$f(\lambda) = \lambda^n - \Delta_1\lambda^{n-1} + \Delta_2\lambda^{n-2} - \ldots + \Delta_{n-2}\lambda^2 - \Delta_{n-1}\lambda + 1.$$

The absolute term $= \Delta = 1$. Now Δ_r is the *sum* of leading minors of order r of Δ. But since $\Delta = 1$, each leading minor is equal to its complementary minor, since Δ is identical with its reciprocal. Hence $\Delta_r = \Delta_{n-r}$. *There are thus* $\frac{n}{2}$ *independent invariants* $\Delta_1, \Delta_2, \Delta_3, \ldots \Delta_{\frac{n}{2}}$, *when n is even,** and $f(\lambda)$ may be written in the reciprocal form

$$\lambda^n + 1 - \Delta_1(\lambda^{n-1} + \lambda) + \ldots \pm \lambda^{\frac{n}{2}} \Delta_{\frac{n}{2}}.$$

Dividing by $\lambda^{\frac{n}{2}}$ and putting $\lambda + \frac{1}{\lambda} = 2\cos\theta$, we reach the following equation, which may be expressed as an equation of degree $\frac{n}{2}$ in $\cos\theta$:—

$$2^m \cos m\theta - 2^{m-1}\Delta_1 \cos(m-1)\theta + \ldots \pm \Delta_m,$$

where $2m = n$.

(2) Let n be odd and $= 2m + 1$. Then in like manner $\Delta_r = \Delta_{n-r}$, and there are m independent invariants (equal in number to that of the angles) $\Delta_1, \Delta_2, \ldots \Delta_m$.† There is no central term, hence

$$f(\lambda) = -\lambda^n + 1 + \Delta_1(\lambda^{n-1} - \lambda) + \ldots \pm \Delta_m(\lambda^{m+1} - \lambda^{m-1}).$$

Hence $f(1) = 0$, and we may divide across by $\lambda - 1$. By putting

$$\lambda + \frac{1}{\lambda} = 2\cos\theta,$$

we get an equation of the m^{th} degree for $\cos\theta$.

20. *Determination of the rotatory flats.*—Suppose first that n is even, and that we refer to the self-returning origin (§ 21). This amounts to finding an orthogonal substitution of the form

$$\begin{aligned} X &= \alpha_1 x + \beta_1 y + \gamma_1 z + \delta_1 u + \ldots \\ Y &= \alpha_2 x + \beta_2 y + \gamma_2 z + \delta_2 u + \ldots \\ Z &= \alpha_3 x + \ldots \\ W &= \alpha_4 x + \ldots \\ &\text{etc.,} \end{aligned}$$

* That they are independent in general may be proved by noting that the canonical form is possible with arbitrary values of $\theta, \phi, \ldots$ and that there must be the same number of independent invariants as there are angles.

† There is also an invariant of translation (§ 23).

such that the original equations of motion

$$x_1' = l_1 x + m_1 y + \text{etc.},$$

take the canonical form (§ 17). Now this would give rise to n^2 linear equations, which it would be very difficult to solve and harmonize even if $n = 4$. The equations will be n of the form

$$l_1 a_1 + l_2 \beta_1 + l_3 \gamma_1 + \ldots . = a_1 \cos\theta + a_2 \sin\theta,$$

where on the left l is replaced by m, n, p, etc., in turn, and on the right a is replaced by β, γ, δ, etc., in turn; n more equations similarly constructed of the form

$$l_1 a_2 + l_2 \beta_2 + l_3 \gamma_2 + \ldots . = - a_1 \sin\theta + a_2 \cos\theta.$$

The remaining equations will similarly involve the other angles (ϕ, ψ, etc.) in groups of $2n$ for each angle. We shall also require

$$\Sigma a_r^2 = 1, \quad \Sigma a_r a_s = 0, \quad \text{for all values of } r \text{ and } s \ (r \neq s).$$

The use of the determinant $f(\lambda)$ simplifies the work in a truly astonishing manner. Let $\mu_1 + i\mu_2$ be a root λ_1 of $f(\lambda) = 0$, corresponding to θ, where $i^2 = -1$. Let $\xi_1, \eta_1, \zeta_1, \omega_1, \ldots$ be the corresponding ratios which satisfy

$$\begin{aligned} l_1\xi_1 + m_1\eta_1 + n_1\zeta_1 + p_1\omega_1 + \ldots . &= (\mu_1 + i\mu_2)\xi_1 \\ l_2\xi_1 + m_2\eta_1 + \ldots\ldots\ldots\ldots . &= (\mu_1 + i\mu_2)\eta_1 \\ l_3\xi_1 + \ldots\ldots\ldots\ldots\ldots\ldots . &= (\mu_1 + i\mu_2)\zeta_1 \\ \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot & \quad \cdot \end{aligned}$$

Summing the squares of both sides

$$\xi_1^2 + \eta_1^2 + \zeta_1^2 + \ldots . = (\mu_1 + i\mu_2)^2 (\xi_1^2 + \eta_1^2 + \zeta_1^2 + \ldots .).$$

But the transformation is orthogonal, hence

$$\Sigma\xi_1^2 = \lambda_1^2 \Sigma\xi_1^2$$

and since λ_1 generally is not $= 1$, we have*

$$\Sigma\xi_1^2 = 0.$$

Let the values of $\xi_1, \eta_1, \zeta_1 \ldots .$, and their conjugates $\xi_2, \eta_2, \zeta_2 \ldots .$, found from the linear equations be

$$\begin{aligned} \xi_1 &= a_1 + i a_2 & \xi_2 &= a_1 - i a_2 \\ \eta_1 &= \beta_1 + i\beta_2 & \eta_2 &= \beta_1 - i\beta_2 \\ \zeta_1 &= \gamma_1 + i\gamma_2 & \zeta_2 &= \gamma_1 - i\gamma_2 \\ &\text{etc.} & &\text{etc.} \end{aligned}$$

Hence, since

$$\Sigma\xi_r^2 = 0,$$

$$\Sigma a_1 a_2 = 0, \quad \Sigma a_1^2 = \Sigma a_2^2 = 1,$$

for we may take 1 as their common value.

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* If one or more roots = 1, we have a singularity not here considered (see Note, p. 73).

Making these substitutions in the linear equation for $\xi_1, \eta_1, \zeta_1 \ldots$ and equating real and imaginary parts, it will be seen after a little linear transformation that $a_1, \beta_1, \gamma_1, \ldots a_2, \beta_2, \gamma_2 \ldots$ satisfy the same equations as the numbers represented by the same letters at the beginning of this section. Hence the flat of rotation corresponding to θ, where*

$$\cos\theta = \mu_1, \quad \sin\theta = \pm\,\mu_2$$

is the S_{n-2} defined by

$$X \equiv \Sigma a_1 x = 0, \quad Y \equiv \Sigma a_2 x = 0.\dagger$$

Consider the next angle ϕ, and proceed as before. Then

$$e^{i\phi} = \mu_3 + i\mu_4,$$

and the corresponding rotatory $(n - 2)$-flat is defined by

$$Z \equiv \Sigma a_3 x = 0, \quad W \equiv \Sigma a_4 x = 0.$$

We also prove that Z and W are orthogonal to X and Y. For

$$\Sigma l_1 \xi_1 = \lambda_1 \xi_1 \qquad \Sigma l_1 \xi_3 = \lambda_3 \xi_3$$
$$\Sigma l_2 \xi_1 = \lambda_1 \eta_1 \qquad \Sigma l_2 \xi_3 = \lambda_3 \eta_3$$
$$\cdot \quad \cdot \quad \cdot \quad \cdot$$

Hence $$\Sigma \xi_1 \xi_3 = \lambda_1 \lambda_3 \Sigma \xi_1 \xi_3.$$

But in general $\lambda_1\lambda_3 \neq 1$, hence

$$\Sigma \xi_1 \xi_3 = 0,$$

which establishes the orthogonality in question.

The rotatory flats are thus defined by

$$X^2 + Y^2 = \Sigma \xi_1 \xi_2 = 0,$$
$$Z^2 + W^2 = \Sigma \xi_3 \xi_4 = 0,$$

where ξ_1, ξ_2, &c., are the *ratios* satisfying linear equations *which give rise to*

$$f(\lambda) = 0,$$

and the roots of this equation are the various values of $e^{\pm i\theta}$.

When n is odd, the $\frac{n-1}{2}$ rotatory flats are determined in like manner, if we take the origin on the "central axis," or axis of uniform translation (§ 22).

21. In § 20 a special origin was chosen in each case—n even. Here we

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* $$\Sigma \xi_1 \xi_2 = (\mu_1^2 + \mu_2^2)\,\Sigma \xi_1 \xi_2$$

and does not vanish. Hence

$$\mu_1^2 + \mu_2^2 = 1\,;$$

therefore *the angle θ is always real.*

† On inspection it will be seen that the ambiguity in the sign of θ introduces no ambiguity in the transformation.

may take as origin *the unique point which returns to itself,* and thus the constants a, b, c, d . . . disappear. That there is such a point follows from solving the equations

$$\begin{aligned} x &= a + l_1 x + m_1 y + \ldots \\ y &= b + l_2 x + m_2 y + \ldots \\ z &= c + l_3 x + \ldots \\ & \ldots \end{aligned}$$

The determinant $f(1)$ does not vanish in general.* Hence $x, y, z, \ldots$ may be found uniquely.

22. *The central axis when n is odd.*—In § 19 we have taken the origin on the central axis. *In general no point returns to itself,* since the determinant $f(1)$ vanishes (§ 19). But we can directly prove the existence of the central axis and find its equation. It is a line such that every point thereon returns to the line. Now, suppose that $(P), x, y, z, \ldots,$ $(A), \alpha, \beta, \gamma, \ldots$ are two points on such a line, and that its direction-cosines are $L, M, N, \ldots$ Then

$$x = \alpha + L\theta, \qquad y = \beta + M\theta, \text{ etc.}$$

Now the displacement of P must be equal to the diplacement of A, and we have therefore n equations of the form

$$(l_1 - 1)x + m_1 y + n_1 z + \ldots = (l_1 - 1)\alpha + m_1\beta + n_1\gamma + \ldots,$$

and the conditions are satisfied if $L, M, N, P, \ldots$ are proportional to the minors formed by omitting any row of $f(1)$. The equation of the central axis is then

$$\frac{a + (l_1 - 1)\alpha + m_1\beta + n_1\gamma +}{L} = \frac{b + l_2\alpha + (m_2 - 1)\beta + n_2\gamma +}{M} = \text{etc.}$$

and each of those equals the *invariant of translation.*

23. *The invariant of translation when n is odd.*† This is the quantity which remains unaltered when the axes are translated parallel to themselves, and is

$$t = La + Mb + Nc + Pd + \ldots$$

The transformation consists first in choosing any origin on the central axis, when the equations are

$$\begin{aligned} x' &= Lt + l_1 x + m_1 y + n_1 z + \ldots \\ y' &= Mt + l_2 x + m_2 y + n_2 z + \ldots \\ z' &= Nt + l_3 x + m_3 y + n_3 z + \ldots \\ & \text{etc.} \end{aligned}$$

* See note, p. 70.

† This invariant does not exist when n is even, since f (1) does not vanish in the general case.

We then rotate the axes by the method of § 20, when the equations take the canonical form, which is *the same for all origins on the central axis*, the last equation being $T' = t + T$.

We have further to prove that the central axis thus found is normal to all the $(n - 1)$-flats $x, y, z, u, \ldots$ This amounts to proving

$$\Sigma L \xi_r = 0$$

for all values of ξ. And it is proved in the same way as we proved

$$\Sigma \xi_1 \xi_3 = 0.$$

In fact $(L, M, \ldots)$ correspond to the *unit* root of $f(\lambda) = 1$, and

$$\Sigma l_1 L = L, \text{ etc.;}$$

also

$$\Sigma l_1 \xi_r = \lambda_r \xi_r, \text{ etc.;}$$

and therefore $\Sigma L \xi_r = 0$, since $\lambda_r \neq 1$.

NOTE.

A few days after this paper was read before the Academy, I had the good fortune to come across Dr. Hilton's *Homogeneous Linear Substitutions* (Oxford, 1914), in which the theory of orthogonal transformations is exhaustively treated. The theorem on p. 47 of Dr. Hilton's work includes the algebra required to prove my kinematic conclusions in the particular case when the origin is self-returning, and there is therefore no uniform translation.

I should add that I have not considered those rare singularities which arise (1) when two or more of the angles of rotation are equal, and (2) when (n being even) one or more of the $\frac{n}{2}$ rotations reduce to uniform translations (the rotatory flats being at infinity), or (n being odd) one or more of the $\frac{n-1}{2}$ rotations likewise reduce to uniform translations. Here Dr. Hilton's algebra will assist the inquirer who is fond of singularities.

Those who are interested in the geometry of n dimensions will find ample references to guide them in Dr. Sommerville's copious bibliography.*

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* *Bibliography of Non-Euclidean Geometry, including the Theory of Parallels, the Foundations of Geometry, and Space of n dimensions*, by Duncan M. Y. Sommerville, M.A., D.Sc. (St. Andrews University, 1911).

V.

IONIC MOBILITIES IN AIR AND HYDROGEN.

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[Read December 11, 1922. Published January 22, 1923.]

The work described in the present paper consists for the greater part of a careful examination by the Rutherford-Franck method of the ionic mobilities in hydrogen. As certain emendations and additions can be made to the results for air previously reported,[1] and as it is necessary to deal with criticism[2] which some of this work has received, it is convenient to devote the first part of the paper to ionic mobilities in air.

Ionic Mobilities in Air.

The conclusions to which the author has been led as a result of his examination of ionization in air may be broadly stated thus: (1) that the ordinary ionization in air is composite, that is to say, that it consists of a mixture of groups of different ions, each of a definite mobility; and (2) that in the ordinary ionization there are present in small numbers ions of mobility much higher than what is usually regarded as the normal value. The experiments which suggested these conclusions originated in an investigation of the ionization produced by breaking up water. Among these ions were found some of mobility twice the normal value,[3] and in later work some of four times the normal value[4] were observed. In these values there was nothing surprising to anyone familiar with the work of Aselmann,[5] or to anyone accustomed to regard the small ion from the point of view of the cluster theory. In later work, when it was sought to define these ions

[1] J. J. Nolan, Proc. Royal Irish Academy, vol xxxv, Sect. A, p. 38, 1920; and J. J. Nolan and Harris, vol. xxxvi, Sect. A, p. 31, 1922.

[2] Blackwood, Physical Review, March, 1922, p. 281.

[3] Proc. Royal Society, Sect. A, vol. xc, p. 543, 1914.

[4] Proc. Royal Irish Academy, vol. xxxiii, Sect. A, p. 9, 1916.

[5] Ann. der Phys., xix, p. 960, 1906, quoted by J. J. Thomson, "Conduction of Electricity through Gases," second edition, p. 429.

more closely, and to get accurate values for their mobility, it was found that the ionization was more complex than had appeared at first sight.[1] Evidence of the existence of separate groups of ions of very high mobility was obtained, and it was also found that groups of ions existed having mobilities roughly corresponding to some or other of the values commonly attributed to small ions produced by the ordinary ionizing radiations. Thus for negative ions the values 1·94, 1·70, 1·49, and 1·34 cm./sec./volt/cm. as corresponding to the mobilities of four distinct groups were obtained. Almost identical values were obtained for the positive ions. It was suggested that the ordinary small ion in air was identical with these ions, and that it assumed one or other of the four forms at any one time, the choice being determined by questions of sign and humidity. It was not then suspected that the ordinary ionization in air might be a mixture of all four. But this was the result at once found when an attempt was made to obtain accurate measurements of the mobilities of small ions produced in air by an ionizing radiation.[2] In addition, evidence was obtained of the existence *in small quantities* of ions of mobilities corresponding to the higher values previously found in the air from a water-spray. As it is this work which has been the subject of criticism, it would be well to deal with it somewhat fully. The method of observation was devised with the intention of securing sharp values for mobility, and was in principle identical with that employed previously for the observation of the spray-ions. Air is drawn between two parallel plates, the ionization being produced in a restricted region close to one of them. The current to the other is read for various values of the field between them. As the ions are produced at about the same place, they will travel along almost identical paths (if they have the same mobility), and will all arrive together at the upper plate for a certain field, or fail to reach it for a certain smaller field. Thus, if a current-voltage graph is plotted, the air-stream being steady, there will be a sharp increase in current at a certain point, indicating the arrival of the ions. If more than one class of ion is present, each class will show up as an abrupt upward inclination on the curve. The mobility can be readily calculated as the velocity of the air-stream is known. For, taking x along the air-stream and y at right angles to it and to the plates, for any ion of mobility u,

$$\frac{dx}{dy} = \frac{va}{Vu},$$

v being the velocity of the air, V the voltage difference, and a the distance

[1] Proc. Royal Society, Sect. A, vol. xciv, p. 112, 1918.
[2] Proc. Royal Irish Academy, vol. xxxv, Sect. A, p. 28, 1920.

between the plates. An ion produced at the edge of the lower plate will therefore be carried over to the further edge of the upper plate by the voltage difference V if

$$u\frac{V}{a}\cdot L = \int_0^a v\,dy,$$

L being the length of the plates. But $b\int_0^a v\,dy$ is the volume of air passing between the plates per second, b being the breadth of the space. Calling the volume of air per second Q, we have

$$uV = \frac{Qa}{Lb}.$$

It is here assumed that the air-velocity is constant over any plane parallel to the plates. This is not true, but the error will not be very serious in the experiments described where b was more than three times a.

From the curves obtained it was concluded that the bulk of the ions consisted of four definite classes, the mobility values ranging from about 2 to 1·35. In addition it was found that ions of mobility up to 12 were present in small quantities.

Blackwood[1] has endeavoured to repeat these observations, using an apparatus apparently identical with that used by the author. He shows that the greater part of the current in his experiments is due to ions produced throughout the general volume of the apparatus; that therefore the ions from the restricted source play but a small part. He states that if the general ionization is allowed for, a curve is obtained giving a normal mobility value for the ions. That the general ionization plays a considerable part in the carrying of the current observed (a part the exact magnitude of which will depend on the source of ionization and the nature of the shielding) was not in need of any experimental demonstration. It was clearly realized and is referred to in the author's original paper as follows:—"We have assumed that all the ionization is produced in a certain restricted region; but the more penetrating radiations will cause a weak general ionization throughout the whole air-space. The current due to this ionization will increase smoothly as the voltage increases, so that our experimental curve will really be due to the superposition of the step-like curve on this smooth curve." It is clear, then, that it was the step-like singularities in the curve which were sought for, and that the general contour of the curve was not a matter of any special interest. When these steps were found they were naturally attributed to the ions from the restricted source; the current-voltage curve was plotted accurately in the neighbourhood of the singularities and the

[1] *Loc. cit.*

critical voltages determined. The curves reproduced in the second paper show the manner of working. That, on allowing for the general ionization, Blackwood should have found indications only of ions of normal mobility is what might have been anticipated. The ions of high mobility are present in small numbers, and show up only as "nicks" on current-voltage curves very carefully plotted. The bulk of the ions have mobilities lying between 2 and 1·35. In Blackwood's experimental determination and separation of the current due to the general ionization from that due to the localized radiation, the small number of high mobility ions are obscured, and the others yield only a mean value. Ions of mobilities lying so close together will not be separated by any method depending on variation of current with voltage unless very accurate current readings are taken, and very small increments in voltage used. The results given by the author's original method have since, of course, been amply supported by the evidence obtained from the Rutherford-Franck alternating-field method, and are extended in the present paper to ionization in hydrogen. In addition it is now proposed to give some evidence obtained by a somewhat different alternating-field method which was referred to but not described in the original paper.[1]

Alternating-Field Method with Variable Periodic Time.

The method employed will be clear from the diagram (fig. 1). Ions are produced by a source of α-rays in the space above a sheet of metal gauze

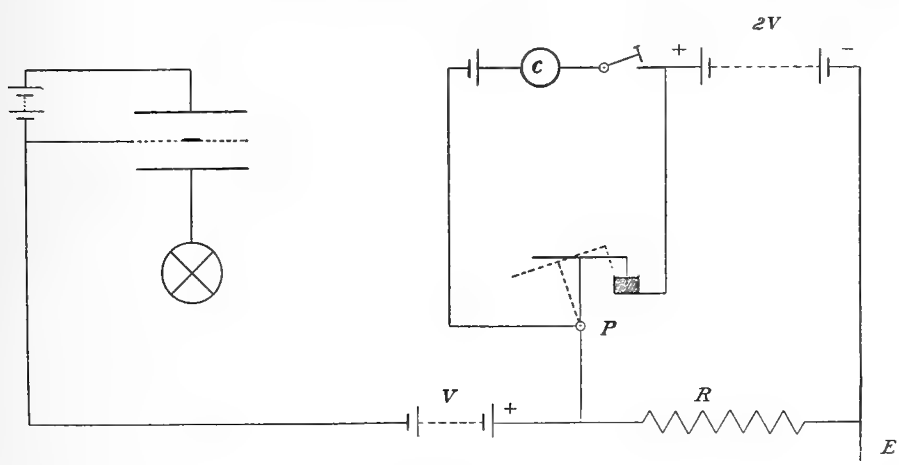

FIG. 1.

through which ions of one sign are caused to diffuse by a steady field. Below the gauze and parallel to it is a metal plate insulated, furnished with a

[1] Proc. Royal Irish Academy, 1920, p. 43.

guard-ring, and connected to an electrometer. The gauze is charged to potentials $+V$ and $-V$ alternately, the alternating field being therefore of what is sometimes called "square" wave-form. This is effected by a rocking device driven by clockwork, which, by means of a needle dipping into a mercury cup, makes and breaks a contact. While the contact is broken, the lower battery in the diagram has its positive pole earthed through the high non-inductive resistance R. The negative pole being connected to the metal gauze, the latter is therefore at the potential $-V$. While the contact is made, the point P is at potential $+2V$, and therefore the plate is at potential $+V$. The times of contact can be determined by means of the Hipp chronoscope (C) to the $\frac{1}{1000}$ of a second.

If the periodic time is varied, and if the charge received by the electrometer plate for one alternation of the field is considered, it is clear that an ion of mobility u will contribute nothing until a periodic time is reached such that $ut = \frac{d^2}{V}$, where d is the distance between the plates, and t is half the periodic time, the positive and negative fields being supposed to be of equal duration. If the quantity of electricity received per alternation be plotted against the voltage, the curve will show upward bends at points corresponding to the mobilities of the different classes of ions. The product of the current recorded by the electrometer and t is proportional to the quantity of electricity per alternation, and it is this product that has been plotted. In these experiments V was 10 volts, d was 3·05 cms., and the values for periodic time varied from ·4 to ·8 seconds. The electrometer therefore did not so much record a steady current as a series of impulses. The damping of the needle was very high and the motion fairly smooth.

The only source of trouble was the rocking device used as contact maker and breaker. It was easy to adjust this to give for any one periodic time equal intervals of make and break, that is, equal durations of $+V$ and $-V$, or, as was generally done, to make the times slightly unequal so as to secure that ions which did not reach the electrometer plate on the downward journey were discharged at the end of their upward journey. For any one adjustment the contact maker would give the times quite steadily in a definite ratio; but if the periodic time was altered, the ratio of the time of make and break altered slightly also. This was not of any direct consequence, as the time of the downward field (the field of the same sign as the ions under examination), which alone enters into the calculation of mobility, was in each case accurately measured. But the indirect consequences were, as will appear later, rather disturbing.

Some of the results obtained with this apparatus are given in fig. 2. The lower curve is the result of taking some widely scattered observations over the whole range. It shows some irregularities, but nothing definite except a rise towards the end. Anyone who is inclined to regard the first part of the curve as being due to some fortuitous irregularities, will draw a line as has been shown, and will conclude that the curve indicates the presence of ions of mobility

$$\frac{(3{\cdot}05)^2}{10} \Big/ {\cdot}606 = 1{\cdot}54,$$

and of nothing more. When it is worked over carefully in detail, however, distinct evidences of a definite structure in the earlier part of the curve are

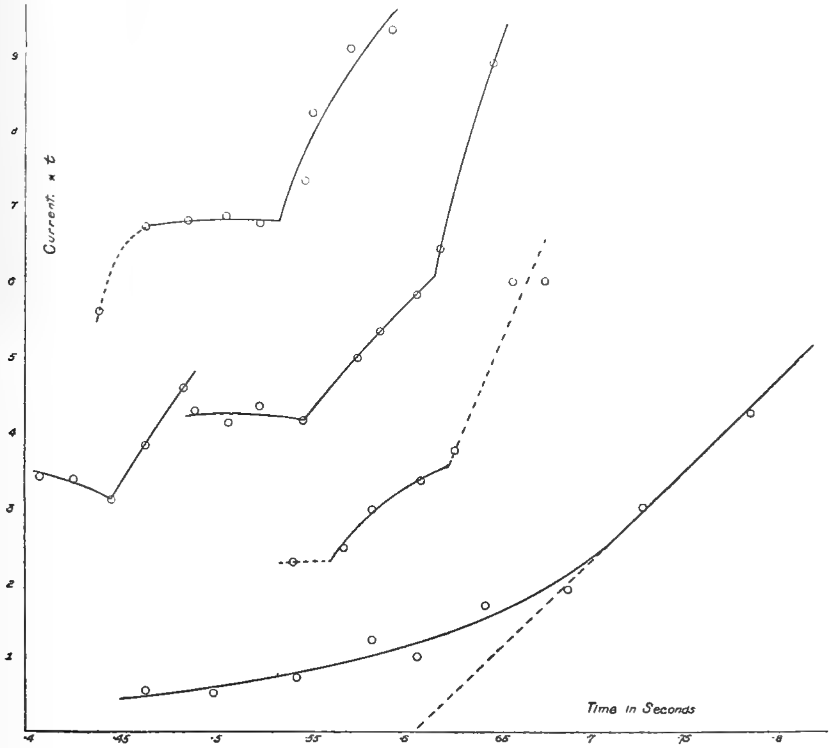

FIG. 2.

found. Some of these are given in fig. 2; the scale of time is the same as for the lower curve, but the scale of current has been magnified, the ratio being, in some cases, 3 and in others 5. The current values are plotted to various arbitrary zeros for convenience. There can hardly be any doubt as to the significance of these curves. They show sharp increases of current at certain points: the mobilities calculated from those points being 2·08, 1·69, and 1·50. If we take the point where the rise on the lower curve begins, we have also the ion of mobility 1·35. These are the same four ions that the other methods have revealed.

One point, however, has to be explained. There is a distinct downward trend in some of the curves, whereas the slope in all cases should be upward, the indication of separate classes of ions being the sudden steepening of the slope. The explanation of this effect is quite clear. The source of radiation available at the time these experiments were carried out did not give pure α-radiation; a certain amount of γ-radiation was also present. The ionization was not therefore confined to the space above the gauze. The existence of a general ionization in the space between the gauze and the electrometer-plate would not matter very much if the positive and negative fields were exactly equal and of equal duration. But the upward field is of slightly longer duration than the downward, and therefore the charge on the plate after one alternation will be diminished by an amount proportional to the difference in the times. This difference tends to increase as the times themselves increase, and it could easily happen that the resulting effect would increase more rapidly with time than the effect due to the ions which have come through the gauze, and have been captured on the lower plate. The result would be a downward trend of the curve. It is clear that this is most likely to happen at the earlier stages of the curve when only a relatively small number of the more mobile ions are concerned; and this is just what is found experimentally. In practice this effect was not altogether a disadvantage, as it helped to show up more clearly where the sudden rises in the curve occurred. But it was necessary to see that it did not occur in excess. If the rocking device was adjusted so as to give almost exactly equal times for small values of time, the differences that appeared as the periodic time increased were not generally excessive.

This matter is entered on here because it is necessary to explain the shape of the curves which are given. It would have been easy to have improved the experiments by using a pure source of α-rays, and by improving the contact-making device—a task which would in any case have been necessary. The experiments in this form were, however, discontinued when it was found that a steady source of sinusoidal E.M.F was available. The latter makes possible experiments over very wide ranges, and is independent of any commutating device. The results obtained by the method just described, while rather scanty, have this special value, that they furnish a set of proofs from a third source of the composite nature of the ordinary small ion in air.

Summary of Results for Air.

The final results given by the air-stream method were that the bulk of the ions were divided between the following four mobilities:—2·04, 1·79, 1·52, and 1·37, the negative ions tending to assume the higher values, and the positive the lower values. In addition the following mobilities were present in small numbers:—12·2, 6·62, 4·23, and 3·0. Some observations of a negative ion of mobility 24 were obtained. The method just described gives the four values 2·08, 1·69, 1·50, and 1·35. The other alternating-field method gave for undried air the values: 2·5, 2·04, 1·73, 1·54, and 1·42. In air which had been subjected to long drying, the following values were obtained for both signs: 12·3, 8·2, 5·61, 4·39, 3·04, and 2·53. In the very dry air no negative ion of mobility lower than this was found, but the normal positive ions were present. An ion of mobility 24·6 was found in all cases among the negative, and in one case among the positive ions. As these higher mobility values were deduced from fairly low voltages on the current-voltage curve, it was considered unsafe to regard them as accurate. Accordingly further experiments were conducted[1] with another apparatus of such dimensions that the critical voltages were increased about 25 times. The results obtained were in approximate agreement with those just quoted. It has since been found, however, that an error of about 10 per cent. occurred in calculating the constants for the second apparatus, so that the mobilities deduced from the second apparatus should be reduced in that proportion. This would yield the following values, which are doubtless more correct than any of the others quoted:—22, 11·2, 7·1, and 5·1. The lower values were not conveniently within the range of apparatus.

It was suggested in a previous paper that the chance of detecting very mobile ions by the alternating-field method would be much increased by diminishing the time of the ions in the space above the gauze, that is, by increasing the accelerating field. An attempt has since been made on these lines to detect the very mobile ions in ordinary undried air. This attempt was at once successful. These ions were found in quantities very small, but quite accurately measurable. An apparatus which had been prepared for observations on hydrogen (and which is described later) was used. The ion which came out best had a mobility, positive and negative, of 5·23, corresponding to 5·1 above. The mobility 10·6 was also obtained, and it was quite clear that a negative ion of still higher mobility was present. It is hoped to deal with this work at greater length on some subsequent occasion.

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[1] Proc. Royal Irish Academy, 1922, p. 43.

Mobilities in Hydrogen.

Haines,[1] working with pure and freshly prepared hydrogen, found that in addition to free electrons there were present a number of groups of negative ions of mobilities higher than the normal. As the gas became contaminated by remaining in the apparatus these ions gradually disappeared. Results suggestive of abnormal mobilities for negative ions in hydrogen have also been obtained by Lattey and Tizard[2] and by Chattock and Tyndall.[3] On the other hand, Kia-Lok Yen[4] has endeavoured to repeat Haines' experiments without success.

In pure hydrogen Haines found that the positive ion had a mobility value of 5·4, and that this value was constant. He distinguishes three main classes of negative ions: Class A, mobility 7·9, Class B, mobility 15·9, and Class C, mobility 40·6. In addition he finds subordinate classes of mobilities 9·2 and 19·6. These results are very much on the lines of those obtained by the author for air. Purity in the hydrogen seems to play the same part as dryness in the air in bringing out the high mobilities. Certain differences remain. At no time does Haines find the positive ion to be of a composite character, nor does he find the negative ion composite under normal conditions. It seemed important therefore to make a close examination of the ions in hydrogen under normal conditions, and then under such conditions of purity and dryness as could be readily attained.

Experiments on Hydrogen not specially dried.

The apparatus and method of working need only be treated of briefly here. Ions were produced in the space above a sheet of brass gauze of fine mesh. This gauze was supported on ebonite pillars exactly 4 cms. above an insulated plate furnished with an earthed guard-ring. The plate was connected to the Dolezalek electrometer used for the current readings. The source of ionization was, as in the previous work, polonium. The ions were exposed to an accelerating field, generally about 10 volts per cm., so that those of the sign under examination were caused to diffuse through the gauze. The alternating voltage applied to the gauze was read off directly on an Ayrton and Mather electrostatic voltmeter. Two of the latter were used, covering different ranges. The hydrogen was generated in a Kipp's apparatus from H_2SO_4 and granulated zinc, passed through lead nitrate and silver

[1] Haines, Phil. Mag., Oct., 1915, and April, 1916.
[2] Lattey and Tizard, Proc. Royal Soc., 1912, p. 349.
[3] Chattock and Tyndall, Phil. Mag., 1910.
[4] Kia-Lok Yen, Physical Review, xi, 1918.

sulphate, and finally bubbled through strong sulphuric acid before entering the apparatus. The gas was allowed to flow through the apparatus for several days. Most of the observations recorded subsequently were taken with a stream of hydrogen passing slowly through.

In fig. 3 the general form of the negative and positive current-voltage curves are shown. The lower part of each curve is approximately linear, the intersections with the voltage axis being at 203 in the case of the negative

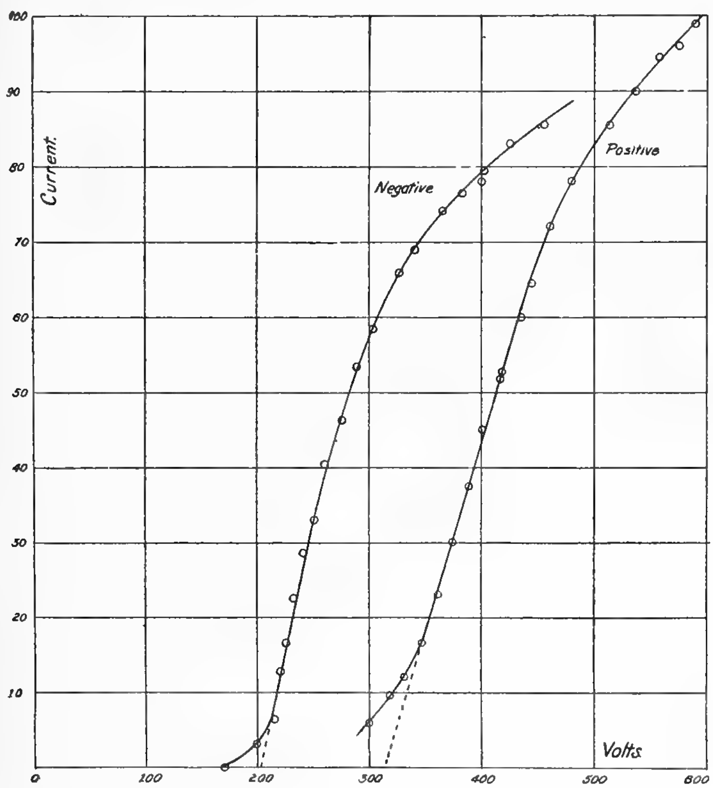

FIG. 3.

and 313 in the case of the positive. On this occasion the alternation frequency was 51·9, hence the product Vu (critical voltage × mobility) = $\pi \times 51{\cdot}9 \times 16/\sqrt{2} = 1840$. Following the usual procedure then, we could interpret these curves as indicating the existence of negative ions of mobility $\frac{1840}{203} = 9{\cdot}06$, and positive ions of mobility $\frac{1840}{313} = 5{\cdot}88$. But this ignores the fact that the curves do not approach the voltage axis in a linear fashion. This is not so noticeable in the case of the negative, but it is quite clear that the positive curve has a well-developed "tail." That the effect is not due to casual irregularities is easily seen when the lower parts of the curves are examined more closely. We will consider in detail the examination of the positive curve.

If the region between 300 and 400 volts is examined working with reduced capacity in the electrometer system, curve A of fig. 4 is obtained. Here we find a sharp change of slope occurring at a voltage of 352. We deduce the presence of an ion of mobility $\frac{1840}{352} = 5{\cdot}23$. Curve B covers the range from 260 volts to 350 volts. Here we find another sharp change of slope occurring at 299, corresponding to an ion of mobility 6·15.

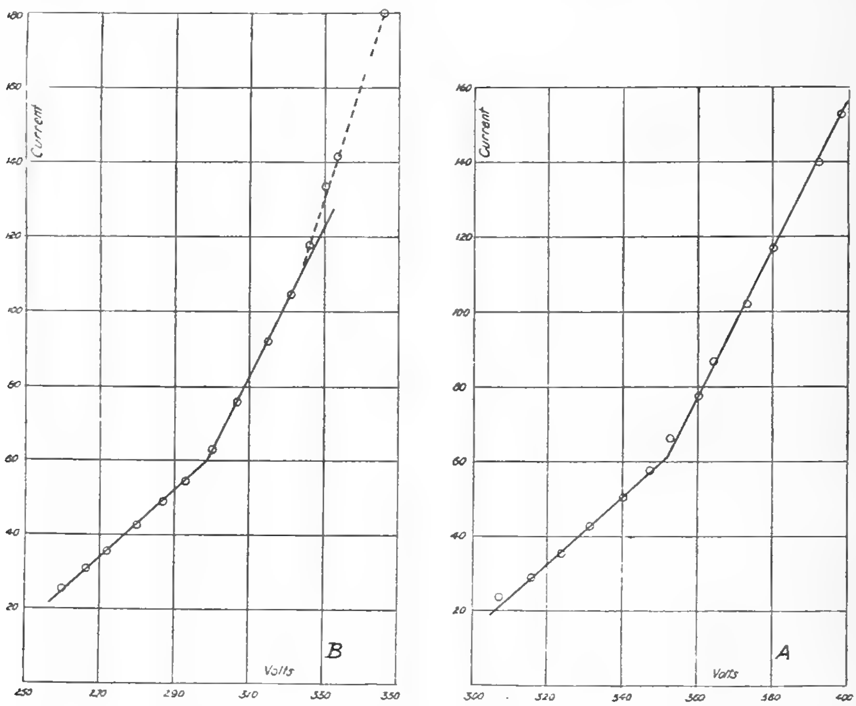

Fig. 4.

There is a tendency for the upper part of the curve to be concave upwards which is not so noticeable in the lower part of A, which covers the same range. The scale of B is three times as open as that of A, so that it is natural that the effect, if genuine, should be more noticeable with B. Now a concavity in the curve must mean the access of new ions. It is possibly due to a group of ions the critical voltage for which (as shown by the dotted line in B) is 324. We may accept, then, with some reserve a subordinate group of mobility 5·68. In fig. 5 the rest of the current-voltage curve is given in two parts, C and D, plotted once more to different scales. Curve C gives an ion of mobility 7·93 and a subordinate group of mobility 6·77. Curve D gives ions of mobilities 9·4, 11·0, and 15·0, the latter being the fastest ion present. Most of these mobilities have been obtained many times under the conditions described. It is believed that the values deduced from the curves just given

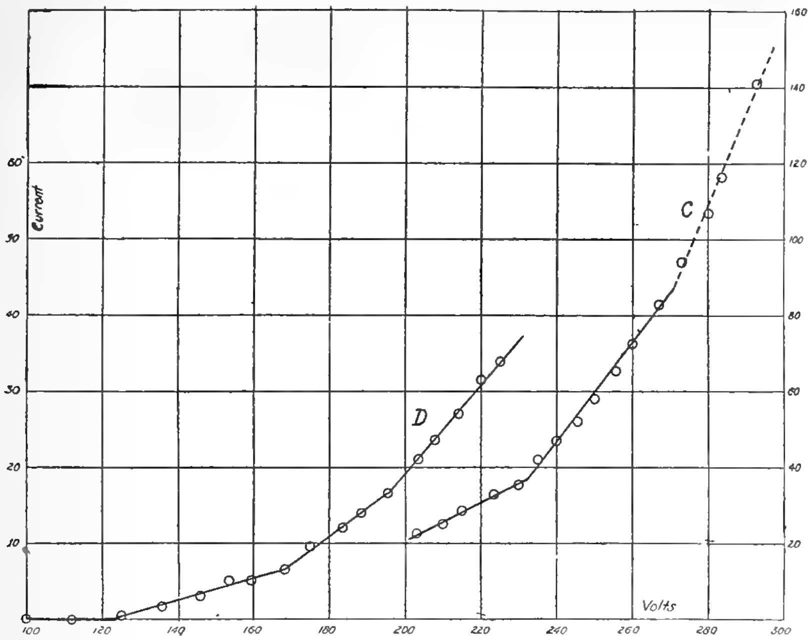

FIG. 5.

are fairly accurate and a good average representation of the results obtained as a whole. All these results were obtained at a pressure of 75·6 cms. and temperature 19° C. The values are collected in the following table and compared with mobility values found by Haines for negative ions:—

Negative ions (Haines).	Positive ions (Nolan).	REMARKS.
15·9	15·0	—
—	11·0	—
9·2	9·4	—
7·9	7·93	Mobility well established.
—	6·77	Three other observations approx. 7·0.
—	6·15	Mobility well established.
—	5·68	Some observations tend towards 5·9.
5·4	5·23	Mobility well established.

Examination of the Negative Ions.

The curve given in fig. 3 shows that the slowest negative ion appears at a voltage of about 200, and therefore has a mobility value of about 9. In fig. 6, curve A gives the result of a close examination of the current-voltage curve in this region. It is clear that there are two bends quite close together. The voltages are 191 and 202. On this occasion the product Vu had the value 1832. This gives for the mobilities of the two ions the values 9·59 and 9·07. These values have been obtained repeatedly, and the curve A is only one of many which are almost exactly identical. On another occasion the curve B was obtained. Here it would seem that the slowest ion appeared

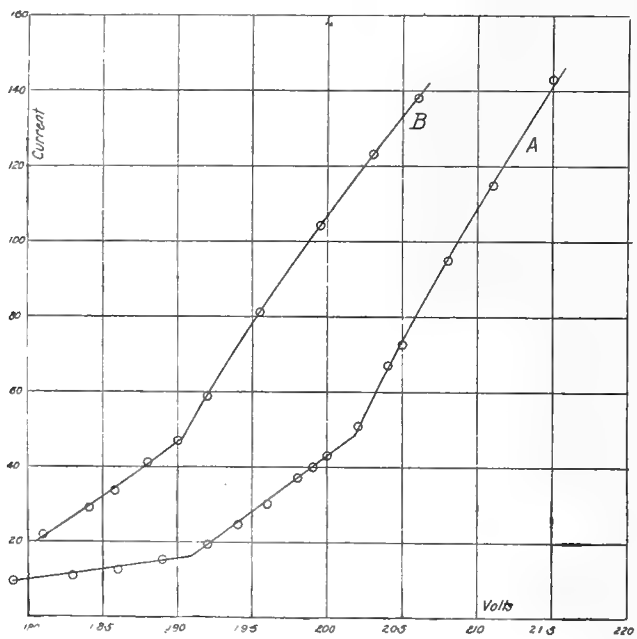

Fig. 6.

at a voltage of 190·5. The product Vu was now 1834, so that we find for the mobility of the slowest ion the value 9·63. The current values are much greater in this case for corresponding voltages, the difference being greater than would appear from the figure, as the scale has been adjusted for convenience of plotting. For example, the current values for 200 volts are almost exactly in the ratio 4 : 1.

Curve B was obtained soon after the vessel had been refilled with hydrogen. It seems to correspond to some condition of dryness or purity which we are at present unable to define exactly. The normal condition when the hydrogen has been in the vessel for some days is represented by curve A. It is possible that the positive ion of mobility 9·4 would be found on close examination to resolve into two groups, corresponding to the two negative ions found normally.

If we consider now the other end of the negative curve, we find that it crosses the voltage axis at about 97 volts. This indicates an ion of mobility 18·8, which would correspond to Haines' ion B_2 of mobility 19·6. The part of the curve lying between 100 volts and 190 volts is rather complex, and seems to suggest a considerable number of groups of ions. Some of them we have already found in the positive ionization (15·0 and 11·0), others are new; for example, ions of mobility about 14, 12, and 10. In working over this part of the curve it is easy to see at any one time that the ionization consists of a mixture of different groups, but the identification and segregation from one another of these groups from day to day is not easy. Small quantities of air finding admission to the apparatus will pull down all the mobility values. This, if not recognized, will lead to much confusion. It is advisable then, as a test of purity, to locate an ion of well-established mobility. In this work the author has adopted the practice of taking observations each day in the region of the slowest positive ion as a test. This ion comes out very distinctly. If under ordinary circumstances the bend in the curve occurs about 350 volts, it is assumed that the gas is pure. As a test of purity this may be illusory, but it is at least a method of getting corresponding conditions from day to day.

The results so far described have been obtained with hydrogen that was not specially purified in any way, and which could be considered as only moderately dry. The only drying action to which it was exposed was bubbling through a layer of strong sulphuric acid about 2 cms. deep. The effect on the ions of making the gas moister was next tested.

Mobilities in Moist Hydrogen.

Water was substituted for the strong sulphuric acid just mentioned. When a slow stream of hydrogen bubbles had been passing through the water and into the vessel for some time, the examination of the ionization was resumed. With the positive ionization no change was detected. The current values were the same as before for corresponding voltages. The five slower ions (7·9–5·2) came out quite distinctly. The region of the three faster ions (15·0–9·4) was not examined, but from the general run of the curve there is hardly any doubt that these also were present. On the other hand, the increase of moisture produced a considerable effect on the negative ionization. The negative curve when plotted boldly, as in figure 3, now cut the voltage axis at about 235 volts instead of 200. When the lower part of the curve was closely examined, it was found that there were two very sharp bends at 223 and 236 volts. The constant Vu was 1828, hence the mobilities are 7·7 and 8·2. Ions of mobility higher than this were present, but only in very small quantities. As regards the upper part of the curve, the current readings for voltages such as 400 were the same as before. But the curve between 236 and 400 volts was not smooth. A number of well-marked depressions were found, which came out consistently in each experiment. Mobilities calculated from these were in good agreement with the values obtained for the positive ions over this range, except in the case of the slowest. There was nothing to correspond to the well-established positive ion of mobility 5·23, but instead an ion appeared of mobility 4·78. The positive ions were once more examined, and while it was found that an ion of mobility 5·18 (in good agreement with the usual value) was the most prominent, a definite concavity was found in the curve in such a position as to correspond to the presence of ions of the lower mobility value in small quantities.

The extra moisture, then, may be said to have left the positive ion unaffected, except in the very small degree just mentioned. A great part of the negative ionization, however, is thrown into two close-lying groups of mobilities 7·7 and 8·2 (cf. positive, 7·9). Faster ions are present in very small and slower in moderate quantities. While these are the results obtained from experiments on moist hydrogen up to the present, the writer would prefer not to regard them as final.

It is interesting to note that in the experiments on air previously reported the fastest ion recognizable in the *moist* gas had a mobility of about 2. If we assume that the carrier is the same in the two gases, and that it is big in comparison with the gas molecules, the ordinary theory of mobility will give for the mobility of this ion in hydrogen the value

$$2\sqrt{\frac{\text{Density of air}}{\text{Density of hydrogen}}} = 2 \times 3{\cdot}8 = 7{\cdot}6.$$

in good agreement with the value found above. A similar relationship seems to exist between the slowest negative ion found in dry air and in dry hydrogen. The value for air was 2·5. This multiplied by the ratio of the square root of the densities gives 9·5, which seems to correspond with 9·63 for hydrogen (curve B, fig. 6). It is perhaps unsafe to push this very far, but we may note the following relationships, which can hardly be accidental. The two already given are included :—

Mobilities : Hydrogen.	Air. (1)	Air. (2)	Air. Mean	Ratio. $\left(\frac{\text{Mob. in } H_2}{\text{Mob. in air}}\right)$
5·23	1·37	1·42	1·38	3·79
5·68 or 6·15	1·52	1·54	1·53	3·71 or 4·02
6·77	1·79	1·73	1·76	3·85
7·93	2·04	2·04	2·04	3·89
9·63	—	2·5	2·5	3·85
11·0	3·00	3·04	3·02	3·64
15·0	4·23	4·39	4·31	3·48
18·8	—	5·1	5·1	3·69

In this table the air mobilities (1) are those found by the air-stream method, and (2) are those found by the alternating-field method. For the second last ion the value 4·31 is probably too high, for reasons mentioned earlier in this paper (page 81). For the same reasons the value 5·1 for the last ion is taken.

Extreme Drying.

Experiments are now being conducted on the effects of extreme drying. It is hoped to present the results of these experiments shortly.

The results on hydrogen so far obtained go generally to confirm the observations of Haines. All his ions have been found except his fastest, and that was hardly to be expected, since no special measures for purity or drying were adopted. The principal difference is that Haines did not find the positive ionization to be of a complex character. The results of the author on air and hydrogen involve, first, the composite character of the ordinary ionization, and, second, the existence of small numbers of ions of high mobility. We will consider the evidence now available under these heads.

Under the first head we have the author's evidence by three different methods for air and the present work on hydrogen. We find also that Erikson,[1] using a method resembling the author's air-stream method, and Wahlin,[2] using an alternating-field method, are prepared to admit the co-existence in air of positive ions of mobility about 1·80 and 1·35. Erikson believes that these represent ions composed of one molecule and two molecules respectively. How then are we to explain the mobility found for the positively charged recoil-atom ?[3]

With regard to the high-mobility ions, we have, first, the work of Altberg,[4] quoted in a previous paper. Using Zeleny's method of bringing the ions in an air-stream to rest by an opposing field, and using X-rays as the source of ionization, Altberg finds for the mobility of the fastest ion in air the value 10·1. He does not distinguish different groups, but finds that there are ions present of mobilities up to this value. Then we have the work of Haines on hydrogen. Yen,[5] on repeating Haines' work, was unable to find the mobile ions, but we cannot be sure that his experimental conditions were favourable. (We may note in passing that for the mobility of the positive ion in air, Yen finds a set of values ranging from 1·10 to 1·22, with a mean value 1·14, using low voltages and low frequencies; while for high voltages and high frequencies he finds values from 1·55 to 1·66, mean value 1·61. He gives, without comment, a mean of 1·14 and 1·61 as the mobility of this ion.) Finally we have the work of the author by two methods for air and the work on hydrogen now reported, which agrees with the results of Haines.

Further Criticism by Blackwood.

When this paper was just completed, the November number of the Physical Review reached Dublin (December 4). This contains a paper by Blackwood, which is an extension of the brief paper already referred to. The criticism based on the alleged neglect by the present writer of the general volume ionization in his original air-stream method is repeated. In view of the quotation already given from the author's first paper, and of a similar

[1] Erikson, Physical Review, August, 1922.

[2] Wahlin, Physical Review, September, 1922.

[3] Rutherford, Phil. Mag., 5, p. 95, 1903, and Franck, Verh. d. D.P.G., 11, p. 397, 1909.

[4] Altberg, Ann d. Physik, 37, p. 849, 1912.

[5] Yen, Physical Review, xi, p. 337, 1918.

reference in the second paper (p. 32, Nolan and Harris, Proc. R.I.A., 1922), it is difficult to believe that Blackwood can have carefully read the papers which he sets out to criticize. Blackwood states that, using gasometers to produce the air-stream, he at first found singularities on the current-voltage curve, but that these disappeared when the gasometers were replaced by a pumping arrangement. He considers that the pumping arrangement gave a more uniform flow than the gasometers. It is possible that the converse was the case, as the author, who has used both methods with identical results as far as mobilities are concerned, found that the gasometer method was the steadier. Blackwood has modified the author's original experiment by using polonium as the source of ionization, and thus getting rid of effects due to volume ionization. Curves obtained by this method are reproduced, from which mobility values of 1·96 and 2·13 are deduced. These results, "within 30 and 42 per cent. of the accepted value for moist air," are considered by Blackwood as "sufficient to show that the method indicates the existence of only *one size* of ion of approximately normal mobility." It is difficult to make any such deduction from the curves reproduced. The latter, in so far as evidence bearing on this point can be obtained from them, are not inconsistent with the present writer's two contentions: (1) that the normal ion is complex and not simple, and (2) that among the components are small numbers of ions of high mobility value. As it is stated that the two curves upon which Blackwood relies were the only ones obtained, it cannot be said that the amount of proof which he brings forward is very strong. He appears to consider that the failure of the present writer and Harris to detect the very mobile ions in undried air by the alternating-field method is in some way a confirmation of his present claim, i.e., that there is only one class of ion; in spite of the fact that these experiments showed the complex character of the ordinary ion, confirming the results got by the other method. As recorded already in this paper, the writer has since obtained by the alternating-field method ample evidence of the existence of the mobile ions in small quantities in ordinary undried air. Blackwood also quotes Erikson (whose work has been already referred to) in support of his views, although, if he accepts Erikson's results, he must admit the existence of two positive ions.

The general tendency of the results given in this paper is clear. A detailed discussion must be postponed until the further information is available which the author hopes to obtain from an examination of very dry and pure hydrogen. It is also hoped to obtain more accurate values for the mobilities of the faster ions described in this paper, when, as is expected, they will be brought into greater prominence by extreme drying.

Summary.

1. The composite character of ionization in air is shown by a third method.

2. An examination of the ionization in hydrogen not specially dried or purified gives results closely related to those already found for air, and in many respects identical with the results obtained by Haines for very pure and freshly prepared hydrogen.

3. Ionization in moist hydrogen is examined.

4. Criticisms of Blackwood in connexion with results obtained by the author's air-stream method are considered.

VI.

EXPERIMENTS ON LARGE IONS IN AIR.

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AND

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[Read May 14. Published July 24, 1923.]

We propose in this paper to set forth the results of some experiments on the origin, constitution, and behaviour of the large ion in air. The work described deals principally with the effect on the large ions of certain substances such as SO_2 and NH_3, with the effect of temperature, with the decay of large ions by combination with small ions, and with the occurrence of multiple charges.

Genesis of the Large Ion.

The ions dealt with in our experiments are almost exclusively those produced by ordinary Bunsen flames. Large ions may be produced in many ways, but there appears to be no doubt that whatever the manner of production, or whatever differences may appear at the beginning, the ions under similar conditions ultimately become identical. It has been well established, for example, that large ions, produced in different ways, will, under normal circumstances, ultimately attain a mobility of about $\frac{1}{3000}$ cm./sec. in a field of 1 volt /cm. For the production of large ions two things would appear to be essential. In the first place, something must be present which will serve as an original nucleus. This, in many cases, appears to be a body of a hygroscopic character, which in a moist atmosphere rapidly accumulates water and grows to a stable size. The stable water spherule thus formed is the ordinary uncharged " nucleus." The second essential to the formation of the large ion is, of course, the electric charge, which is generally supplied in the form of a " small " ion.

In the gas from a Bunsen flame both the large ions and the uncharged nuclei are present, normally about half of the total nuclei being uncharged. If, by means of an electric field, the ions are removed from the flame-gas, the uncharged nuclei, while recombining slowly amongst themselves, will pick up charges gradually from the natural ionisation of the space in which they are confined. If supplied with small ions in large quantity, the process of charging will be more rapid, and in either case the resulting body behaves in all respects like the original ion.

In the ordinary Bunsen flame the two essentials, the nucleus-forming material and the small ions, are always present, and large ions are always found in great numbers. Aitken has shown, however, that a flame of pure hydrogen will produce no nuclei; and de Broglie[1] has shown that a flame of pure and dry hydrogen burning in a cool chamber will produce no large ions. Here it is clear that the original nucleus-forming material has been eliminated. Dr. H. Kennedy,[2] working in this laboratory, has found that an ordinary non-luminous flame fed with filtered air and coal-gas, burning in a vessel of fused quartz which had undergone long preliminary heating, produced no large ions or nuclei. Using Aitken's counter, one nucleus per c.c. of air could easily be detected, but no indications of any were found. Kennedy found that the luminous gas-flame burning in the same fashion always gave a copious supply of large ions and nuclei. Presumably the incomplete combustion of the luminous flame favours the escape of the nucleus-forming material. In the absence of the nuclei the small ions from the non-luminous flame rapidly recombine and vanish.

These experiments show the necessity for the presence of the nucleus-forming material as an essential to the formation of the large ion. It can also be shown that nuclei may be produced, originally uncharged, which, when small ions are supplied, are transformed into large ions. Thus de Broglie[3] has shown that nuclei may be produced by heating moist pumice. These nuclei could be converted into large ions when small ions were supplied by means of radium. McClelland and McHenry[4] have shown that the nuclei produced by the action of ultra-violet light on a moist gas or by the heating of glass and metal surfaces may be converted into large ions when small ions are supplied by means of uranium. The large ions thus produced appear to be identical with those produced in other ways. We have thus evidence from two sides of the conditions necessary for the formation of the large ion. Nuclei set free from a surface by heat remain uncharged in the absence of a flame or other source of ionisation. Small ions produced in a flame recombine and vanish in the absence of nuclei produced from the flame or some object in its vicinity.

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[1] de Broglie, C. R. 151, p. 67, 1910.

[2] Unpublished work.

[3] de Broglie. Ann de Chimie et de Physique, 16, 1909.

[4] McClelland and McHenry, Proc. Roy. Dublin Soc., xvi, p. 282, 1921.

The real problem then is the nature of the original kernel. This would seem to be ordinarily a particle of some hygroscopic material. In certain cases it is probable that such a particle is unnecessary. Thus in the case of large ions produced by spraying, splashing, and bubbling of water, it is probable that aggregates of water of various sizes are formed, and that those above a certain size tend to grow towards the final nuclear size. The function of the hygroscopic substance in the case of ionisation by flames, arcs, phosphorus, etc., is to produce the first stage of growth of the water spherule. Such an agent is unnecessary if stable or quasi-stable sizes can be arrived at mechanically. These views find a general support from the experiments now described.

Effect of SO_2, NH_3, and NaCl on Ion-production in Hydrogen and Coal-gas Flames.

A small flame of specially purified hydrogen was burnt inside a glass vessel. Combustion was maintained by a supply of filtered air. The gases from the flame were drawn away and fed into a stream of filtered air which was drawn at a steady rate through the electrical testing vessel. This was of the usual type, consisting of a cylinder with a central electrode connected to an electrometer. The total number of ions of one sign could be estimated by applying the saturation voltage to the outer cylinder. If necessary, measurements of mobility could be made by plotting the current-voltage graph.

With this arrangement, no large ions due to the hydrogen flame could be detected. We do not assert that none were formed; it is possible that our precautions were not rigid enough to stop the formation of ions completely. We can only say that if ions were formed they were present in such numbers that it was impossible to detect them by our methods of observation. When SO_2 was mixed with the air supply to the hydrogen flame, large ions were produced in considerable numbers. The following observations were made on one occasion :—

	Current.	
Air passing through, ...	6	Scale divisions /min.
Hydrogen flame burning, ...	6	,, ,, ,,
SO_2 supplied to flame, ...	50	,, ,, ,,
Flame extinguished, SO_2 still passing, . .	6	,, ,, ,,
Flame relighted, SO_2 still passing, ...	50	,, ,, ,,
Supply of SO_2 stopped. Current fell gradually to	6	,, ,, ,,
SO_2 passed into main air-stream, ...	6	,, ,, ,,

These tests show that SO_2 supplied at the seat of combustion supplies centres for the growth of the water-nuclei which when charged became large ions. When SO_2 is fed in at a later stage, it is ineffective. Similar experiments with ammonia showed no effect. It would appear that this substance has not the property of starting the growth of the nucleus.

Effect on Mobility.

The effects of these substances on the development of the ions can be tested by measurements of mobility. If sufficient time is allowed between the production and observation of the ions so that they may attain their final stable states, a considerable loss by recombination is incurred. It is necessary then that the ionisation should be very dense at the beginning in order that readable observations may be obtained. For measurements of this sort small flames are unsuitable.

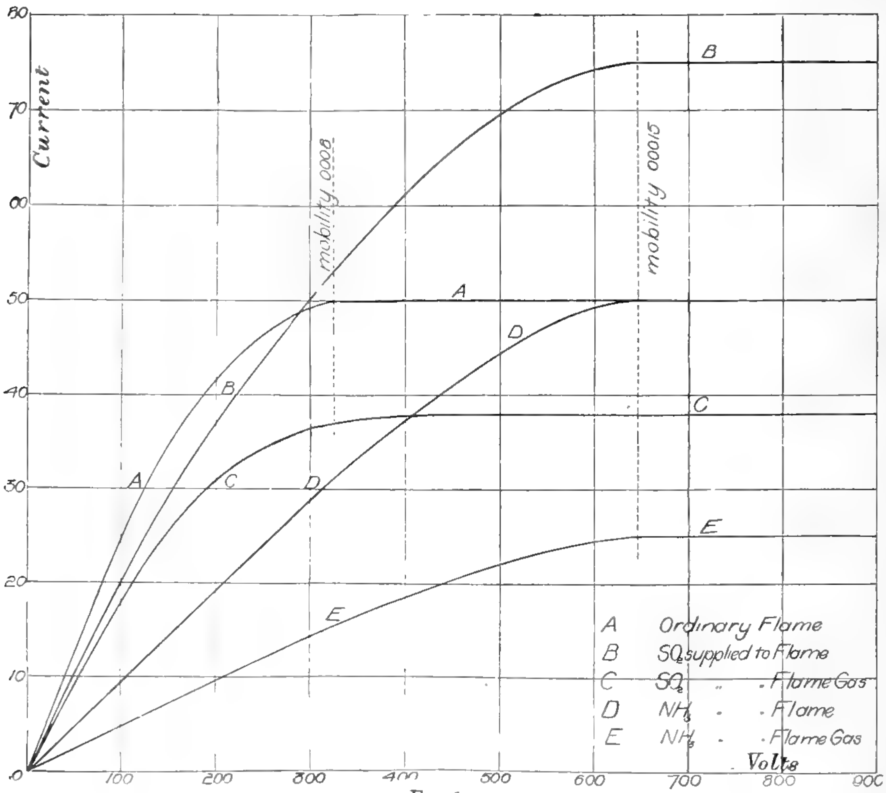

Fig 1.

We therefore used a large Bunsen flame burning inside a chimney. Through this the ordinary room air was drawn, carrying with it the ions produced by the flame. The substances to be tested could be fed in at the flame or mixed with the gas subsequently. The ionised air was drawn through a number of vessels in series, so that a considerable time elapsed before it reached the testing vessel. The effects produced by SO_2 and NH_3 are shown in the graphs of fig. 1. The graph A is the current-voltage graph obtained from an ordinary Bunsen flame. The saturation value of the current is attained at a voltage corresponding to a mobility of ·00033. The curve is convex upwards, indicating the presence of ions of higher mobilities. It has been well established that various discrete groups of ions are generally present.[1] These groups have been investigated in the ionisation produced by spraying, bubbling, oxidation of phosphorus, etc. Corresponding results with the flame ions have been obtained by Dr. H. Kennedy in this laboratory. He found that the ion of mobility *circa* ·0012 was usually present in the flame-gas along with the well-known ion of mobility ·00033. Similar results for flame-gas have been found by Lauster.[2] To show up the groups separately it is necessary to take a great number of close-lying readings of current and voltage. As we are not specially interested in showing up the groups in this work, we have taken more widely spaced observations, and have drawn the general outlines of the curves without attempting to show details.

Curve B shows the effect of supplying SO_2 plentifully to the flame. The number of ions is increased very considerably, and there is also a decided change in the mobility. The bulk of the ions now have a mobility of about ·00016, about half the normal value. The effect of mixing SO_2 with the products of combustion at a short distance from the flame is shown by curve C. The most marked effect is a considerable reduction in the number of ions. There is also a change in mobility, some of the ions now having a mobility lower than the normal value.

Curves D and E show the effect of ammonia. This gas when applied at the seat of combustion has no effect on the number of ions, but when present in sufficient quantity it changes the mobility from ·00033 to ·00016 in the same fashion as SO_2. The curves obtained for smaller admixtures of ammonia lie between A and D, and seem to indicate a mixture of the two ions just mentioned. When ammonia is mixed with the products of combustion (Curve E) it produces a considerable reduction in the number of ions and also reduces the mobility to half.

From these curves certain conclusions can be drawn. Ammonia, as already found in the case of the hydrogen flame, cannot act as a starting-point for nucleation. Sulphur dioxide and ammonia, if supplied to the flame or subsequently to the flame-gas, cause the ions to grow beyond their normal size. The transition in size is not gradual but abrupt. When the alteration is

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[1] P. J. Nolan, Physical Review, Sept., 1921.
[2] Lauster, Zeit für Physik, 3, 5, p. 396, 1920.

produced by the action of the gases on the ions already formed, there is a reduction in the number of ions. From curve D it would appear that when the alteration is produced by a substance injected into the flame there is no change in the number of ions. When NH_3 or SO_2 are present, it would appear that the stable size of the ion regarded as a compact sphere is three times the normal. For if the mobility varies inversely as the square of the radius, ions having masses in the ratio of 3 : 1 will have mobilities in the ratio $1 : 3^{\frac{2}{3}} = 1 : 2{\cdot}08$, which is roughly the ratio we have found. If, on the other hand, the ion be regarded as a loose grouping, it is probable that the slower ion is formed from two of the ordinary size. When the NH_3 and SO_2 reach the ions after formation and in a region where the supply of

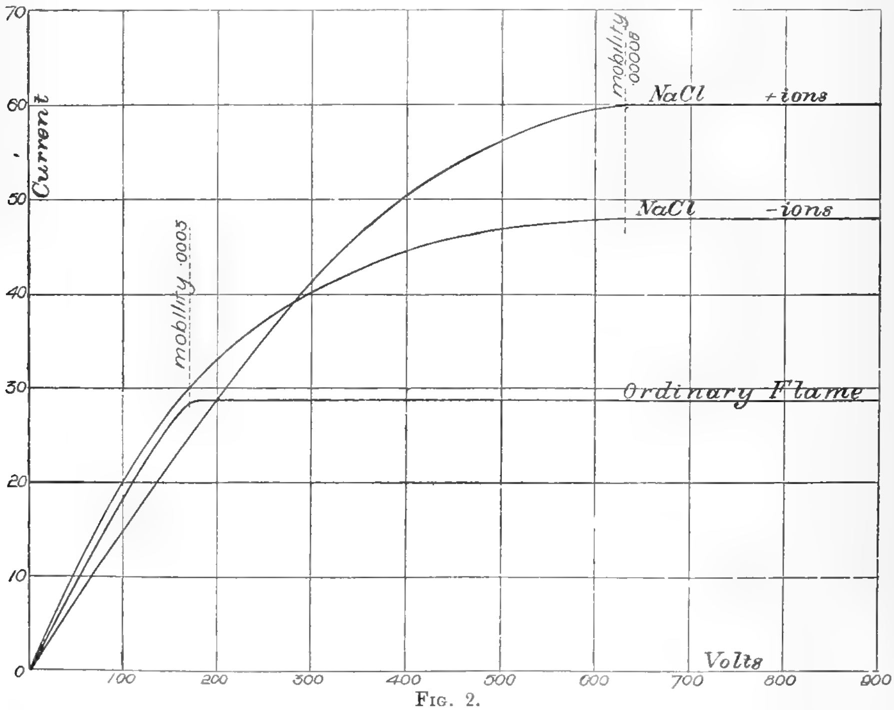

Fig. 2.

water-vapour is not so great as in the immediate vicinity of the flame, it is possible that the new stable size is attained largely by the formation of groupings among the ions themselves and the uncharged nuclei which accompany them. This would account for the reduction in the number of ions which we have noted.

Effect of NaCl.

The effect of adding NaCl to the flame is shown in fig. 2. The observations were taken with an air-current of half the velocity used previously. This was necessary in order that saturation might be attained with the available voltages. The number of ions is increased, the increase being greater in the case of the positive ions. Saturation is attained with a voltage approximately four times that sufficient to saturate the ordinary ions, thus indicating the existence of ions of mobility about ·00008. In addition to the difference in quantity, there is a difference in the character of the positive and negative ionisation, the negative containing the greater proportion of ions of higher mobility. Whether the increase in the ionisation is due to the NaCl supplying extra nuclei or extra ions to the flame is not clear, but the unsymmetric character of the increase suggests the latter alternative. The stable nuclear size has undergone a further increase. The action of NaCl in this respect is not, however, as remarkable as that of phosphorus, as in the ionisation from phosphorus McClelland and P. J. Nolan[1] found separate groups of ions not only of mobilities ·00031, ·00015, and ·000085, but as low as ·000053.

Effect of Variation of Temperature on Large Ions.

Since McClelland's original experiments it has been known that the mobility of the ions produced in a flame diminishes very rapidly as the gas is removed from the flame. We have seen that if sufficient time is allowed, the bulk of the ions normally attain a mobility of about ·00033, but that some other groups are generally present. If this be regarded as the equilibrium size peculiar to normal temperatures, it is important to know how the equilibrium size varies when the temperature is varied. There are two ways of approaching this experimentally. We could measure the mobilities of the ions coming immediately from the flame at different temperatures, without allowing any cooling. On the other hand, we could allow the flame-gas to cool so that the ions attain their normal size, and then measure their mobility when the gas is heated. We tried the latter method in the first instance. The gas was drawn off from the flame and kept for a sufficient time so that almost all the ions had reached the ·00033 mobility. The gas was then passed through the testing apparatus, which was heated to a steady known temperature. The heating was produced electrically, and the heating coils surrounded not only the measuring vessel but the tube leading up to it for a distance of one metre. The temperature was measured by two independent platinum-iron thermo-couples of small heat capacity. The heating coils were wound in sections, and by controlling the current it could easily be arranged that both thermo-couples indicated the same steady value of the temperature over a long interval without a fluctuation of more than 1° C.

[1] McClelland and P. J. Nolan, Proc. Roy. Irish Acad., vol. xxxv, A, p. 1, 1919.

As the mean velocity of the air through the tubing was 35 cm secs., it will be seen that the ions were exposed to the temperature for nearly three seconds before they came under observation.

Even if the constitution and dimensions of the ion are unchanged by heating, its mobility in the hot gas will be increased. This is due to two causes: the change in density of the gas and the change in the velocity of thermal agitation of the ion. Since in these experiments the velocity of the air-stream is measured by the displacement of *cool* gas, the first of these changes is automatically allowed for. If the ion retains its constitution, we should expect that owing to the second cause its mobility should increase proportionately to the square root of the absolute temperature.

Before dealing with the measurements of mobility at different temperatures we give the results of an experiment made with a steady supply of ions passing into the apparatus, the temperature being gradually raised. The following were the values of the current to the central terminal, a saturation voltage being applied. They are thus a measure of the number of ions coming into the measuring apparatus.

Temperature.	Current.
8° C.	120
50° C.	120
81° C.	120
105° C.	119
128° C.	112
147° C.	100
168° C.	86
194° C.	64

The reduction in the number of ions at high temperatures is due to the increased recombination of ions which have had their mobility increased. As we shall see, this increase in mobility is so marked that it must be attributed to a radical change in the ion itself. It is noteworthy that the increased recombination does not set in until the temperature has gone above 100° C.

In fig. 3 are shown the current-voltage graphs plotted for various temperatures between 17° C. and 167° C. There is not much difference between the curves for 17° C., 55° C., and 100° C. The number of ions is unaltered in agreement with the results given in the table above. Each curve shows saturation at very nearly the same point corresponding to the ordinary ion of mobility ·00033. The increasing convexity of the curves as the temperature increases shows that a certain number of the more mobile ions are appearing. The small shift in the saturation voltage between 17° C. and

100° C. might well be such as would make the mobility vary as the square root of the absolute temperature; but our observations are not accurate enough to decide.

The curve for 125° C. shows that a more serious change has set in. The number of ions is reduced, and saturation is now obtained at a voltage corresponding to an ion of mobility ·00066. The shape of the curve shows that a considerable number of more mobile ions are present. At 140° C. the ion of mobility ·00066 is still present, but the more mobile ions have

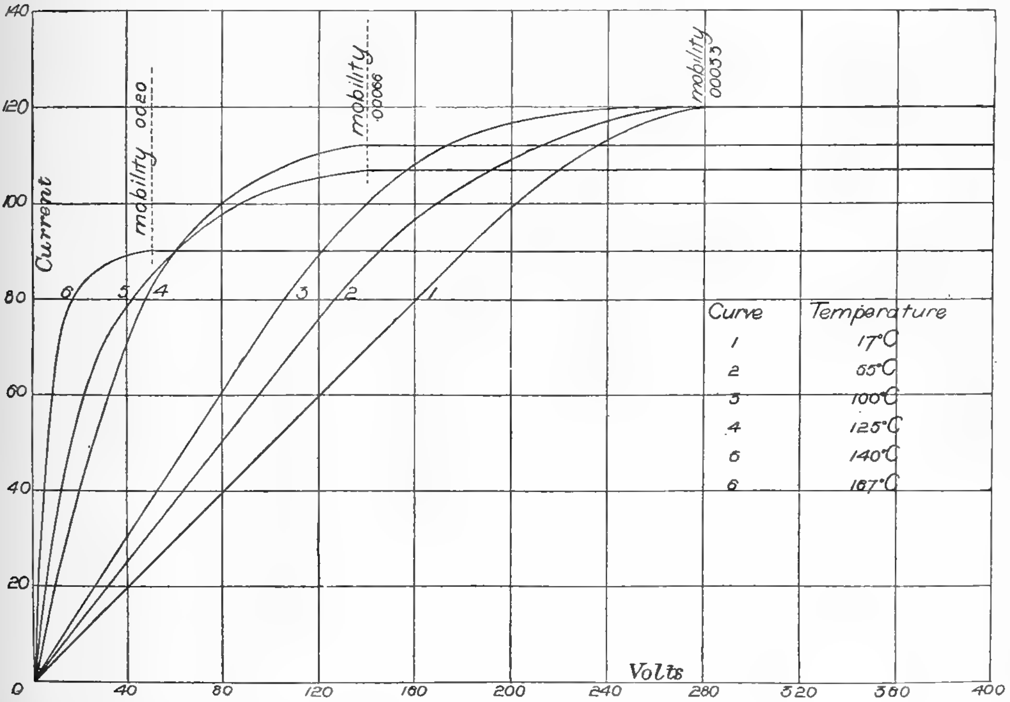

FIG. 3.

increased in number, while at 167° C. the slowest ion present has a mobility of ·0020. It is evident that at temperatures above 100° C. the ion breaks down. The new forms which appear seem to be identical, when allowance is made for the change of temperature, with the ions of mobility ·00063 and ·0014 obtained from alcohol and ·00064 and ·0012 obtained from phosphorus by McClelland and P. J. Nolan.[1]

The fact that the disintegration of the ions begins about 100° C. seems at first sight to be connected with the boiling-point of water. While there is hardly any doubt that the ions are composed of water, it is difficult to see

[1] McClelland and P. J. Nolan, Proc. Roy. Irish Acad., vol. xxxiv, A, 1918, and vol. xxxv, A, 1919.

why they should be specially affected at the temperature at which water boils under normal pressure. The results obtained by Lauster[1] are of interest in this connexion. Lauster investigated the effect of temperature by removing the ions in an air-stream previously heated. He determined the mobilities in close proximity to the flame. Under these circumstances the mobility of the ions without any special heating varied from about ·1 to about ·02, the value found increasing with the rapidity of the air-stream. When the temperature is increased the mobility remains constant up to a certain point, and then a rapid increase sets in. The critical temperature is about 45° C. for the ion of mobility ·1, and seems to increase to about 50° C. for the ion of mobility *circa* ·2. Lauster regards the rapid increase of mobility at the critical temperature as indicating the disintegration of the ionic complex. As the critical temperature increases with the size of the ion it is possible that the temperatures determined by him correspond to our value 100° C. for the large ion.

A number of experiments were carried out in which the gas from the flame was conveyed to the measuring vessel without being allowed to cool. The following values for the mobilities were obtained:—

Temperature.	Mobility.
50° C.	·00088
80° C.	.0040
120° C.	·0082
165° C.	·018

All those values are higher than those found at similar temperatures by the other method. It is clear that in this case the ions have not attained a stable condition. The equilibrium sizes peculiar to each temperature are probably closer to the values given by the graphs of fig. 3 than they are to the values found with the uncooled gas.

Experiments on the effect of temperature have also been carried out by Dr. H. Kennedy with a different apparatus. His results on the effects of heating up ions which had been allowed to grow to their stable condition, while not so complete as those given above, are in general agreement. From a great number of observations carried out by him at different temperatures when the ions came directly from the flame it would appear that the size of the ions depends not so much on the temperature as on the time, size of the flame, and other conditions. Generally there was present a mixture of ions of two classes. The mobilities were higher than those found by us.

[1] Lauster, *loc. cit.*

The view has been put forward that the large ion is a cluster,[1] each ion being formed by a grouping together of those of the next smaller class. On this view the effect of heat is to break up the ions into smaller units, just as the effect of adding certain substances is to cause the ions to form more complex aggregations.

Recombination of Large Ions with one another and with Small Ions.

Large ions disappear by recombination with one another and with small ions, if the latter are present. Kennedy has found[2] that the nuclei which form the large ions disappear at the same rate whether they are charged or uncharged. Where n is the number of nuclei per c.c. the rate of disappearance obeys the law $\frac{dn}{dt} = -\gamma n^2$ over a considerable range. The value of the constant γ determined by Kennedy is 14×10^{-10}. Kennedy also measured the rate of decay of charge. Expressing it as the rate of decay of electronic charges of one sign per c.c., he determined the decay constant β. He showed that if x is the number of electronic charges per ion, $\beta x = 2\gamma$.

The value of β is variable, as the charge per ion is variable. One value found for β was $6{\cdot}3 \times 10^{-10}$. This gives for the electronic charge per ion the value 4·5. By direct experiments Kennedy showed that the large ion can have from one to six electronic charges, the higher charges tending to appear when the air is drawn away rapidly from the flame.

The collision frequency of the ions is $\frac{n^2\sigma^2\pi u}{\sqrt{2}}$, where n is the number per c.c., σ the diameter of the ions, and u their mean velocity of agitation. It has been shown[3] that if the ion of mobility ·00033 be regarded as a compact sphere of water carrying one electronic charge, its radius is 4.1×10^{-6} cms. Of the assumptions made here, the first is the most serious, as both from the fact that de Broglie found that large ions could not be seen in the ultramicroscope,[4] and from our own experiments on the effects of temperature and of such substances as SO_2, we would prefer to regard the large ion as a loose cluster. Using this value, however, as a basis for calculation, and writing M_1 and u_1 for the mass and average velocity of the hydrogen molecule, we find that the recombination coefficient

$$\gamma = \frac{\pi(8{\cdot}2 \times 10^{-6})^2}{\sqrt{2}}\, u_1 \sqrt{\frac{M_1}{\frac{4}{3}\pi(4{\cdot}1 \times 10^{-6})^3}} = 28{\cdot}6 \times 10^{-10}.$$

[1] J. J. Nolan, Proc. Roy. Soc., vol. xciv, p. 112, 1918.
[2] Kennedy, Proc. Roy. Irish Acad., vol. xxxiii, A, 1916.
[3] J. J. Nolan, Proc. Roy. Soc., xciv, p. 112, 1919.
[4] de Broglie, C. R., vol. clxviii, p. 1317, 1909.

This is just twice the value found by Kennedy, and would imply that only half of the total collisions result in coalescence. If the ion be regarded as a loose cluster, the value of γ will be greater, and coalescence must be assumed to occur at a still smaller proportion of the collisions. We may note that the fact that the law $\frac{dn}{dt} = - \gamma n^2$ holds over a considerable range shows that when two nuclei coalesce the body formed rapidly assumes the size peculiar to the original nuclei. We may easily imagine two spheres of water uniting to form a sphere which rapidly evaporates to the stable size. But the conditions of stability of an ion consisting of a loose cluster are not easily imagined, and it would seem as if combination between such bodies must result in the accumulation of still greater complexes, so that the rate of recombination should progressively increase.

Combination with Small Ions.

The interaction between nuclei, large ions, and small ions is of considerable importance in connexion with atmospheric electricity. We have seen earlier in this paper that nuclei are produced by the action of ultra-violet light on moist air, and that in the presence of small ions the nuclei pick up charges, and are converted into large ions. There is hardly any doubt that this process is going on very actively in the higher layers of the atmosphere. It is possible that the bulk of the nuclei of condensation are formed in this way. Where large ions, nuclei, and small ions are present, the equilibrium concentration of each will depend upon their rate of combination with one another, as well as upon the rate of internal recombination peculiar to each.

The fact that large ions with six electronic charges can be formed, and can persist in sufficient numbers to be easily observed, shows quite clearly that the sign and magnitude of the charge already present have not much influence on the collisions and unions between large ions and small ions. This enables us to simplify the treatment of this point very considerably, for while recognizing that the chance of union of, say, a negative small ion with a positive large ion of five charges is greater than its chance of union with an ion of five negative charges, we shall not be far wrong in working on the basis of a uniform rate of combination between small ions and nuclei of all sorts. The recognition of the fact that the charge in the nucleus has not very much influence in the collisions helps us to another estimate of the size of the ions. Townsend[1] has shown that the number of ions coming in contact with a spherical conductor is appreciably influenced by a charge on the

[1] Townsend, Electricity in Gases, pp. 214-16.

conductor when the radius of the sphere is 10^{-5} cms. With increasing radius the effect of the charge diminishes. This line of reasoning would indicate that the radius of the large ion was distinctly greater than 10^{-5} cms.

Experimental Investigation.

We have investigated this type of combination experimentally by measuring the rate of disappearance of small ions in the presence of a mixture of large ions and nuclei. A diagram of the apparatus is given in fig. 4. A steady stream of air carrying large ions, which have been brought to their stable condition, passes through the chamber B, where it is exposed to a thin pencil of X-rays. The gas before entering the chamber passes through the tube A, and after leaving passes through C and D in succession. A and D are identical, being each fitted with a central insulated electrode 50 cms. long. Voltages up to 800 volts can be applied to each tube, so that the gas passing through can be completely freed from large ions, or if the central electrode is

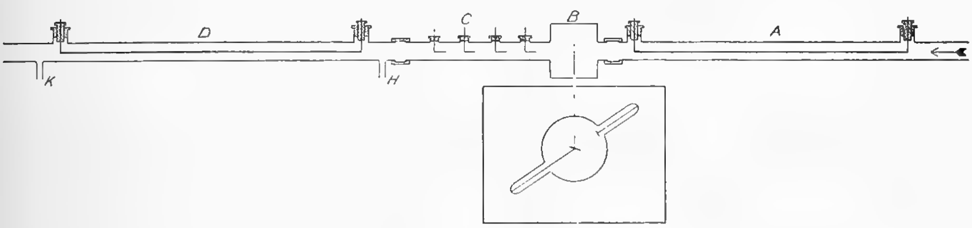

FIG. 4.

connected to the electrometer, measurements of the total charge can be made. The tube C is fitted with four short insulated electrodes to serve for the capture of the small ions at different times after they have been produced by the X-rays. The voltage on this tube and the lengths of the terminals are so adjusted that when each in turn is connected to the electrometer (the others being connected to the outer tube), all the small ions arriving at that particular terminal are captured. The number of large ions drawn in at the same time is not detectable. At H and K side tubes are provided by means of which samples of the gas can be drawn off and examined for nuclei by Aitken's counter.

It is important in work of this kind that a very steady source of large ions should be available. A diagram is given (fig. 5) of an arrangement which proved very satisfactory in this respect. The flame burns inside a large glass bell-jar sealed on to an iron plate. Through the plate passes a tube fitted with a small platinum nozzle. Filtered coal-gas is supplied through this tube and burns at the nozzle. Filtered air is passed in at a steady rate from a gasometer. The flame can be ignited without opening up the apparatus, by heating the platinum spiral **X** to incandescence by the current from a few cells with the gas turned on. The gas pressure is then slowly reduced until the flame is about 4 or 5 mm. high. It may be noted that the flame burning in this way does not heat the wire **X** to even a dull red heat, so that there is no question of the wire acting as a source of ions. The air carrying the large ions and nuclei passes through the water-jacket R, and then through the larger vessel S, which has a layer of a few centimetres of water at the bottom. The rate of flow of the air and the volume of S are so chosen that the ions passing out of S and into the other part of the apparatus have attained their stable states.

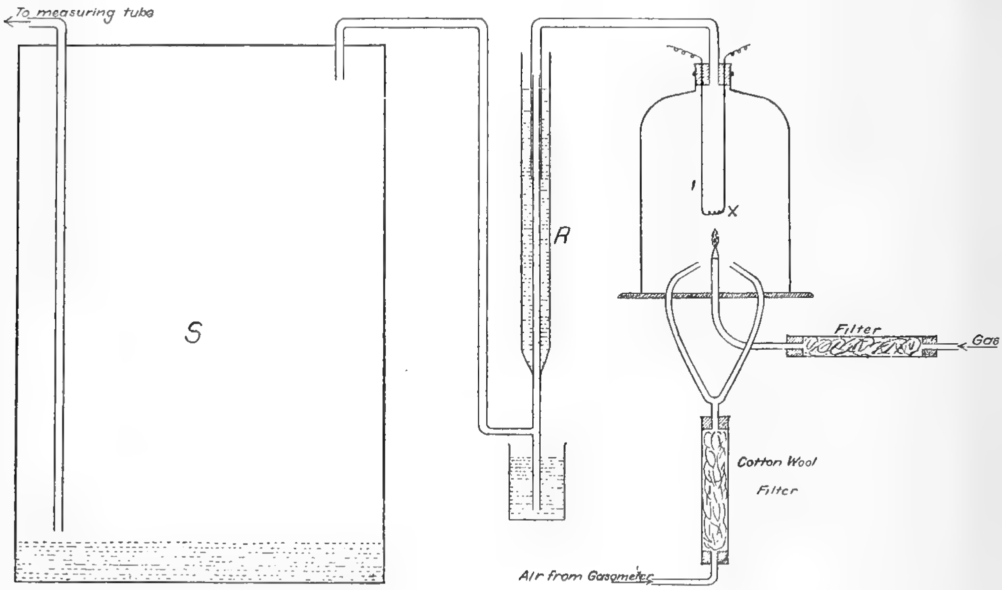

Fig. 5.

In order to test the apparatus we made a determination of the coefficient of recombination of small ions, nuclei of all sorts being absent. With no flame burning, filtered air was passed through. Samples of air were drawn off and tested by Aitken's apparatus. When the air was absolutely free from nuclei, the X-rays were turned on and the currents measured at each of the terminals in C. Since the rate of flow of air is known, the time interval corresponding to the passage of the air from one terminal to the next is known. Experiments were carried out with different rates of flow. In this and in subsequent experiments the zero of time is taken as the instant when the gas passes a point 10 cms. in front of the first terminal. Plotting $\frac{1}{N}$ against time, we attained, as usual, a straight line, N being the number of small ions per c.c. From the slope of the line the recombination coefficient a was calculated. The value found was $1{\cdot}610 \times 10^{-6}$, the electronic charge being taken as $4{\cdot}77 \times 10^{-10}$ E.S.U. This agrees well with M'Clung's value $1{\cdot}614 \times 10^{-6}$, and Townsend's value $1{\cdot}631 \times 10^{-6}$, and shows that the method can be relied on to determine the rate of disappearance of small ions accurately.

Decay of Small Ions in presence of Large Ions.

Two methods were adopted in making these experiments. In our first set of observations, gas containing nuclei only was exposed to the X-rays; in the second, the ordinary flame-gas was used. We have already shown reason to believe that charged and uncharged nuclei should not differ much in their rate of combination with small ions; but, apart from that, as later experiments will show, the distribution of charges among nuclei which have been exposed to X-rays will be very much the same after one or two seconds, whether the nuclei were originally partially charged or not. One would expect, therefore, that the two methods should give the same results. Observations show that the rate of decay is faster when the small ions are mixed with the natural flame-gas; but the difference is perhaps not very great, considering the difficulties and uncertainties of experiments of this class.

In the first experiments, when the air-stream carrying the flame-gas had been running for some time, and when tests had shown that conditions were steady, a potential difference of 800 volts was established in condenser A, so that uncharged nuclei alone came through. The number of nuclei per c.c. of gas was determined by Aitken's counter. The X-ray tube was turned on, and the number of small ions driven in at each of the terminals in C was ascertained. Fig. 6 A shows a decay curve obtained in this way. Now, if N is the concentration of small ions of one sign

$$\frac{dN}{dt} = aN^2 + \eta N n_0,$$

where n_0 is the concentration of nuclei (including large ions of both signs), and η is the recombination constant for small ions and nuclei

$$\therefore \eta = \frac{\dfrac{dN}{dt} - aN^2}{N n_0}$$

$\frac{dN}{dt}$ can be found from the slope of the curve, the other quantities are known, hence the value of η can be determined.

In the set of experiments in which curve A was obtained the number of nuclei per c.c. was $22{\cdot}6 \times 10^3$. In the following table four determinations of η based upon the decay curve are given:—

N	$\frac{dN}{dt}$	aN^2	$\frac{dN}{dt} - aN^2$	$\eta = \frac{\frac{dN}{dt} - aN^2}{Nn_0}$
150×10^3	75×10^3	$36{\cdot}4 \times 10^3$	$38{\cdot}6 \times 10^3$	$11{\cdot}5 \times 10^{-6}$
200	108	65	43	9·5
300	217	145	72	10·6
400	348	258	90	10·0

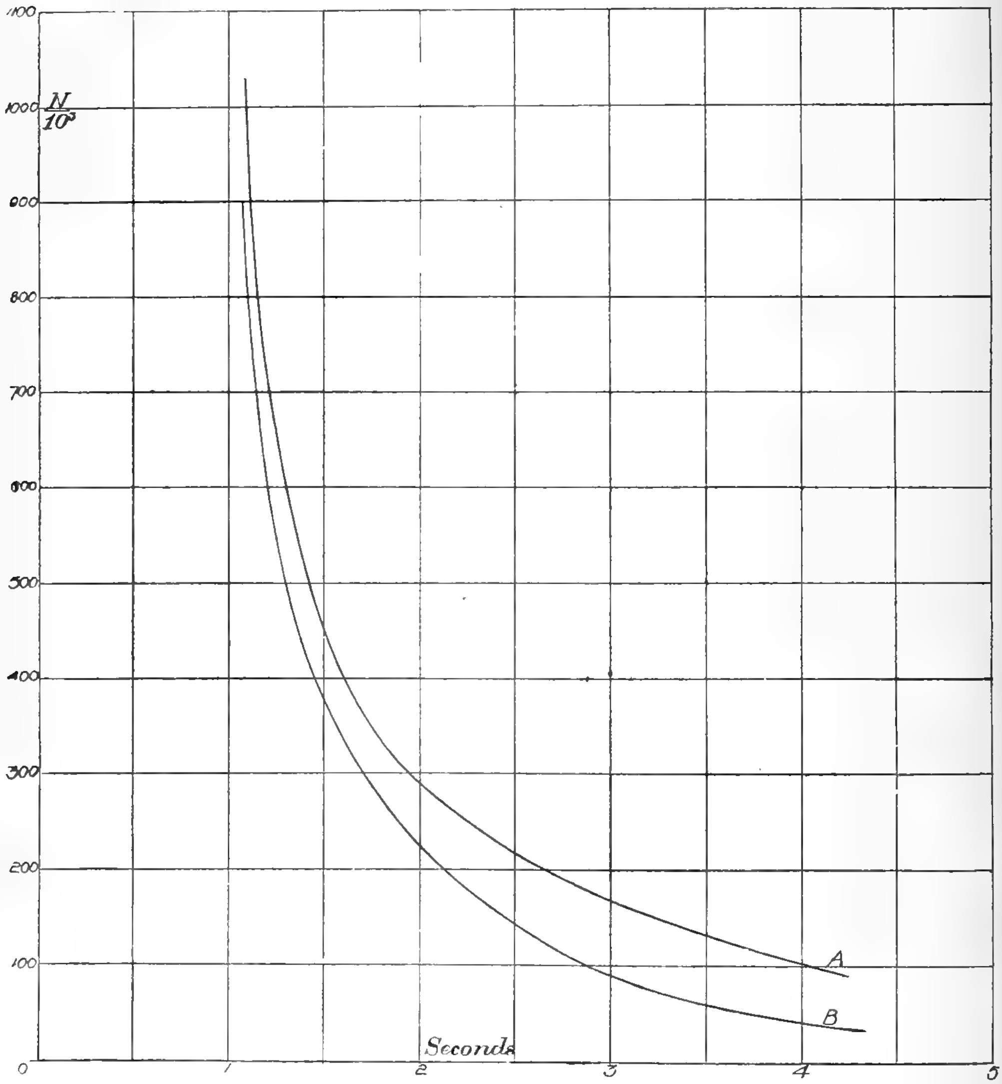

Fig. 6.

These figures show that over a considerable range the recombination coefficient has a fairly constant value of about 10×10^{-6}. If, however, the early part of the curve is included, the values of η are no longer constant, but tend to increase to a value about 40×10^{-6}. This is a feature of all curves obtained, and suggests that on their first entry into the tube C the nuclei have not steadied down to the normal and stable distribution of charge which the latter part of the curve seems to indicate.

Curve B, fig. 6, was obtained when the ordinary mixture of ions and uncharged nuclei as produced by the flame was exposed to the X-rays. In this case there were present $22 \cdot 6 \times 10^3$ uncharged nuclei per c.c., as before, and, in addition, 16×10^3 ions, making $38 \cdot 6 \times 10^3$ nuclei per c.c. in all. The following table shows five determinations of η made from curve B.

N	$\frac{dN}{dt}$	αN^2	$\frac{dN}{dt} - \alpha N^2$	$\eta = \frac{\frac{dN}{dt} - \alpha N^2}{N n_0}$
50×10^3	32×10^3	4×10^3	28×10^3	$14 \cdot 5 \times 10^{-6}$
100	88	16	72	18·6
200	185	65	120	15·5
300	297	145	152	13·1
400	516	258	258	16·7

The values of η are on the average about 50 per cent. higher than those found previously, and they are not nearly so constant. In this case also the value of η, if calculated from the first part of the decay curve, comes out very high, the value of the maximum reading being about the same as that found in the other case, i.e. 40×10^{-6}.

It is not quite clear why the two methods should yield results differing by 50 per cent. It must not be forgotten, however, that we are treating in a very simple form a process which is no doubt very complex. We have many kinds of ion in addition to the uncharged nuclei. These are present in unknown proportions; each has its characteristic combination coefficient with small ions of one sign and the other. It is possible that in the second experiment a greater proportion of the nuclei were charged during the time when the recombination was under observation, and that the effect of this on the whole was a more rapid disappearance of the small ions. We could probably, without serious error, fix the recombination coefficient between small ions and nuclei between the limits 5 and 20×10^{-6}, the lower value being characteristic of the uncharged nuclei and the higher values of the ions with various charges. In the case of large ions occurring naturally, narrower limits could be fixed, as highly charged ions are unlikely. As far as phenomena of the atmosphere are concerned, the recombination coefficient probably lies between 5 and 10×10^{-6}, and probably closer to the lower than to the higher figure.

The collision frequency between small ions and uncharged nuclei of radius a, present in concentrations N and n_0, is $\pi a^2 N n_0 u$, where u is the velocity of agitation of the small ion. The coefficient of combination is therefore $\pi a^2 u$. If for the coefficient the value 5×10^{-6} is taken, we have for the radius of the nucleus

$$a = \sqrt{\frac{5 \times 10^{-6}}{3 \cdot 14 \times 1 \cdot 5 \times 10^4}} = 1 \cdot 03 \times 10^{-5} \text{ cms.}$$

Thus again we find that the experimental results force us to regard the nuclei and large ions as, if anything, greater than 1×10^{-5} cms. in radius. From the point of view of the loose grouping theory of the large ion, this itself does not offer any difficulty. In fact, it is to be expected that the volume occupied by the loose group should be large in comparison with its mass. There remains the difficulty of the recombination rate of the nuclei among themselves. If this value for the radius of the nucleus be accepted, we have to assume, as our previous calculations show, that only a small fraction of the collisions between nuclei result in coalescence. There is also the difficulty, previously mentioned, as to the disposal of the products of recombination.

The Charge on the Large Ion.

All arguments as to the size of the large ion founded on mobility results are complicated by the question of multiple charges on the ions. Charges vary from one to six electrons under different conditions, but no corresponding variations in mobility are easily made apparent. What we are accustomed to regard as the standard mobility (·00033) is nearly always found, and there is often associated with it an ion of mobility about three times this value. Such other variations from the standard mobility as are found, for example, in the experiments with SO_2, NH_3, and Na Cl, or in the heating experiments, cannot be associated with variation in charge.

As the apparatus which we have used for the recombination observations is very suitable for the determination of the charge on the ions, we have carried out some experiments on this point. The gas containing the ions is passed through the apparatus at a uniform rate until everything has become steady. The total number of nuclei per c.c. is then found by means of the Aitken apparatus. A field of 800 volts is applied to A so that all the ions are removed. The Aitken apparatus then gives the number of uncharged nuclei per c.c. If the electrometer is connected to the central electrode at A, the total number of electronic charges of one sign per c.c. of gas can be determined, and, therefore, the mean charge per ion. The following table gives the results of some observations on the ordinary flame-gas:—

Total nuclei per c.c. n	Uncharged nuclei per c.c. n_1	Ions of one sign per c.c. $\frac{n-n_1}{2}$	Electronic charges per c.c. ν	Electronic charges per ion x
$38{\cdot}6 \times 10^3$	$22{\cdot}6 \times 10^3$	8×10^3	$25{\cdot}4 \times 10^3$	3·2
70·5	34·5	18·0	53·5	3·0
84·0	41·0	21·5	61·7	2·9
325	192	66·5	171	2·6
230	105	62·5	214	3·4
225	133	46	116	2·5
391	213	89	289	3·2
500	229	135	344	2·6
567	317	125	360	2·9

It will be seen that usually about half of the nuclei are charged, and that the average charge per ion is three electrons. That this condition is quickly arrived at is seen from the following observations, which refer to air completely freed from ions and exposed to the X-rays:—

n	n_1	$\frac{n-n_1}{2}$	ν	x
240	117	62·5	182	2·9
256	144	56·0	185	3·3
532	245	143·5	381	2·7
322	190	66·0	174	2·6
370	290	40·0	137	3·4

In the last two observations the ions were removed by applying a field close up to the flame.

We tested the effect of weakening the ionisation by interposing sheets of tinfoil in the path of the X-rays. The following observations correspond to successive diminutions in the intensity of the ionisation:—

n	n_1	$\frac{n-n_1}{2}$	ν	x
190×10^3	112×10^3	39×10^3	81×10^3	2·1
130	60	35	61	1·7
130	58	36	39	1·1
132	110	11·0	very small	—
132	120	6·0	” ”	—

At first the effect is to lower the charge per ion. The half-and-half distribution of the nuclei between charged and uncharged persists up to the point where there is no longer available a charge apiece for half of the nuclei. Further reduction in the ionisation leads to a reduction in the number charged.

These results enable us to conclude with some certainty that the large ion in the atmosphere carries a single electronic charge. The bulk of the large atmospheric ions in regions free from contamination are probably, as we have previously suggested, due to the action of ultra-violet light on moist air. They gain their charge from the weak natural ionisation of the atmosphere, and, therefore, in view of the results given above, carry probably only a single charge. But it may be said that we have no evidence that the greater part of the atmospheric ions at low levels are not due to flames and such sources which, as we have seen, tend to produce trebly charged ions. Our results show that a connexion exists between the charge per ion and the distribution of the nuclei between charged and uncharged of such a kind that if the uncharged are strongly in excess no multiple charges are likely to exist. There are no direct observations available, as far as we know, of the number of nuclei and large ions in the atmosphere at any one time, but values of the order of 20,000 to 30,000 electronic charges per c.c. are obtained for large ions in localities where the observations of Aitken and Barus would suggest the presence of nuclei in concentrations greater than 50,000. Again, McClelland and Kennedy give a curve[1] showing the production of large ions (by reaction between the nuclei and small ions due to the natural ionisation) in atmospheric air freed from its large ions. In four hours over 80 per cent. of the original ionisation was reproduced. Seeing that decay had been going on during this time, it is clear that the large ions must have been considerably less than half of the total nuclei originally present. On these grounds, therefore, in view of the results given above, we conclude that it is most unlikely that atmospheric ions carry other than single electronic charges.

There is another way in which we may test our results in application to ionisation in the atmosphere. When equilibrium is reached the following relation should hold:—

$$q = \alpha N^2 + \eta N n.$$

Where q is the number of small ions of one sign produced per second, N is the concentration of small ions of one sign and n the concentration of nuclei of all kinds. When N is small the first term on the right is negligible, and, therefore, $q = \eta N n$. We have no simultaneous observations of N and n, but we have the observations of M'Clelland and Kennedy on small ions and

[1] McClelland and Kennedy, Proc. Roy. Irish Acad., vol. xxx, A, 1912.

large ions. We may write the equation $q = \eta N k n_1$, where n_1 is the number of large ions and k the ratio of the total to the charged nuclei. The product Nn_1 should be constant while k is constant. We have examined the results of M'Clelland and Kennedy on occasions when the concentration of small ions was small, and we find that the constancy of the product holds fairly well in almost all cases. We find a group of observations, taken on quite different days, where N is about 70 and n_1 about 20,000. Another group of observations gives $N = 40$ and $n_1 = 32{,}000$ roughly. In this we assume that the large ions carry single charges. If we take Nn_1 as 1,350,000 and for η assume the value 5×10^{-6} we have

$$\begin{aligned} q &= 5 \times 1{\cdot}35\,k \\ &= 6{\cdot}75\,k. \end{aligned}$$

The value of q is not likely to be as high as 13·5, so that if half the nuclei are charged, that is $k = 2$, it would seem that we have overestimated the value of η. If our value of η is correct, and if q is of the order 5 – 10, then either k is less than 2, or the ions must carry more than one charge. Simultaneous observations of the small ions, large ions, and nuclei of the atmosphere are necessary for the clearing up of this and other difficulties.

Charge and Mobility.

As there is good agreement among all observers that the mobility of the atmospheric ion is under normal conditions about ·00033, there can hardly be any doubt that this is the correct value for the singly charged ion. While this ion is always present, the ions of two, three, etc., times this value corresponding to the different multiple charges do not show up clearly. The various mobilities, ·00033, ·0013, ·0023, ·0040, etc., worked out especially by McClelland and P. J. Nolan,[1] seem to correspond to different sizes (as the heating experiments show) rather than to different charges. It is possible that the ion of mobility about ·001, which frequently appears, corresponds to the ordinary ion with three charges. But it does not ever seem to be present in sufficient quantity to agree with the preponderance of trebly charged ions in flame-gas which our results indicate.

This difficulty has been discussed in a previous paper.[2] It was there suggested that if two or three ions of the same size come together to form a loose group, the resistance to motion of the group might well be increased in the same proportion as the charge, so that the mobility might remain unaffected. Many difficulties arise in the application of this idea to special

[1] McClelland and P. J. Nolan, *loc. cit.*

[2] J. J. Nolan, Proc. Roy Soc., vol. xciv, p. 112, 1918.

cases; but we are unable at present, in the absence of further information from the experimental side, to go any further in the direction of correlating the observed values of mobilities and charges.

General Conclusions.

The idea of the large ion as a rather loose group, originally suggested by de Broglie and adopted[1] to explain certain mobilities observed, is practically forced on us by our observations of recombination between large ions and small ions. The units out of which we have supposed the ions to be built, the various homogeneous groups of ions which in so many cases accompany the final more stable body, reappear when the ion breaks up under the action of high temperature. The further complex stages observed in the case of phosphorus ionisation appear when the ions are affected by the presence of sulphur dioxide, ammonia, or sodium chloride.

The large ions present in the atmosphere are possibly in great part produced by the action of ultra-violet light on the moist gas. They carry single electronic charges, and their constant of combination with small ions is between 5 and 10×10^{-6}.

The greater part of the experimental work described in this paper was carried out between the years 1916 and 1919 under the direction of the late Professor McClelland. We wish to express our indebtedness also to Dr. H. Kennedy, who has permitted us to make free use of his unpublished work.

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[1] J. J. Nolan, Proc. Roy. Soc., A, vol. xciv, p. 112, 1918.

VII.

SOLUTIONS OF SYSTEMS OF ORDINARY LINEAR DIFFERENTIAL EQUATIONS BY CONTOUR INTEGRALS.

By PROFESSOR W. M'F. ORR, D.Sc., F.R.S.

[Read April 23. Published July 28, 1923.]

In a paper on Extensions of Fourier's Theorem,[1] etc., I have virtually used, incidentally, the solutions given below. They may be said to differ only in notation from those given by Routh.[2]

The usual forms of solution may, of course, be obtained by replacing the contour integrals by sums of residues.

It is not easy to show rigorously what is the most general solution of a system of simultaneous differential equations, (linear, and with constant coefficients). The treatment of this point in text-books is unsatisfactory. Even Routh's highly instructive, and otherwise full, discussion does not meet this issue. The question has been satisfactorily discussed by Chrystal.[3]

I consider it an interesting feature of this paper, and perhaps the main justification for publishing it, that it not merely gives *a* solution, and this in a compact and comprehensive form, but proves that it is *the* solution. It would, however, prove a meagre substitute for Routh's and Chrystal's discussions.

And, although I prove, rigorously, and, I think, simply, that I obtain the most general solution, I have not succeeded, except in one case, in proving what is the number of independent constants which it contains, that is, without recourse to Chrystal's argument, or a very similar one. The exceptional case is that in which the order of the characteristic determinant, Δ, is equal to the sum of the orders of the system in each of the unknowns separately, understanding, by the order in any particular unknown, that of the highest derivative of that unknown which occurs anywhere in the system. When this equality holds, I shall, for convenience, speak of Δ as "normal"; and, when Δ is of order lower than the sum of the orders in the unknowns separately, I shall describe it as "abnormal."

[1] "Extensions of Fourier's and the Bessel-Fourier Theorem": Second Paper, Articles 5-8, P.R.I.A., 1911.

[2] "Dynamics of a System of Rigid Bodies."

[3] "Equivalence of Systems of Ordinary Linear Differential Equations," Trans. Roy. Soc. Edin., xxxviii, pp. 163-178.

§ 1. The equation $\phi(D)x = 0$.

§ 1·1. *A solution containing the proper number of constants.*

In the equation D denotes d/dt, and ϕ is a polynomial. Obviously the equation is satisfied by

$$2\pi i x = {}_{C}\!\int \frac{\psi(\lambda)}{\phi(\lambda)} e^{\lambda t} d\lambda, \tag{1}$$

wherein ψ is any analytic function without poles, and the integral is taken along any contour enclosing all the zeros of $\phi(\lambda)$. For (1) gives

$$2\pi i \phi(D)x = {}_{C}\!\int \psi(\lambda) e^{\lambda t} d\lambda,$$

which is zero.

In particular, ψ may be a polynomial of order lower by unity than that of ϕ, and with arbitrary coefficients; if ϕ is of degree r, the number of these coefficients is r, and this is known to be the proper number of arbitrary constants in the most general solution.

If the contour in (1) encloses only *some* zeros of ϕ, (1) is still a solution, though not the most general.

§ 1·2. *The solution for assigned initial values of x and its derivatives:*

A definite and natural problem is that of finding a solution so that the initial values of x and its derivatives up to the $(r-1)^{th}$, inclusive, may have given arbitrarily assigned values.

If the values in question are denoted by $x_0, x_1, \ldots x_{r-1}$; and if

$$\phi(\lambda) \equiv a_r\lambda^r + a_{r-1}\lambda^{r-1} + \ldots, \tag{2}$$

then the solution is given by (1), where

$$\begin{aligned}\psi(\lambda) = {} & a_r(\lambda^{r-1}x_0 + \lambda^{r-2}x_1 + \ldots + x_{r-1}) \\ & + a_{r-1}(\lambda^{r-2}x_0 + \lambda^{r-3}x_1 + \ldots + x_{r-2}) \\ & + \ldots \\ & \ldots \\ & + a_1 x_0;\end{aligned} \tag{3}$$

the right-hand member of this may be written

$$\left[\frac{\phi(D) - \phi(\lambda)}{D - \lambda} x\right]_{t=0}. \tag{4}$$

To prove that this is the solution it is necessary and sufficient to show further that this expression for x gives to it and its derivatives the assigned values initially. For this purpose we suppose the contour to be everywhere at a great distance from the origin.

As regards x itself, the initial value of the integrand in (1), with ψ as given by (3), tends asymptotically, as λ increases indefinitely, to equality with $\lambda^{-1}d\lambda \,.\, x_0$, the error being of order λ^{-2}; so that the integral is $2\pi i x_0$.

Again, each derivative may be found by differentiating under the sign of integration; thus the initial value of $D^p x$ is given by

$$2\pi i D^p x = {}_C\int \psi_p(\lambda)\, d\lambda \,/\, \phi(\lambda), \tag{5}$$

where

$$\begin{aligned}\psi_p(\lambda) \equiv {} & (a_r\lambda^{p+r-1} + a_{r-1}\lambda^{p+r-2} + \ldots + a_1\lambda^p)x_0 \\ & + (a_r\lambda^{p+r-2} + \ldots + a_2\lambda^p)x_1 \\ & + \ldots \\ & \ldots \\ & + a_r\lambda^p x_{r-1}.\end{aligned}$$

And, in the contour integral in (5), we may subtract from $\psi_p(\lambda)$ the product of $\phi(\lambda)$ and any polynomial; we may thus replace ψ_p by another polynomial, of order $r-1$, *viz.*, the remainder, in the usual sense, when $\psi_p(\lambda)$ is divided by $\phi(\lambda)$. When p lies between 1 and $r-1$ inclusive this remainder is

$$\begin{aligned}& - a_0\lambda^{p-1}x_0 - (a_1\lambda^{p-1} + a_0\lambda^{p-2})x_1 - \ldots - (a_{p-1}\lambda^{p-1} + \ldots)x_{p-1} \\ & + (a_r\lambda^{r-1} + a_{r-1}\lambda^{r-2} + \ldots)x_p + (a_r\lambda^{r-2} + \ldots)x_{p+1} + \ldots \\ & + a_r\lambda^p x_{r-1}.\end{aligned} \tag{6}$$

When the distance of the contour from the origin increases indefinitely the integrand tends asymptotically to the value $\lambda^{-1}x_p d\lambda$, so that the (initial) value of the integral is $2\pi i x_p$.

In the symbolic notation

$$\psi_p(\lambda) = \left[\frac{\lambda^p(\phi(D) - \phi(\lambda))}{D - \lambda}x\right]_{t=0}; \tag{7}$$

the quotient, on division by $\phi(\lambda)$ is

$$\left[\frac{D^p - \lambda^p}{D - \lambda}x\right]_{t=0}; \tag{8}$$

and the remainder is

$$\left[\frac{\lambda^p\phi(D) - D^p\phi(\lambda)}{D - \lambda}x\right]_{t=0}. \tag{9}$$

§ 1·3. *The above solution obtained from the differential equation.*

I think it of considerable interest that the above solution may be obtained directly from the differential equation,[1] thus showing that it is the most general solution.

Writing the equation, with t' as the independent variable, in the form

$$\phi(D')x = 0, \tag{10}$$

where D' denotes d/dt', multiply across by $e^{\lambda(t-t')}dt'$,[2] and integrate from 0 to t.

[1] Compare Cotter:—"A new method of solving Legendre's and Bessel's equations, and others of a similar type," P.R.I.A., xxvii, A, 1911, p. 157.

[2] Here, and at corresponding stages throughout, it would be simpler to omit the factor $e^{\lambda t}$ until just before integration with respect to λ.

As repeated integration by parts for any term gives

$$\int_0^t e^{\lambda(t-t')} D'^n(x) dt' = e^{\lambda t} \Big| e^{-\lambda t'} (D'^{n-1} + \lambda D'^{n-2} + \ldots + \lambda^{n-1}) x \Big|_0^t$$

$$+ \lambda^n \int_0^t e^{\lambda(t-t')} x dt'$$

$$= e^{\lambda t} \Big| e^{-\lambda t'} \frac{(D'^n - \lambda^n)}{D' - \lambda} x \Big|_0^t + \lambda^n \int_0^t e^{\lambda(t-t')} x dt', \qquad (11)$$

we obtain the general formula

$$\int_0^t e^{\lambda(t-t')} \phi(D') x \,.\, dt'$$

$$= e^{\lambda t} \Big| e^{-\lambda t'} \frac{\phi(D') - \phi(\lambda)}{D' - \lambda} x \Big|_0^t + \phi(\lambda) \int_0^t e^{\lambda(t-t')} x dt'; \qquad (12)$$

accordingly, if x satisfies (10), so that the left-hand member is zero, the right-hand member of this is also zero for all values of λ.

Let us multiply both sides by $d\lambda/\phi(\lambda)$ and integrate round the same infinite contour. The latter term on the right gives zero. The first expression on the right at the lower limit, $t' = 0$, has the value

$$e^{\lambda t} \Big| \frac{\phi(D) - \phi(\lambda)}{D - \lambda} x \Big|_{t=0}, \qquad (13)$$

i.e., the same expression as (4). At the upper limit, $t' = t$, it is

$$\Big| \frac{\phi(D) - \phi(\lambda)}{D - \lambda} x \Big|_t; \qquad (14)$$

there is one term of order $r - 1$ in this, *viz.*, $a_r \lambda^{r-1} x_t$, and all others are of lower order; consequently, when multiplied by $d\lambda/\phi(\lambda)$, the integrand tends asymptotically to $x_t d\lambda/\lambda$, and thus the integral is $2\pi i x_t$. Thus we obtain directly the equation

$$2\pi i x_t - \int_C \frac{e^{\lambda t} d\lambda}{\phi(\lambda)} \left[\frac{\phi(D) - \phi(\lambda)}{D - \lambda} x \right]_{t=0} = 0. \qquad (15)$$

§ 2. The equation $\phi(D) x = f(t)$.

§ 2·1. *The solution for definite initial data obtained from the equation itself.*

If we replace (10) by

$$\phi(D') x - f(t') = 0, \qquad (16)$$

and follow treatment precisely similar to that in § (1·3), the solution (15) is obviously replaced by

$$2\pi i x_t = \int_C \frac{e^{\lambda t} d\lambda}{\phi(\lambda)} \left[\frac{\phi(D) - \phi(\lambda)}{D - \lambda} x \right]_{t=0}$$

$$+ \int_C \frac{d\lambda}{\phi(\lambda)} \int_0^t e^{\lambda(t-t')} f(t') dt'. \qquad (17)$$

§ 2·2. *Verification that this solution satisfies the equation and the initial conditions.*

Apart from the interest of the analysis, the subjoined verification will show, if, indeed, it is necessary to do so, that a solution can be obtained with arbitrarily assigned initial values of x and its derivatives up to and including that of order lower by unity than that of ϕ.

To verify the solution it is necessary and sufficient to add to the results of §§ (1·1), (1·2) proofs that the final term on the right of (17) and its derivatives up to the $(r-1)^{th}$, inclusive, vanish initially, and that it satisfies the differential equation.

It is easily shown that

$$D^p \int_0^t e^{\lambda(t-t')} f(t')\,dt' = \lambda^p \int_0^t e^{\lambda(t-t')} f(t')\,dt' + \frac{D^p - \lambda^p}{D - \lambda} f(t). \qquad (18)$$

The first term on the right vanishes initially, and, consequently, the initial value of the p^{th} derivative of the final term on the right of (17) is a contour integral in which the integrand tends asymptotically to the value

$$\frac{\lambda^{p-1}}{\phi(\lambda)}\,d\lambda\,f(t). \qquad (19)$$

Thus, if $p < r$, the contour integral vanishes, and the initial value of the p^{th} derivative of the term in question is, therefore, zero.

Again, from (18) it follows that

$$\phi(D) \int_0^t e^{\lambda(t-t')} f(t')\,dt' = \phi(\lambda) \int_0^t e^{\lambda(t-t')} f(t')\,dt' + \frac{\phi(D) - \phi(\lambda)}{D - \lambda} f(t). \quad (20)$$

Therefore the value of $\phi(D)$ of the final term on the right of (17) comes solely from the second term on the right of (20), and is

$$\int_C \frac{d\lambda}{\phi(\lambda)} \cdot \frac{\phi(D) - \phi(\lambda)}{D - \lambda} f(t). \qquad (21)$$

In this the integrand tends asymptotically to $\lambda^{-1} d\lambda f(t)$; so that the integral is $2\pi i f(t)$.

The verification has thus been given.

§ **3.** SIMULTANEOUS EQUATIONS ADMITTING OF SOLUTIONS ZERO, AND HAVING THE CHARACTERISTIC DETERMINANT "NORMAL."

In discussing simultaneous equations I limit myself to the case of two unknowns. This makes the formulæ less cumbrous, and does not detract from the generality of the argument.

Let the equations be

$$\phi_{11}(D)\,x + \phi_{12}(D)\,y = 0, \tag{22}$$

$$\phi_{21}(D)\,x + \phi_{22}(D)\,y = 0, \tag{23}$$

of orders m in x and n in y, i.e. the highest derivatives being $D^m(x)$ and $D^n(y)$. The characteristic determinant, with D as the "variable," is

$$\begin{vmatrix} \phi_{11}(D), & \phi_{12}(D) \\ \phi_{21}(D), & \phi_{22}(D) \end{vmatrix}, \tag{24}$$

which will be denoted by $\Delta(D)$.

§ 3·1. *The solution, for certain initial data, stated and verified.*

When the determinant is "normal" we may obtain a solution which satisfies the conditions that initially x and its derivatives up to the $(m-1)^{th}$, y and its derivatives up to the $(n-1)^{th}$, inclusive, shall have arbitrarily assigned values.

The solution in x is

$$2\pi i x = \int_C \frac{e^{\lambda t}\,d\lambda}{\Delta(\lambda)} \begin{bmatrix} \dfrac{\phi_{11}(D) - \phi_{11}(\lambda)}{D-\lambda}\,x + \dfrac{\phi_{12}(D) - \phi_{12}(\lambda)}{D-\lambda}\,y, & \phi_{12}(\lambda) \\ \dfrac{\phi_{21}(D) - \phi_{21}(\lambda)}{D-\lambda}\,x + \dfrac{\phi_{22}(D) - \phi_{22}(\lambda)}{D-\lambda}\,y, & \phi_{22}(\lambda) \end{bmatrix}_{t=0}; \tag{25}$$

the determinant in this is obtained from Δ by altering, as indicated, the constituents of the first column. For y, the elements of the second column of Δ, instead of those of the first, are replaced by those of the first column in (25).

In the very special case of $m = 0$, x_0 does not occur in the solution; each numerator in the first column of the determinant has the form $c - c$, where c is constant.

As the symbolic notation is somewhat puzzling, I give in the more usual notation the value of x for the equations

$$(a_{11}D^2 + b_{11}D + c_{11})\,x + (a_{12}D^2 + b_{12}D + c_{12})\,y = 0, \tag{26}$$

$$(a_{21}D^2 + b_{21}D + c_{21})\,x + (a_{22}D^2 + b_{22}D + c_{22})\,y = 0. \tag{27}$$

It is

$$2\pi i x = \int_C \frac{d\lambda . e^{\lambda t}}{\Delta(\lambda)} \begin{vmatrix} (a_{11}\lambda + b_{11})x_0 + a_{11}x_1 + (a_{12}\lambda + b_{12})y_0 + a_{12}y_1, & a_{12}\lambda^2 + b_{12}\lambda + c_{12} \\ (a_{21}\lambda + b_{21})x_0 + a_{21}x_1 + (a_{22}\lambda + b_{22})y_0 + a_{22}y_1, & a_{22}\lambda^2 + b_{22}\lambda + c_{22} \end{vmatrix} \tag{28}$$

x_0, x_1, y_0, y_1, being the initial values of x, dx/dt, y, dy/dt.

Returning to (25) and its analogue for y, in the first place these expressions satisfy (22), (23). In fact, these differential equations are satisfied by values of the forms of (25) and its analogue if the constituents of the first column in (25) are replaced by any analytic functions, $\psi_1(\lambda)$, $\psi_2(\lambda)$, whatever, provided these have no poles. For these substitutions would give

$$2\pi i\,(\phi_{11}(D)\,x + \phi_{12}(D))\,y = \int_C d\lambda\, e^{\lambda t} \begin{vmatrix} \psi_1(\lambda), & \phi_{12}(\lambda) \\ \psi_2(\lambda), & \phi_{22}(\lambda) \end{vmatrix}, \tag{29}$$

which is zero.

Again, (25) gives the proper initial values. It gives, as the initial value of $2\pi i D^p x$, a contour integral which differs from that in (25) in having $e^{\lambda t}$ replaced by unity and the constituents of the first column by the determinant replaced respectively by

$$\lambda^p\Big[\,[\{\phi_{11}(D) - \phi_{11}(\lambda)\}x + \{\phi_{12}(D) - \phi_{12}(\lambda)\}y]/(D-\lambda)\Big]_{t=0}, \tag{30}$$

$$\lambda^p\Big[\,[\{\phi_{21}(D) - \phi_{21}(\lambda)\}x + \{\phi_{22}(D) - \phi_{22}(\lambda)\}y]/(D-\lambda)\Big]_{t=0}. \tag{31}$$

Consider, firstly, the terms in this determinant which involve the initial values of the first unknown, x, and its derivatives, viz. :—

$$\begin{vmatrix} \lambda^p\left[\dfrac{\phi_{11}(D) - \phi_{11}(\lambda)}{D-\lambda}\,x\right]_{t=0}, & \phi_{12}(\lambda) \\ \lambda^p\left[\dfrac{\phi_{21}(D) - \phi_{21}(\lambda)}{D-\lambda}\,x\right]_{t=0}, & \phi_{22}(\lambda) \end{vmatrix}. \tag{32}$$

For the purpose of the contour integration we may subtract from the elements of the first column

$$\phi_{11}(\lambda)\left[\frac{D^p - \lambda^p}{D-\lambda}\,x\right]_{t=0}, \tag{33}$$

$$\phi_{22}(\lambda)\left[\frac{D^p - \lambda^p}{D-\lambda}\,x\right]_{t=0}, \tag{34}$$

respectively, as this is equivalent to subtracting from the determinant

$$\Delta(\lambda)\left[\frac{D^p - \lambda^p}{D-\lambda}\,x\right]_{t=0}, \tag{35}$$

and this may be done without altering the integral.

After these subtractions the elements of the column become

$$\left[\frac{\lambda^p\phi_{11}(D) - D^p\phi_{11}(\lambda)}{D-\lambda}\,x\right]_{t=0}, \tag{36}$$

$$\left[\frac{\lambda^p\phi_{21}(D) - D^p\phi_{21}(\lambda)}{D-\lambda}\,x\right]_{t=0}. \tag{37}$$

If p lies between zero and $m-1$ inclusive, there is no term in either of higher order than $m-1$ in λ; and there is a term of this order in at least one of them, arising from the second terms of the numerators. The terms of this order in one or both are the same as those in

$$\lambda^{-1}\phi_{11}(\lambda)x_p, \quad \lambda^{-1}\phi_{21}(\lambda)x_p, \tag{38}$$

x_p being the letter used in (25) to denote the initial value of $D^p x$. Consequently, the integrand in the contour integral tends asymptotically to

$$\lambda^{-1}x_p, \tag{39}$$

and thus the terms depending on x and its derivatives contribute to the integral the value $2\pi i x_p$.

It is important to note that this result would not follow if Δ were "abnormal"; for then, although there would be no terms in (32), as thus altered, of order $m + n - 1$, the asymptotic value of the integrand is not necessarily (39), and, indeed, is often of higher order.

Consider, next, the terms in the determinant (in the numerator of the integrand for $2\pi i D^p x$) which depend on the initial values of the other unknown, y, and its derivatives, viz.,

$$\begin{vmatrix} \lambda^p\left[\dfrac{\phi_{12}(D) - \phi_{12}(\lambda)}{D - \lambda}\, y\right]_{t=0}, & \phi_{12}(\lambda) \\ \lambda^p\left[\dfrac{\phi_{22}(D) - \phi_{22}(\lambda)}{D - \lambda}\, y\right]_{t=0}, & \phi_{22}(\lambda) \end{vmatrix}. \tag{40}$$

It should be noted that at least one element in the first column is of order $p + n - 1$, and in developing this determinant directly this element has to be multiplied by an expression which may be of order n, so that, if $n > m$, we must adopt some device different from that which was applied to (32). The determinant (40) is, however, equivalent to

$$\left[\begin{vmatrix} \lambda^p\phi_{12}(D)y, & \phi_{12}(\lambda) \\ \lambda^p\phi_{22}(D)y, & \phi_{22}(\lambda) \end{vmatrix} \Big/ (D - \lambda)\right]_{t=0}; \tag{41}$$

for this latter is an integral polynomial in D and λ, since it vanishes on replacing D by λ, and the numerators in it and in (40) (which have $D - \lambda$ as denominator) differ by a determinant which has two columns identical and is therefore zero.

Consequently, if $p < m$, (40) does not affect the initial value $D^p x$; for (41) does not, being of too low an order in λ. It has thus been shown that (25) gives the assigned initial values.

In the very special case in which m is zero, the arbitrarily assigned initial values referred to at the head of this § do not include that of x.

§ 3·2. *The solution obtained directly from the equations.*

On writing (22), (23), with t' as the independent variable, we may obtain from them

$$\begin{vmatrix} \int_0^t e^{\lambda(t-t')}\left[\phi_{11}(D')x + \phi_{12}(D')y\right]dt', & \phi_{12}(\lambda) \\ \int_0^t e^{\lambda(t-t')}\left[\phi_{21}(D')x + \phi_{22}(D')y\right]dt', & \phi_{22}(\lambda) \end{vmatrix} = 0, \qquad (42)$$

since each member of the first column is zero.

Transforming the integrals as in § (1·3), the left-hand member becomes

$$e^{\lambda t}\left\|\begin{matrix} \dfrac{\{\phi_{11}(D') - \phi_{11}(\lambda)\}x + \{\phi_{12}(D') - \phi_{12}(\lambda)\}y}{D' - \lambda}e^{-\lambda t'}, & \phi_{12}(\lambda) \\ \dfrac{\{\phi_{21}(D') - \phi_{21}(\lambda)\}x + \{\phi_{22}(D') - \phi_{22}(\lambda)\}y}{D' - \lambda}e^{-\lambda t'}, & \phi_{22}(\lambda) \end{matrix}\right\|_0^t$$

$$+ \begin{vmatrix} \phi_{11}(\lambda), & \phi_{12}(\lambda) \\ \phi_{21}(\lambda), & \phi_{22}(\lambda) \end{vmatrix} \int_0^t e^{\lambda(t-t')}x\,dt'. \qquad (43)$$

Multiplying by $d\lambda / \Delta(\lambda)$, and integrating round the contour, the last term contributes nothing, as the determinant in front of the integral is $\Delta(\lambda)$.

Considering the contribution from the first term, at the upper limit, i.e. $t' = t$, the integrand is of the same form as the initial value of that in (25), except that the x, y, in it relate to time t instead of to zero time. And the same argument which proved that the initial value of the contour integral in (25) is $2\pi i x_0$ proves that the integral arising from the first term at the upper limit is $2\pi i x_t$.

And at the lower limit the first term in (43) gives to the contour integral the value stated in (25) to be a solution.

In the very special case of $m = 0$, the above argument does not apply, however; we may then use a similar argument to that used below, when Δ is "abnormal," in replacing (48) by (52).

Thus the solution has been obtained directly.

§ 4. SYSTEMS WHICH DO NOT ADMIT ZEROS AS SOLUTIONS, AND SYSTEMS WHICH HAVE AN "ABNORMAL" DETERMINANT.

I now suppose that the equations to be solved are of types

$$\phi_{11}(D)x + \phi_{12}(D)y = f_1(t), \qquad (44)$$

$$\phi_{21}(D)x + \phi_{22}(D)y = f_2(t), \qquad (45)$$

where the order of Δ is (usually) less than $m + n$; the argument holds, however, when Δ is normal.

The division into the two classes discussed in § 3 and in § 4 may appear artificial; but, on the whole, I think it the most convenient. It might appear simpler and more natural to separate from the class of equations now to be discussed either, (1), those in which the right-hand members are zero but Δ "abnormal," or else, (2), those in which the right-hand members are not zero but Δ is "normal." Of these cases, however, (1) is really very little simpler than the more general, and in the case of (2), in attempting to write down the solution first, and verify it afterwards, I tried a form which, although correct when Δ is "normal," proved to be incorrect in the contrary case.

§ 4·1. *The solution obtained directly from the equations.*

Proceeding as in § (3·2) we obtain, instead of (42),

$$\begin{vmatrix} \int_0^t e^{\lambda(t-t')}\left[\phi_{11}(D')x + \phi_{12}(D')y - f_1(t')\right]dt', & \phi_{12}(\lambda) \\ \int_0^t e^{\lambda(t-t')}\left[\phi_{21}(D')x + \phi_{22}(D')y - f_2(t')\right]dt', & \phi_{22}(\lambda) \end{vmatrix} = 0, \qquad (46)$$

and, integrating by parts, as with (42), the left-hand member may be written

$$e^{\lambda t}\left[\begin{vmatrix} \dfrac{\{\phi_{11}(D') - \phi_{11}(\lambda)\}x + \{\phi_{12}(D') - \phi_{12}(\lambda)\}y}{D' - \lambda}, & \phi_{12}(\lambda) \\ \dfrac{\{\phi_{21}(D') - \phi_{21}(\lambda)\}x + \{\phi_{22}(D') - \phi_{22}(\lambda)\}y}{D' - \lambda}, & \phi_{22}(\lambda) \end{vmatrix} e^{-\lambda t'}\right]_0^t$$

$$+ \begin{vmatrix} \phi_{11}(\lambda), & \phi_{12}(\lambda) \\ \phi_{21}(\lambda), & \phi_{22}(\lambda) \end{vmatrix} \int_0^t e^{\lambda(t-t')}x\,dt' - \begin{vmatrix} \int_0^t e^{\lambda(t-t')}f_1(t')dt', & \phi_{12}(\lambda) \\ \int_0^t e^{\lambda(t-t')}f_2(t')dt', & \phi_{22}(\lambda) \end{vmatrix}. \qquad (47)$$

We will eventually multiply this by $d\lambda/\Delta(\lambda)$, and integrate round the infinite contour, as was done with (43). But, as has been indicated in § (3·1), the argument used of (43) is inapplicable when Δ is "abnormal." For, if we treat (47) as we did (43), the coefficient of $d\lambda$ in that part of the integrand in λ which comes from the determinant in the first term will be a fraction whose denominator is $\Delta(\lambda)$, and whose numerator may be of order as high as, or higher than, $\Delta(\lambda)$. I, therefore, proceed to replace this determinant by another, equivalent as regards the solution, which contains no terms of order as high as that of Δ.

Regarding the determinant in question as a fraction whose denominator is $D' - \lambda$, consider the numerator, viz.:—

$$\begin{vmatrix} \{\phi_{11}(D') - \phi_{11}(\lambda)\}x + \{\phi_{12}(D') - \phi_{12}(\lambda)\}y, & \phi_{12}(\lambda) \\ \{\phi_{21}(D') - \phi_{21}(\lambda)\}x + \{\phi_{22}(D') - \phi_{22}(\lambda)\}y, & \phi_{22}(\lambda) \end{vmatrix}, \qquad (48)$$

taken at any time t'.

This may be written

$$\begin{vmatrix} \phi_{11}(D')x + \phi_{12}(D')y, & \phi_{12}(\lambda) \\ \phi_{21}(D')x + \phi_{22}(D')y, & \phi_{22}(\lambda) \end{vmatrix} - \Delta(\lambda)x, \tag{49}$$

or, *by virtue of the given differential equations*,

$$\begin{vmatrix} f_1(t'), & \phi_{12}(\lambda) \\ f_2(t'), & \phi_{22}(\lambda) \end{vmatrix} - \Delta(\lambda)x. \tag{50}$$

Again, *by virtue of the differential equations*,

$$\Delta(D')x = \begin{vmatrix} f_1(t'), & \phi_{12}(D') \\ f_2(t'), & \phi_{22}(D') \end{vmatrix}, \tag{51}$$

(the operators in the second, and other,[1] columns affecting the functions in the first which they multiply, when the determinant is expanded). This is seen by multiplying each equation by the first minor (of $\Delta(D')$) of its coefficient in x, and adding.

Thus (49) may be written in the form

$$\{\Delta(D') - \Delta(\lambda)\}x - \{\Phi_{11}(D') - \Phi_{11}(\lambda)\}f_1(t') \\ - \{\Phi_{21}(D') - \Phi_{21}(\lambda)\}f_2(t'), \tag{52}$$

where each Φ is the first minor of the corresponding ϕ in Δ. (I introduce the minors to obtain a form suitable when there are more than two unknowns; for two unknowns $\Phi_{11} = \phi_{22}$, etc.) And this is true for all values of λ.

But a word of warning is necessary before replacing the determinant in the first term of (47) by the quotient of (52) by $D' - \lambda$. In the transformations in previous §§ the use of the symbols D, D', has been only to *simplify notation*; each transformation has been purely algebraic. But this is not the case here; in obtaining (52) we have used the given differential equations. We are not, therefore, necessarily entitled to replace the one quotient now in question by the other. If u, v, are functions of t', we cannot, in fact, from $u = v$ infer $u/(D' - \lambda) = v/(D' - \lambda)$, unless u, v, are identical polynomials in D' and λ, and each divisible by $D' - \lambda$; the two members of the latter equation may differ by a constant multiple of $e^{\lambda t'}$.

Here, however, the two quotients (in the ordinary sense) with which we are concerned are polynomials in λ, and, therefore, it cannot be the case that, for all values of λ, their difference should be of the form $Ce^{\lambda t'}$. Hence they must be identical.

[1] *i.e.* when there are more than two unknowns.

Deferring consideration of that part of (47) which depends on the value of its first term at the lower limit, $t' = 0$, the other terms are, therefore, after an obvious rearrangement, equal to

$$\frac{\Delta(D) - \Delta(\lambda)}{D - \lambda} x_t + \Delta(\lambda) \int_0^t e^{\lambda(t-t')} x dt'$$

$$- \frac{\Phi_{11}(D) - \Phi_{11}(\lambda)}{D - \lambda} f_1(t) - \frac{\Phi_{21}(D) - \Phi_{21}(\lambda)}{D - \lambda} f_2(t)$$

$$- \int_0^t \{\Phi_{11}(\lambda) f_1(t') + \Phi_{21}(\lambda) f_2(t')\} e^{\lambda(t-t')} dt'. \qquad (53)$$

But, by virtue of equations of type (20), the terms after the first two are identical with

$$- \left[\Phi_{11}(D) \int_0^t e^{\lambda(t-t')} f_1(t') dt' + \Phi_{21}(D) \int_0^t e^{\lambda(t-t')} f_2(t') \, dt'\right], \qquad (54)$$

which will be sufficiently indicated for the general case by the form for two unknowns, viz. :—

$$- e^{\lambda t} \begin{vmatrix} \int_0^t e^{-\lambda t'} f_1(t') dt', & \phi_{12}(D) \\ \int_0^t e^{-\lambda t'} f_2(t') dt', & \phi_{22}(D) \end{vmatrix}. \qquad (55)$$

On now bringing in the value of the first term of (47) at the lower limit, and placing it on the right-hand side of the equation below, it follows that (46) may be written in the form

$$\frac{\Delta(D) - \Delta(\lambda)}{D - \lambda} x_t + \Delta(\lambda) \int_0^t e^{\lambda(t-t')} x dt'$$

$$- e^{\lambda t} \begin{vmatrix} \int_0^t e^{-\lambda t'} f_1(t') dt', & \phi_{12}(D) \\ \int_0^t e^{-\lambda t'} f_2(t') dt' & \phi_{22}(D) \end{vmatrix}$$

$$= e^{\lambda t} \begin{vmatrix} \dfrac{\{\phi_{11}(D) - \phi_{11}(\lambda)\} x + \{\phi_{12}(D) - \phi_{12}(\lambda)\} y}{D - \lambda}, & \phi_{12}(\lambda) \\ \dfrac{\{\phi_{21}(D) - \phi_{21}(\lambda)\} x + \{\phi_{22}(D) - \phi_{22}(\lambda)\} y}{D - \lambda}, & \phi_{22}(\lambda) \end{vmatrix}_{t=0}. \qquad (56)$$

Now multiply both sides by $d\lambda / \Delta(\lambda)$ and integrate round the contour at infinity. The first term on the left gives $2\pi i x_t$; the second gives zero.

Transferring the third term to the right-hand side of the equation, we obtain, as the solution for x,

$$2\pi i x_t = \int_C \frac{e^{\lambda t}d\lambda}{\Delta(\lambda)} \left| \begin{matrix} \dfrac{\{\phi_{11}(D) - \phi_{11}(\lambda)\}x + \{\phi_{12}(D) - \phi_{12}(\lambda)\}y}{D-\lambda}, & \phi_{12}(\lambda) \\ \dfrac{\{\phi_{21}(D) - \phi_{21}(\lambda)\}x + \{\phi_{22}(D) - \phi_{22}(\lambda)\}y}{D-\lambda}, & \phi_{22}(\lambda) \end{matrix} \right|_{t=0}$$

$$+ \int_C \frac{e^{\lambda t}d\lambda}{\Delta(\lambda)} \left| \begin{matrix} \int_0^t e^{-\lambda t'} f_1(t')dt', & \phi_{12}(D) \\ \int_0^t e^{-\lambda t'} f_2(t')\,dt', & \phi_{22}(D) \end{matrix} \right|. \qquad (57)$$

The second term on the right is thus a "Particular Integral"; in it, if there are more than two unknowns, D occurs in all elements save those of the first column, and the operations indicated by functions of D are to be performed on those elements of the first column which they multiply. It may be well to emphasize that D in this term indicates differentiation with respect to t performed after integrations with respect to t'.

In the corresponding value of y, the first columns of the two determinants in (57) become the second columns instead.

The form which first suggested itself to me as a solution differed from (57) and its analogues in having D in the second term replaced by λ. This gives the same value for x when Δ is "normal," but usually not in the contrary case.

§ 4·2. *The solution* (57) *satisfies the differential equations, and does so if the constants are replaced by any whatever.*

If, in the first determinant in (57), the constants which represent the initial values of the unknowns and their derivatives are replaced by any others whatever, the differential equations are still satisfied. (But it is not the case that in such a form of solution these constants *necessarily* represent initial values of such unknowns and derivatives when Δ is "abnormal." (See § (4·4), below.)

In the first place, if we substitute in the equations (44), (45), for x, y, the values given by the first terms of (57) and its analogues, the left-hand members vanish; this follows as in § (3·1).

It remains to be shown that the second terms give "Particular Integrals." When the values of x, y, given by these second terms are substituted in (44), the left-hand member becomes

$$(2\pi i)^{-1} \int_C \frac{e^{\lambda t}d\lambda}{\Delta(\lambda)} \cdot \Delta(D) \int_0^t e^{\lambda(t-t')} f_1(t')dt'; \qquad (58)$$

but, from (20),

$$\Delta(D) \int_0^t e^{\lambda(t-t')} f_1(t')dt' = \Delta(\lambda) \int_0^t e^{\lambda(t-t')} f_1(t')dt' + \frac{\Delta(D) - \Delta(\lambda)}{D-\lambda} f_1(t). \qquad (59)$$

On substituting in the contour integral, the first term integrates to zero; the asymptotic value of the integrand arising from the second is $\lambda^{-1}d\lambda f_1(t)$; the integral is therefore $2\pi i f_1(t)$. Thus the result has been established.

§ 4·3. *The solution (57) satisfies the differential equations if the elements of the altered row in the first determinant are replaced by any polynomials whatever.*

The proof is as in § (4·2) and the beginning of § (3·1).

§ 4·4. *The solution (57) gives as initial values of x, y, and their derivatives up to $D^{m-1}(x)$, $D^{n-1}(y)$, the constants which occur in the first column of the first determinant, provided these are compatible with the differential equations.*

When Δ is "abnormal" the present discussion pays no regard to, and, indeed, fails to settle, the number of independent constants in the general solution. From other discussions it is known that this number is the number which indicates the order of Δ, and thus, that, when Δ is "abnormal," not all the $m + n$ initial values of x, y, and other derivatives can be assigned arbitrarily. It is in keeping with this fact, known otherwise, but not assumed here, that I cannot prove that the solution (57) will necessarily give as initial value of $D^p x$ (say), $p < m$, the letter, x_p, which indicates it in (57), but merely that it gives a combination of the letters denoting initial values which is equal to x_p if those letters in the formula (57) actually represent values compatible with the equations which are to be solved.

On writing the determinant in the second term in the right-hand member of (57), by the aid of (20), in the form[1]

$$\Phi_{11}(\lambda)\int_0^t e^{\lambda(t-t')}f_1(t')dt' + \Phi_{21}(\lambda)\int_0^t e^{\lambda(t-t')}f_2(t')dt'$$
$$+ \frac{\Phi_{11}(D) - \Phi_{11}(\lambda)}{D-\lambda}f_1(t) + \frac{\Phi_{21}(D) - \Phi_{21}(\lambda)}{D-\lambda}f_2(t), \tag{60}$$

differentiating (57) under the integral sign, and again using (20) to transform further the part obtained from the second term, we obtain

$$2\pi i D^p x = \int_C \frac{e^{\lambda t}d\lambda}{\Delta(\lambda)}\begin{vmatrix} \dfrac{\lambda^p\{\phi_{11}(D) - \phi_{11}(\lambda)\}x + \{\phi_{12}(D) - \phi_{12}(\lambda)\}y}{D-\lambda}, & \phi_{12}(\lambda) \\ \dfrac{\lambda^p\{\phi_{21}(D) - \phi_{21}(\lambda)\}x + \{\phi_{22}(D) - \phi_{22}(\lambda)\}y}{D-\lambda}, & \phi_{22}(\lambda) \end{vmatrix}_{t=0}$$
$$+ \int_C \frac{e^{\lambda t}d\lambda}{\Delta(\lambda)}\left[\lambda^p\Phi_{11}(\lambda)\int_0^t e^{\lambda(t-t')}f_1(t')dt' + \lambda^p\Phi_{21}(\lambda)\int_0^t e^{\lambda(t-t')}f_2(t')dt'\right.$$
$$\left. + \frac{D^p\Phi_{11}(D) - \lambda^p\Phi_{11}(\lambda)}{D-\lambda}f_1(t) + \frac{D^p\Phi_{21}(D) - \lambda^p\Phi_{21}(\lambda)}{D-\lambda}f_2(t)\right]. \tag{61}$$

[1] Here, again, I introduce the minors, to use notation suitable when there are more than two unknowns.

The initial value of the part arising from the double integrals is zero. Considering the coefficient of $e^{\lambda t}d\lambda/\Delta(\lambda)$ in the remaining portions of the second term of the integrand, it is a fraction whose denominator is $D - \lambda$. The numerator may, *by virtue of the differential equations*, be written in the form

$$\{D^p\Phi_{11}(D) - \lambda^p\Phi_{11}(\lambda)\}\{\phi_{11}(D)x + \phi_{12}(D)y\},$$

$$+ \{D^p\Phi_{21}(D) - \lambda^p\Phi_{21}(\lambda)\}\{\phi_{21}(D)x + \phi_{22}(D)y\}, \qquad (62)$$

or,

$$D^p\Delta(D)x - \lambda^p \begin{vmatrix} \phi_{11}(D)x + \phi_{12}(D)y, & \phi_{12}(\lambda) \\ \phi_{21}(D)x + \phi_{22}(D)y, & \phi_{22}(\lambda) \end{vmatrix}. \qquad (63)$$

This, like its equivalent form in (61), is a polynomial in D, λ, which is divisible by $D - \lambda$. We may, therefore, replace the corresponding quotients in (61) by the quotient of (63) by $D - \lambda$, justifying this by the same argument as was used in § (4·1) to show equivalence connecting (47) and (52). Combining, then, the initial value of this quotient with the first term of (60), we obtain

$$2\pi i\,[D^px]_{t=0} = \int_C \frac{d\lambda}{\Delta(\lambda)} \left| \frac{D^p\Delta(D) - \lambda^p\Delta(\lambda)}{D - \lambda}\, x \right|_{t=0}. \qquad (64)$$

From the numerator in $|\quad|$ we may subtract $|(D^p - \lambda^p)\,\Delta(\lambda)\,x\,|_{t=0}$, since this does not alter the integral. This gives

$$2\pi i[D^px]_{t=0} = \int_C \frac{d\lambda}{\Delta(\lambda)} \cdot \left| D^p \cdot \frac{\Delta(D) - \Delta(\lambda)}{D - \lambda} \cdot x \right|_{t=0}. \qquad (65)$$

The asymptotic value of the integrand is $\lambda^{-1}d\lambda . x_p$; and thus the integral is $2\pi i x_p$. Consequently, at $t = 0$, D^px has the assigned value x_p.

It may appear from the form of (65), and the manner in which it involves the symbol x, that I have verified only an identity; but this is not the case. In the right-hand member of (57) the initial values of x, y, and their derivatives have assigned values, that of D^px being x_p; and it has been verified that the initial value of the p^{th} derivative of this right-hand member is either identically $2\pi i x_p$ or some function of the initial values which is equal to $2\pi i x_p$ in virtue of the differential equations.

It is noticeable that we obtain (65) without the limitations that $p < m$; but, if $p =$ or $> m$, the solution (57) does not contain the symbol x_p at all, so that, although (57) does give $[D^px]_{t=0}$ correctly, this is not one of the assigned initial values which is to be verified.

§ 4·5. *When Δ is "normal", the m + n initial values may be assigned arbitrarily.*

In § (3·1) it has been shown that, when Δ is "normal" (25), which is identical with the part of (57) not involving f_1, f_2, gives the correct initial arbitrarily assigned values.

It suffices, then, to prove further, that the part which does involve f_1, f_2, has no effect on these initial values. And this is easily proved; for, in (61), the part involving the double integrals is initially zero; and the asymptotic initial value of the integrand in the final terms is of order not higher than (and in the case of one, at least, equal to) that of $\lambda^{p-1-m}d\lambda$; consequently, if p lies between zero and $m - 1$, inclusive, the integral is zero.

§ 4·6. *Failure to determine the number of independent constants in the solution when Δ is "abnormal."*

As already stated, I have been unsuccessful in my attempts to determine the number of independent constants in the complete solution. At first sight of the form given here it might appear easy to do so; but when one considers how the independent constants do actually occur in the solutions for the several unknowns, as shown by Routh and by Chrystal, one may be reconciled to the existence of difficulty. The number contained in the value of any one unknown seems almost obvious from the solution given above; e.g. the number in x is the order of Δ diminished by the order of the highest common factor of Δ and its first minors corresponding to the column associated with x.

VIII.

CORRESPONDING POINTS ON THE CURVE OF INTERSECTION OF TWO QUADRICS.

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Section 1.—The curve discussed in this paper is the quartic curve of the first class, namely, the curve of intersection of two quadrics.

For the sake of reference we give the characteristics of this curve, assuming that the two quadrics do not touch.

$$m = 4, \quad n = 12, \quad r = 8, \quad a = 16, \quad \beta = 0$$

$$x = 16, \quad y = 8, \quad g = 38, \quad h = 2.$$

It will be useful to bear in mind that every generator of a quadric containing this curve is a "line through two points," and consequently it follows that, since through any assumed point a quadric containing the curve can be drawn, the two generators of that quadric which pass through the point are two "lines through two points."

This curve has attracted the attention of mathematicians from time to time, and each investigation sheds a fuller light upon the beautiful geometry of the curve.

Section 2.—Let the quadrics be

$$U \equiv x^2 + y^2 + z^2 + w^2, \quad V \equiv \alpha x^2 + \beta y^2 + \gamma z^2 + \delta w^2.$$

Then any quadric $\lambda U - V$ passes through their curve of intersection, which we will call the curve UV. The discriminant of $\lambda U - V$ is $f(\lambda) \equiv \lambda - \alpha . \lambda - \beta . \lambda - \gamma . \lambda - \delta$, and the four cones of the system are those quadrics for which λ has the values $\alpha, \beta, \gamma, \delta$.

For brevity we will write λ_α for $\lambda - \alpha$, $\lambda_{\beta\gamma}$ for $\lambda - \beta . \lambda - \gamma$, &c., and will call the quadric $\lambda U - V$ the quadric (λ).

Also let $L = \beta - \gamma . \alpha - \delta, \quad M = \gamma - \alpha . \beta - \delta, \quad N = \alpha - \beta . \gamma - \delta.$

$\Pi = LMN$, the product of differences of the roots of $f(\lambda) = 0$.

Mr. W. R. Roberts has given expressions for the coordinates of a point on UV of the tangent line and osculating plane. (Salmon, *Analytic Geometry of Three Dimensions*, p. 226). In the present notation we have, in general,

$$\Sigma \frac{l + ma + na^2}{f'(a)} = 0, \tag{1}$$

whatever l, m, n may be, where $f'(a)$ is the result of substituting the value a in the derived function of $f(\lambda)$

Hence the values

$$x^2 = \frac{\lambda - a}{f'(a)}, \quad y^2 = \frac{\lambda - \beta}{f'(\beta)}, \quad z^2 = \frac{\lambda - \gamma}{f'(\gamma)}, \quad w^2 = \frac{\lambda - \delta}{f'(\delta)} \tag{2}$$

satisfy the equations $U = 0$, $V = 0$ for all values of λ, and

$$x = \pm \sqrt{\frac{\lambda - a}{f'(a)}}, \text{ \&c.,}$$

are the coordinates of a point on UV.

A generator of one system of $\lambda U - V$ may be regarded as the intersection of the planes

$$\begin{aligned} -\theta\sqrt{\lambda_\alpha}\,.\,x + i\theta\sqrt{\lambda_\delta}\,.\,w + \sqrt{\lambda_\beta}\,.\,y + i\sqrt{\lambda_\gamma}\,.\,z &= 0, \\ \sqrt{\lambda_\alpha}\,.\,x + i\sqrt{\lambda_\delta}\,.\,w + \theta\sqrt{\lambda_\beta}\,.\,y - i\theta\sqrt{\lambda_\gamma}\,.\,z &= 0. \end{aligned} \tag{3}$$

Forming the line coordinates in the usual way, and dividing out by $-i$,

$$p = 2\theta\sqrt{\lambda_{\alpha\delta}}, \quad q = (1 - \theta^2)\sqrt{\lambda_{\beta\delta}}, \quad r = i(1 + \theta^2)\sqrt{\lambda_{\gamma\delta}}. \tag{3a}$$

$$s = 2\theta\sqrt{\lambda_{\beta\gamma}}, \quad t = (1 - \theta^2)\sqrt{\lambda_{\gamma\alpha}}, \quad u = i(1 + \theta^2)\sqrt{\lambda_{\alpha\beta}}.$$

A generator of the opposite system is the intersection of the planes

$$\begin{aligned} -\phi\sqrt{\lambda_\alpha}\,.\,x - i\phi\sqrt{\lambda_\delta}\,.\,w + \sqrt{\lambda_\beta}\,.\,y + i\sqrt{\lambda_\gamma}\,.\,z &= 0, \\ \sqrt{\lambda_\alpha}\,.\,x - i\sqrt{\lambda_\delta}\,.\,w + \phi\sqrt{\lambda_\beta}\,.\,y - i\phi\sqrt{\lambda_\gamma}\,.\,z &= 0, \end{aligned}$$

and the coordinates of this generator are

$$p' = -2\phi\sqrt{\lambda_{\alpha\delta}}, \quad q' = -(1 - \phi^2)\sqrt{\lambda_{\beta\delta}}, \quad r' = -i(1 + \phi^2)\sqrt{\lambda_{\gamma\delta}}. \tag{4}$$

$$s' = 2\phi\sqrt{\lambda_{\beta\gamma}}, \quad t' = (1 - \phi^2)\sqrt{\lambda_{\gamma\alpha}}, \quad r' = i(1 + \phi^2)\sqrt{\lambda_{\alpha\beta}}. \tag{4a}$$

Hence the coordinates of any two generators of the same system are connected by the relations

$$ps' - p's = 0, \quad qt' - q't = 0, \quad ru' - r'u = 0, \tag{5}$$

while those of opposite systems are connected by the relations

$$ps' + p's = 0, \quad qt' + q't = 0, \quad ru' + r'u = 0. \tag{6}$$

Solving from the equations (3), (4), the coordinates of the intersection of two generators of opposite systems whose parameters are θ and ϕ are given by

$$k\sqrt{\lambda_\alpha}\,.\,x = \theta + \phi, \quad k\sqrt{\lambda_\beta}\,.\,y = \theta\phi - 1, \quad ik\sqrt{\gamma}\,.\,z = \theta\phi + 1, \quad ik\sqrt{\delta}\,.\,w = \theta - \phi,$$

where

$$k = \frac{-2}{\sqrt{\lambda_\beta}\,.\,y - \sqrt{\lambda_\gamma}\,.\,z}. \tag{7}$$

Hence any two generators of a quadric (λ) which have the same parameter meet on the plane $w = 0$, and conversely.

The parameters chosen here have special relation to the grouping YZ, xw of the coordinate planes.

The tangent line to UV at the point $x'y'z'w'$, parameter λ, is the intersection of the tangent lines to U and V, viz. $\Sigma xx' = 0$, $\Sigma axx' = 0$. Hence

$$p = (a - \delta)\,x'w' = \frac{a - \delta}{\sqrt{f'a\,.\,f'\delta}}\sqrt{\lambda_{a\delta}} = \sqrt{\frac{L}{\Pi}}\sqrt{\lambda_{a\delta}}, \tag{8}$$

omitting the common factor $\sqrt{\dfrac{1}{\Pi}}$,

$$p = \sqrt{L\lambda_{a\delta}}, \quad q = \sqrt{M\lambda_{\beta\delta}}, \quad r = \sqrt{N\lambda_{\gamma\delta}}, \tag{9}$$

$$s = \sqrt{L\lambda_{\beta\gamma}}, \quad t = \sqrt{M\lambda_{\gamma a}}, \quad u = \sqrt{N\lambda_{a\beta}}.$$

Comparing these values with those in (3a) we find that if θ be the parameter of the tangent,

$$\frac{1 - \theta^2}{1 + \theta^2} = \sqrt{-\frac{M}{N}} = \sqrt{K}, \text{ say, whence } \theta = \sqrt{\frac{1 - \sqrt{K}}{1 + \sqrt{K}}}. \tag{10}$$

Hence the parameter of a tangent to UV is a constant.

We see from (8) that the tangent at a point whose parameter is λ is a generator of the quadric (λ).

SECTION 3.—If x, y, z, w be the coordinates of a point A on the curve UV, the seven other points derived from A by varying the signs of the coordinates also lie on the curve, and as they have the same parameter λ (§ 2), the tangents at them to the curve are all generators of the same quadric (λ), four of one system and four of the other. We will call a generator of one system, without regard to its parameter, a generator λ_1, one of the other systems a generator λ_2.

These eight points form two groups of *cotangential* points. Any pair belonging to one of the groups is called a pair of *corresponding* points, i.e. corresponding points on the curve are defined as those whose tangent lines are generators of the same system of the same quadric. A pair belonging one to each group may be called a pair of *collinear* points, because, as we shall see, they are collinear with one of the vertices of the tetrahedron of reference.

The following table gives the coordinates of the two groups :—

	x	y	z	w		x	y	z	w
A	+	+	+	+	$\bar{A}$	+	+	+	−
A'	+	−	−	+	$\bar{A}'$	−	+	+	+
A''	−	+	−	+	$\bar{A}''$	+	−	+	+
A'''	−	−	+	+	$\bar{A}'''$	+	+	−	+

(1)

There are three kinds of correspondence, which are related each to one of the three groupings of the roots of the discriminant, $\beta\gamma$, $\alpha\delta$; $\gamma\alpha$, $\beta\delta$; $\alpha\beta$, $\gamma\delta$. These will be called the first, second, and third kinds of correspondence. If we call the four points whose tangents are generators λ_1 of (λ) $A\ A'\ A''\ A'''$, and their collinears $\bar{A}\ \bar{A}'\ \bar{A}''\ \bar{A}'''$, the coordinates being as given in the table, the pairs AA', $A''A'''$ are corresponding points of the first kind, AA'', $A'A'''$ of the second, AA''', $A'A''$ of the third.*

If the vertices of the tetrahedron of reference be X_0, Y_0, Z_0, W_0, the pairs $A\bar{A}$, $A'\bar{A}'$, $A''\bar{A}''$, $A'''\bar{A}'''$, which differ only in the sign of the coordinate w, are collinear with W_0, (2)

$A\bar{A}'$, $A'\bar{A}$, $A''\bar{A}'''$, $A'''\bar{A}''$ with X_0; $A\bar{A}''$, $A''\bar{A}$, $A'\bar{A}'''$, $A'''\bar{A}'$ with Y_0;
$A\bar{A}'''$, $A'''\bar{A}$, $A'\bar{A}''$, $A''\bar{A}'$ with Z_0.

Thus we have a configuration of three groups of four points, including the vertices of the tetrahedron, which are joined by sixteen lines, three points lying on each line, and four lines passing through each point.

Any plane through W_0 meets UV in four points $AB\bar{A}\bar{B}$. The lines AB, $\bar{A}\bar{B}$ intersect, and are, therefore, generators of opposite systems of the same quadric (λ), which is touched by the plane at their intersection. Hence AB, $\bar{A}\bar{B}$ intersect on the plane $w = 0$, which is the polar plane of W_0, with respect to all quadrics of the system $\lambda U - V$.

Similarly $A\bar{B}$, $\bar{A}B$ intersect on $w = 0$.

The plane joining $\bar{A}\bar{B}$ to X_0 passes through the points $A'B'$, which are correspondents of the first kind to A and B (*v.* (2) above), and the chords $\bar{A}\bar{B}$ $A'B'$ intersect on the plane $x = 0$, and so with the other correspondences. Thus, if AB be any two points on UV, the chords AB, $A'B'$, $A''B''$, $A'''B'''$, are all generators of the same quadric (λ) of the opposite systems to $\bar{A}\bar{B}$, and meet that chord in the four points in which it meets the coordinate planes.

Four such chords joining any two sets of cotangential points are called by Harnack a "quadruple." We see from the above that two collinear

* When not otherwise stated, a correspondence is understood to be of the first kind. All statements apply, *mutatis mutandis*, to the other two correspondences.

"quadruples" meet in sixteen points which lie in fours on the coordinate planes. In particular the tangent lines at four cotangential points meet the tangent lines at their collinear points in sixteen points which lie in fours on the coordinate planes.

If four points $ABCD$ lie in a plane, AB, CD are generators of opposite systems of the same quadric (λ). But AB, $A'B'$ are generators of the same system of (λ); $\therefore$ $A'B'$, CD are generators of opposite systems. $\therefore$ $A'B'CD$ are coplanar. Thus, if four points lie in a plane, any two of them are coplanar with a pair of correspondents of the other two of the same kind. By the same reasoning, since $A'B'CD$ are coplanar, so are $A'B'C'D'$. Again, since $AC'BD'$ are coplanar, so are $AC'B''D'''$, since $B''D'''$ are the correspondents of the second kind of BD'; and in general any four points whose affixes are all different are coplanar. Thus if $ABCD$ lie in a plane we have three types of coplanar points: (a) those whose affixes are all the same, (b) those in which they are all different, (c) those in which there are two points with one affix and two with another. (a) gives four planes, (b) twenty-four, and (c) thirty-six. Hence the sixteen points consisting of four coplanar points and their cotangentials lie in sixty-four planes, four points in each plane, and sixteen planes passing through each point.

If we take two points $A\,(xyzw)$ and $B\,(x'y'z'w')$ on the curve, and if (p, q, r, s, t, u) be the coordinates of the chord (AB), those of $A'B'$ are $(-p, q, r, -s, t, u)$, of $A''B''$ $(p, -q, r, s, -t, u)$, of $(A'''B''')$ $(p, q, -r, s, t, -u)$. Hence from (§ 2 (3)) if the parameter of the AB be θ, those of $A'B'$, $A''B''$, $A'''B'''$ are $-\theta, \frac{1}{\theta}, -\frac{1}{\theta}$, and the anharmonic ratio of the four is $\left(\frac{1-\theta^2}{1+\theta^2}\right)^2$. (1)

Hence the A.R. of the four chords which join two sets of cotangential points is independent of the parameter of the quadric of which they are generators, and depends only on the parameters of the chords themselves.

In particular, if A and B coincide, the parameters of the tangents at A, A', A'', A''' are $\theta, -\theta, \frac{1}{\theta}, -\frac{1}{\theta}$, where $\theta = \sqrt{\frac{1-\sqrt{K}}{1+\sqrt{K}}}$ ((10) § 2) Hence the A.R. of the tangents at any set of four cotangential points is

$$\left(\frac{1-\theta^2}{1+\theta^2}\right)^2 = K. \tag{2}$$

Also, since the tangent planes through any chord λ_2 to the curve are the planes joining the chord to the four tangent lines λ_1, the A.R. of the planes, being the same as that of the tangent lines, is K.

The A.R. of the four points in which any line ($pqrstu$) meets the coordinate planes is $-\frac{qt}{ru}$. Hence (§ 2 (9)) the A.R. of the points in which any tangent meets these planes is also K, and this quantity may be called the A.R. of the curve.

SECTION 4.—Let AA', BB' be two pairs of corresponding points of the first kind, their coordinates being

$$(x, y, z, w), \quad (x, -y, -z, w), \quad (x', y', z', w'), \quad (x, -y', -z', w').$$

We have seen (§ 3) that the chords AB, $A'B'$ are generators of the same system of the same quadric, and, since we may interchange B, B' at will, the chords AB' and $A'B$ are also generators of the same system of the same quadric. Let the parameters of the quadrics be λ and λ', and let us call the generators λ_1, λ_1'. Then if $(pqrstu)$, $(p'q'r's't'u')$ be the line coordinates of AB and AB',

$$p = (yz'), \quad s = (xw'), \quad p' = -(yz'), \quad s' = (xw'), \quad \therefore ps' + p's = 0.$$

But (§ 3)

$$\frac{p}{s} = \sqrt{\frac{\lambda_{a\delta}}{\lambda_{\beta\gamma}}}, \quad \frac{p'}{s'} = \sqrt{\frac{\lambda'_{a\delta}}{\lambda'_{\beta\gamma}}}, \quad \therefore \sqrt{\lambda_{a\delta}\lambda'_{\beta\gamma}} + \sqrt{.\lambda_{\beta\gamma}\lambda'_{a\delta}} = 0,$$

whence $\lambda_{a\delta}\lambda'_{\beta\gamma} = \lambda_{\beta\gamma}\lambda'_{a\delta}$,

$$\text{or} \quad (\beta + \gamma - a - \delta)\lambda\lambda' - (\beta\gamma - a\delta)(\lambda + \lambda') + \beta\gamma(a + \delta) - a\delta(\beta + \gamma) = 0. \quad (1)$$

or, if $G_\lambda \equiv u_\lambda v_\lambda w_\lambda$ be the sextic covariant of the discriminant, and u_λ the quadratic factor which corresponds to the grouping $\beta\gamma$; $a\delta$, $u_{\lambda\lambda'} = 0$.

Hence λ, λ' are correspondents in an involution of which the roots of $u_\lambda = 0$ are the foci ; if λ be given, λ' is uniquely determined, and the quadrics (λ), (λ') may be called conjugate quadrics in the first correspondence. If the chord AB be a generator λ_1 of (λ), we can draw from A two generators of (λ'). One of these, which I have called λ_1', passes through the point B'; the other, λ_2', joins A to a point P, which, since $A'B$ is λ_1', is coplanar with $AA'B$. We will call P the *residual* of the points $AA'B$.

If we take another pair of points CD, connected by a generator λ_1 of (λ), and join C to D' and to Q, the residual of $CC'D$; since $CC'DQ$ are coplanar, and CD is λ_1, $C'Q$ is λ_2. But AB is λ_1, $\therefore ABC'Q$ are coplanar. Hence (§ 3) $AB'CQ$ are coplanar. But AB' is λ_1', $\therefore CQ$ is λ_2' and CD' is λ_1'. Hence the system of generators λ_1 and λ_2 of (λ) are related each to a definite system λ_1' and λ_2' of (λ'), so that we may say that λ_1 and λ_1' belong to the same system of generators, the property being that, if from any point be drawn a pair of generators of the same system of a pair of conjugate quadrics, they will pass through a pair of corresponding points. (2)

From this result we can immediately deduce two fundamental properties of pairs of corresponding points of the same kind.

(a) If a pair of corresponding points be joined to any point P on the curve and from any other point Q on the curve chords be drawn to meet the joining lines, these chords will meet the curve again in a pair of corresponding points of the same kind.

Let PA, PA' be generators λ_1, λ_1' of (λ) and (λ'), then (*v.* fig. 1) QB is λ_2, QB' is λ_2'. Hence, by (2) above, BB' are corresponding points of the same kind as AA'.

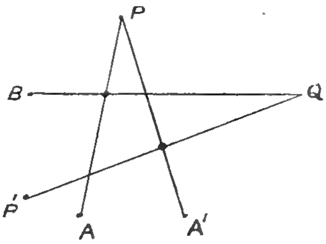

FIG. 1.

(*b*) If through each of a pair of corresponding points a chord be drawn to meet a given chord, they will pass through a pair of corresponding points of the same kind. Since AB, $A'B'$ meet the same chord, they are generators of the same species λ_1 of the same quadric (λ). Since BA, BA' join B to a pair of corresponding points, and BA is λ_1, BA' is λ_1', and $A'B'$ is λ_1, $\therefore$ BB' are corresponding points, from (2) above.

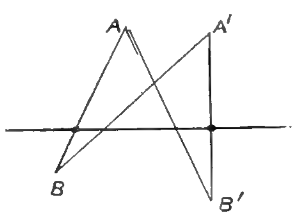

FIG. 2.

The configuration formed by four points in a plane, and their cotangentials, may now be looked at from a new point of view, which is sometimes useful.

Pairs of corresponding points which are connected by generators λ_1, λ_1', of the same system of the same pair of conjugate quadrics may be regarded as constituting a system of quadrangles, any pair of corresponding points being vertices of one quadrangle of the system, and one only. We may denote such a system by the symbol $(\lambda\lambda')_1$.

If in a quadrangle $PP'QQ'$ of the system $(\lambda\lambda')_1$ we suppose P and Q to coincide, P' and Q' will also coincide, and the quadrangle degenerates into a pair of tangents, which are generators λ_1 of (λ) and their chord of contact, which is a generator λ_1' of (λ'). There are two such chords in each system of quadrangles, which join two pairs of cotangential points AA', $A''A'''$.

Again, we may suppose P and Q' to coincide. P' and Q will then coincide, and we get a pair of tangents λ', and their chord λ_1. There are two such chords, joining two pairs of cotangential points A_1A_1'. $A_1''A_1'''$. These four chords may be called the axes of the system.

To any system of quadrangles $(\lambda\lambda')_1$ is related another system $(\lambda\lambda')_2$, in which the generators λ_2, λ_2' take the place of λ_1, λ_1'. This may be called the *collinear* system, and its axes the collinear axes of the other system. They join the points collinear with $A\ldots$, $A_1\ldots$, namely, $\bar{A}\bar{A}'$, $\bar{A}''\bar{A}'''$ and $\bar{A}_1\bar{A}_1'$, $\bar{A}_1''\bar{A}_1'''$.

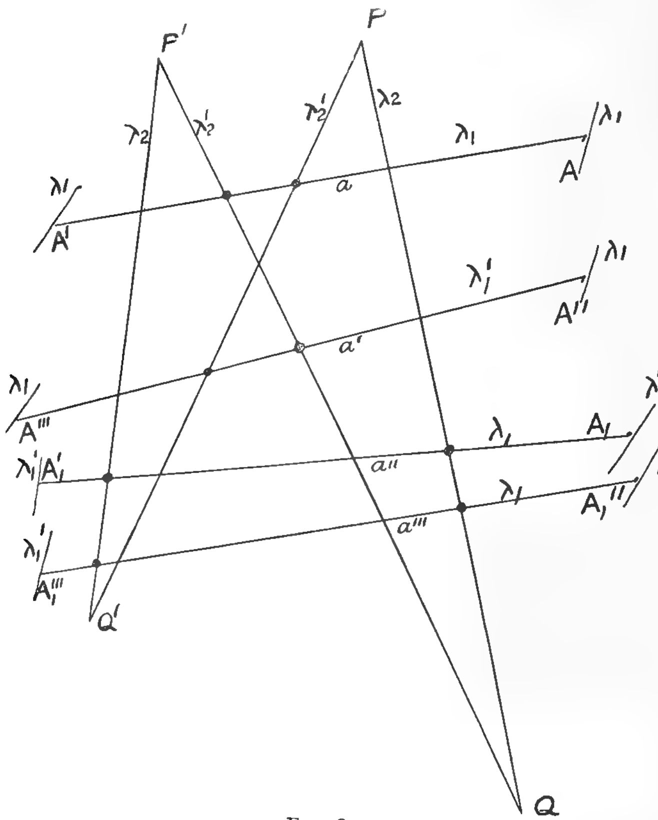

Fig. 3.

Each of the sides PQ, $P'Q'$, PQ', $P'Q$ of a quadrangle meets a pair of the sides of any quadrangle of the collinear system. Thus the quadrangles intersect in eight points, and the vertices lie in fours in eight planes.

A quadrangle intersects the collinear axes in eight points, two on each axis. Further, each pair of sides intersects the four tangents at the extremities of a pair of axes other than those which it intersects. Thus, in the annexed figure, if $PP'QQ'$ be a quadrangle of which $aa'a''a'''$ are the collinear axes, PQ meets a'', a''', and also the tangents to UV at $AA'A''A'''$, so that the planes joining PQ to these points are the tangent planes to UV which pass through the chord $P'Q'$. The tangent planes through $P'Q'$ touch at the same four points, while those through PQ', $P'Q$ touch at the points $A_1A_1'A_1''A_1'''$.

If λ, λ' be connected by the relation

$$u_{\lambda\lambda'} = (\beta + \gamma - a - \delta)\,\lambda\lambda' - (\beta\gamma - a\delta)(\lambda + \lambda') + \beta\gamma(a + \delta) - a\delta(\beta + \gamma) = 0.$$

$$\begin{aligned} k(\lambda' - a) &= (a - \beta)(a - \gamma)(\lambda - \delta). \\ k(\lambda' - \beta) &= -(\beta - a)(\beta - \delta)(\lambda - \gamma). \qquad\qquad (3) \\ k(\lambda' - \gamma) &= -(\gamma - a)(\gamma - \delta)(\lambda - \beta). \quad k = (\beta + \gamma - a - \delta)\,\lambda - (\beta\gamma - a\delta). \\ k(\lambda' - \delta) &= (\delta - \beta)(\delta - \gamma)(\lambda - a). \end{aligned}$$

Hence if the coordinates of the points $AA' \ldots$ be (x, y, z, w), $(x, -y, -z, w)$, &c., and those of A_1, $A_1' \ldots$ be (x_1, y_1, z_1, w), $(x_1, -y_1, -z_1, w_1)$, &c.,

$$\frac{x_1^2}{w_1^2} = \frac{f'\delta}{f'a} \cdot \frac{\lambda' a}{\lambda'\delta} = -\frac{(\delta - \beta)(\delta - \gamma)}{(a - \beta)(a - \gamma)}\frac{\lambda' a}{\lambda'\delta} = -\frac{\lambda\delta}{\lambda a} = \frac{(\delta - \beta)(\delta - \gamma)}{(a - \beta)(a - \gamma)} \cdot \frac{w^2}{x^2}.$$

$$\frac{y_1^2}{z_1^2} = \frac{f'\gamma}{f'\beta} \cdot \frac{\lambda'\beta}{\lambda'\gamma} = -\frac{(\gamma - a)(\gamma - \delta)}{(\beta - a)(\beta - \delta)}\frac{\lambda'\beta}{\lambda'\gamma} = -\frac{\lambda\gamma}{\lambda\beta} = \frac{\gamma - a \,.\, \gamma - \beta}{\beta - a \,.\, \beta - \delta} \cdot \frac{z^2}{y^2}. \qquad (4)$$

Thus the points A_1 and their collinears are connected with the points A and their collinears by relations of the type $x_1 : y_1 : z_1 : w_1$

$$= \sqrt{\delta - \beta \,.\, \delta - \gamma}\; w : \sqrt{\gamma - a \,.\, \gamma - \delta}\; z : \sqrt{\beta - a \,.\, \beta - \delta} \,.\, y : \sqrt{a - \beta \,.\, a - \delta} \,.\, x. \qquad (5)$$

We may call the points A_1 the *inverses* of the points A in the first correspondence.

If $v_{\lambda\lambda''} = 0$, $w_{\lambda\lambda'''} = 0$, we get two other sets of inverse points related similarly to the second and third correspondences. These sets of points will be denoted by $A_2 \ldots A_3 \ldots$, and these "inversions" may be regarded as three linear transformations by which the curve is transformed into itself. By the first transformation λ is transformed into λ', by the second, λ' into λ''', by the third λ''' into λ; so that if the three transformations be applied successively the point A returns to its original position.

From Fig. 3 it is clear that two sets of inverse points $A \ldots$, $A_1 \ldots$ are the extremities of the four axes of a system of quadrangles $(\lambda\lambda')_1$, and the collinear points $\overline{A}, \ldots \overline{A}_1 \ldots$ those of the axes of the collinear system $(\lambda\lambda')_2$. The whole set of 32 points which can be derived from A by linear transformation, viz. four cotangential points and their collinears, and the inverses of these eight points in each of the three correspondences, are called by Harnack the 32 collineations of the curve.

SECTION 5.—The squares of the coordinates of points on uv are systems of four quantities connected by two homogeneous linear relations, just as the coordinates of points on a line are. Hence the same algebraic relations hold among the two systems. Thus, for example, if 1, 2, 3, 4 be any four points on UV, $x_3^2 = kx_1^2 + lx_2^2$, $y_3^2 = ky_1^2 + ly_2^2$, &c.

Hence $(y_1^2z_2^2 - y_2^2z_1^2)(x_3^2w_4^2 - x_4^2w_3^2) = (x_1^2w_2^2 - x_2^2w_1^2)(y_3^2z_4^2 - y_4^2z_3^2)$ (1)

If the four points lie in a plane, $ps' + p's = 0$. (§ 3.)

i.e. $(y_1z_2 - y_2z_1)(x_3w_4 - x_4w_3) = -(x_1w_2 - x_2w_1)(y_3z_4 - y_4z_3)$. (2)

Dividing (1) by (2)

$$(y_1z_2 + y_2z_1)(x_3w_4 + x_4w_3) = -(x_1w_2 + x_2w_1)(y_3z_4 + y_4z_3). \quad (3)$$

Adding and subtracting (2) and (3)

$$\left.\begin{aligned} y_1z_2x_3w_4 + y_2z_1x_4w_3 + y_3z_4x_1w_2 + y_4z_3x_2w_1 = 0 \\ y_1z_2x_4w_3 + y_2z_1x_3w_4 + y_3z_4x_2w_1 + y_4z_3x_1w_2 = 0 \end{aligned}\right\} \quad (4)$$

with two other pairs formed from the groupings zx, yw; xy, zw, giving 6 equations which hold between the coordinates of four coplanar points on UV.

In general, the condition that four points shall lie on a plane is the vanishing of the determinant $(x_1y_2z_3w_4)$. This determinant is formed of six blocks, each containing four terms, all affected with the same sign. If the points lie on UV, each of these blocks vanishes separately.

A more symmetrical relation between the coordinates of four coplanar points is $\Sigma f'(a) \, . \, x_1x_2x_3x_4 = 0$.

It may be obtained as follows:—

If four points 1, 2, 3, 4 lie in a plane, the chords (12), (34) are generators of the same quadric (λ); hence, (1, 2) and (3, 4) are conjugates with respect to that quadric, and $\Sigma(\lambda - a)x_1x_2 = 0$, $\Sigma(\lambda - a)x_3x_4 = 0$ or the plane $P \equiv \Sigma(\lambda - a)x$ contains the points $x_{12} = x_1x_2$, and $x_{34} = x_3x_4$. This plane touches the quadric $\Sigma f'(a) \, . \, x^2 \equiv S$, for all values of λ since $\Sigma \dfrac{\overline{\lambda - a}|^2}{f'(a)} \equiv 0$. Hence it contains two generators of S. One of these is the intersection of the planes $\Sigma x = 0$, $\Sigma ax = 0$, and is fixed. The other varies with λ.

If the parameters of 1, 2, 3, 4 be μ_1, μ_2, μ_3, μ_4,

$$\Sigma f'(a) \, . \, x_{12}^2 = \Sigma \frac{\overline{\mu_1 - a} \, . \, \overline{\mu_2 - a}}{f'(a)} \equiv 0, \text{ and } \Sigma f'(a) \, . \, x_{34}^2 = \Sigma \frac{\overline{\mu_3 - a} \, . \, \overline{\mu_4 - a}}{f'(a)} \equiv 0.$$

Hence S contains the points x_{12}, x_{34}. These points must lie on the variable generator common to S and P, since they do not satisfy the equations $\Sigma x = 0$, $\Sigma ax = 0$. Hence they are conjugate with respect to S, and

$$\Sigma f'(a) x_{12}x_{34} \equiv \Sigma f'(a) x_1x_2x_3x_4 = 0.$$

This condition is satisfied if the chords (12) (34) are generators of the same quadric (λ), whether they be of the same, or of opposite systems.

SECTION 6.—If A (x', y', z', w') and A' $(x', -y', -z', w')$ be a pair of corresponding points of the first kind, the coordinates of the line AA' are

$$p = 0,\ q = z'x',\ r = -x'y',\ s = 0,\ t = y'w',\ u = z'w'. \qquad (1)$$

Hence all such lines meet the two opposite edges yz, xw, of the tetrahedron of reference, and the line through a point A on UV which meets these edges passes through the corresponding point A', since only one line can be drawn through a point to meet two non-intersecting lines.

Hence, if a quadric F have these two edges as generators of one system, it meets UV in four pairs of corresponding points which lie on four generators of the other system.

If $p', q' \ldots$ be the coordinates of any transversal of AA', BB', CC', the ratios $q' : t' : r' : u'$ are constant. For they satisfy three linear relations expressing that the line meets three lines for which p and q vanish. Hence, the equation of F is $q'yw + t'zx + r'zw = u'xy$, where $p', q' \ldots$ are the coordinates of any generator of F of the same system as the lines yz, xw. For it is of this form, since yz, xw are generators, and the coordinates of the line AA' are $q = z'x'$, $r = -x'y'$, $t = y'w'$, $u = z'w'$, so that the equation is satisfied for the points A, B, C.

If we form the discriminant of $k(\lambda U - V) - 2F$, it is easily seen that $\Theta = 0$, $\Theta' = 0$ for any quadric F and any quadric (λ), so the two systems are doubly apolar.

If four points $ABCD$ lie in a plane, and if we take two triads of points ABC'', $A'B'C'''$, the planes $BC''A''D$, $B'C'''A''D$; $C''AB''D$, $C'''A'B''D$; $ABCD$, $A'B'CD$ are cut by any plane in two triangles whose sides intersect in pairs in the points in which the plane meets the lines $A''D$, $B''D$, CD. But $A''B''CD$ lie in a plane (§ 3) $\therefore$ the triangles are in perspective. Hence the lines joining corresponding vertices pass through a point, i.e. the lines AA', BB', $C''C'''$ meet a line passing through D. Hence AA', BB', $C''C'''$, DD' are all generators of the same quadric F. Hence, if four points lie in a plane, the lines joining any three of them to their corresponding points, with the line joining the cotangential corresponding points of the fourth, are generators of the same quadric F.

SECTION 7.—We will call the line joining a pair of corresponding points 1 and 1′, whose coordinates are (x_1, y_1, z_1, w_1), $(x_1, -y_1, -z_1, w_1)$, the "connector" $\{1, 1'\}$. The coordinates of any point (k, l) on this connector are $x = (k+l)x_1$, $y = (k-l)y_1$, $z = (k-l)z_1$, $w = (k+l)w_1$. Since x_1, y_1, z_1, w_1 satisfy the equations $U = 0$, $V = 0$, x, y, z, w satisfy the equations

$$\frac{x^2 + w^2}{(k+l)^2} + \frac{y^2 + z^2}{(k-l)^2} = 0, \qquad \frac{ax^2 + \delta w^2}{(k+l)^2} + \frac{\beta y^2 + \gamma z^2}{(k-l)^2} = 0.$$

Eliminating k, l, the equation of the surface generated by the connectors in the first correspondence is

$$\Phi = (\gamma - \alpha)\, z^2x^2 + (\beta - \delta)\, y^2w^2 + (\beta - \alpha)\, x^2y^2 + (\gamma - \delta)\, z^2w^2 = 0. \qquad (2)$$

This surface is of the type described (Salmon, *Analytic Geometry of Three Dimensions*), being generated by the lines which meet two lines and a quartic curve.

The lines xw, yz, which are the directing lines, are double lines on the surface, since they are met at every point by two intersecting generators.

Taking, for the moment, $XYZW$ as running coordinates, the tangent plane at the point $(xyzw)$ is

$$X\Phi_1 + Y\Phi_2 + Z\Phi_3 + W\Phi_4 = 0;$$

or

$$\{(\gamma - \alpha)\, z^2 + (\beta - \alpha)\, y^2\}\, xX + \{(\beta - \delta)\, y^2 + (\gamma - \delta)\, z^2\}\, wW$$
$$+ \{(\beta - \delta)\, w^2 + (\beta - \alpha)\, x^2\}\, yY + \{(\gamma - \alpha)\, x^2 + (\gamma - \delta) w^2\}\, zZ = 0.$$

Putting in the values $x = (k + l)\, x_1$, &c., the equation becomes

$$(k - l)^2 (k + l)\,[\{\beta y_1^2 + \gamma z_1^2 - \alpha\, (y_1^2 + z_1^2)\}\, xX + \{\beta y_1^2 + \gamma z_1^2 - \delta\, (y_1^2 + z_1^2)\}\, wW]$$
$$+ (k + l)^2\, (k - l)\,[\{\beta\, (x_1^2 + w_1^2) - \alpha x_1^2 - \delta w_1^2\}\, yY + \{\gamma\, (x_1^2 + w_1^2) - \alpha x_1^2 - \delta w_1^2\}\, zZ].$$

Substituting from $U_1 = 0$, $V_1 = 0$,

$$\beta y_1^2 + \gamma z_1^2 - \alpha\, (y_1^2 + z_1^2) = (\alpha - \delta)\, w_1^2, \text{ \&c.}$$

Dividing by $k^2 - l^2$,

$$(k - l)\,(\alpha - \delta)\, x_1 w_1\, (w_1 X - x_1 W) - (k + l)\,(\beta - \gamma)\,(z_1 Y - y_1 Z) = 0. \qquad (3)$$

is the equation of the tangent plane to Φ at the point (k, l) on the connector $\{1, 1'\}$.

Since $w_1X - x_1W$, $z_1Y - y_1Z$ are the planes joining the connector to the double lines, the tangent plane at any point on a connector passes through the connector, and the tangent planes through a connector are homographic with their points of contact, as is the case with all ruled surfaces.

If we identify (3) with the plane $lx + my + nz + dw = 0$, we get the tangential equation of Φ,

$$(\gamma - \alpha)\, m^2d^2 + (\beta - \delta)\, l^2n^2 + (\beta - \alpha)\, n^2d^2 + (\gamma - \delta)\, l^2m^2 = 0.$$

If the tangent planes to a quadric at points 1, 2 on a generator are P_1 and P_2, the tangent plane at the point $kx_1 + lx_2$ is $kP_1 + lP_2$. The tangent planes at the points 1, 1′ through the connector $\{1, 1'\}$ to the quadric of which the connector is a generator are

$$p_1\, (w_1x - x_1w) - s_1\, (z_1y - y_1z) \equiv P_1 \quad \text{and} \quad p_1\, (w_1x - x_1w) + s_1\, (z_1y - y_1z) \equiv P_{1'},$$

where p_1, &c., are the coordinates of the tangent to UV at the point 1. For these planes pass through the connector $\{1, 1'\}$, and are evidently satisfied by the coordinates of any point on the tangents to UV at 1 and 1′ respectively. But (§ 2 (8)) $p_1 = (a - \delta) x_1 w_1$, $s_1 = (\beta - \gamma) y_1 z_1$. Hence the tangent plane at the point (k', l') on the connector $\{1, 1'\}$, to the quadric of which it is a generator, is

$$(k' + l')(a - \delta) x_1 w_1 (w_1 x - x_1 w) - (k' - l')(\beta - \gamma) y_1 z_1 (z_1 y - y_1 z) = 0. \qquad (4)$$

If we identify this plane with (3) above, we find

$$(k + l)(k' + l') = (k - l)(k' - l'), \quad \text{or} \quad kl' + k'l = 0.$$

Hence the points of contact of any plane through a connector with the quadric of which it is a generator, and with Φ, are harmonic with the points in which the connector meets UV.

The equation of a plane through a connector $\{1, 1'\}$ and the point 2 is

$$p_{12}(w_1 x - x_1 w) - s_{12}(z_1 y - y_1 z) = P.$$

where

$$p_{12} = y_1 z_2 - y_2 z_1, \quad s_{12} = x_1 w_2 - w_1 x_2.$$

The plane through the corresponding connector $\{1'', 1'''\}$ and the point 2 is derived from this by changing the signs of x_1, z_1. It is

$$p'_{12}(w_1 x + x_1 w) - s'_{12}(z_1 y + y_1 z) = P',$$

where

$$p'_{12} = y_1 z_2 + y_2 z_1, \quad s'_{12} = x_1 w_2 + x_2 w_1.$$

If P, P' meet any other connector $\{3, 3'\}$ in the points (k, l), (k', l')

$$(k + l) p_{12} s_{13} = (k - l) s_{12} p_{13}; \quad (k' + l') p'_{12} s'_{13} = (k' - l') s'_{12} p'_{13}.$$

But, writing 1 for 4 in § 5 (1),

$$p_{12} p'_{12} \cdot s_{13} s'_{13} = p_{13} p'_{13} \cdot s_{12} s'_{12} \therefore (k + l)(k' + l') = (k - l)(k' - l'), \quad \text{or} \quad kl' + k'l = 0.$$

Hence the planes joining any pair of corresponding connectors $\{1, 1'\}$, $\{1'', 1'''\}$ to any point on UV meet any connector in a pair of points which are harmonic with the points in which the connector meets UV.

In particular, if four connectors $aa'a''a'''$ be the collinear axes of a quadrangle $PP'LL'$ (see fig. 3), the plane PLL' cuts the four connectors in the points in which the planes joining them to P touch the quadrics (λ) (λ'), of which $aa'a''a'''$ are generators. Hence the plane $PL''L'''$ cuts them in the points of contact of these planes with Φ. Hence, if four such connectors be joined by planes to a point P on UV the points of contact with Φ of these planes lie in a plane passing through P, and also through the corresponding connector $L''L'''$ to LL', where $PP'LL'$ form a quadrangle of which the four connectors are the collinear axes. In consequence of this property, four such connectors may be called *cotangential* connectors.

SECTION 8.—The surface Φ and the two other surfaces which are similarly related to the second and third correspondences are the limiting surfaces (surfaces limitées) of a system of surfaces of the eighth order which have been studied by de la Gournerie* under the name of quadricuspidal surfaces. These again, as will be shown, are the limiting surfaces of a system of the sixteenth order. These systems may be derived as follows:—

If a plane $ax + by + cz + dw = 0$ touch the three quadrics (λ), (μ), (ν) its coordinates satisfy the three conditions

$$\Sigma \frac{a^2}{\lambda_a} = 0, \quad \Sigma \frac{a^2}{\mu_a} = 0, \quad \Sigma \frac{a^2}{\nu_a} = 0.$$

Hence

$$a^2 : b^2 : c^2 : d^2 = \frac{\lambda_a \mu_a \nu_a}{f'(a)} : \frac{\lambda_\beta \mu_\beta \nu_\beta}{f'(\beta)} : \frac{\lambda_\gamma \mu_\gamma \nu_\gamma}{f'(\gamma)} : \frac{\lambda_\delta \mu_\delta \nu_\delta}{f'(\delta)}. \qquad (1)$$

If $(pqrstu)$ be the coordinates of a generator of (ν) then (§ 2)

$$s = 2\theta\sqrt{\nu_{\beta\gamma}}, \quad t = (1 - \theta^2)\sqrt{\nu_{\gamma a}}, \quad u = i(1 + \theta^2)\sqrt{\nu_{a\beta}}.$$

If the generator lies in the plane, $as + bt + cu = 0$, or

$$\left\{2\theta \sqrt{\frac{\lambda_a \mu_a}{f'(a)}} \pm (1 - \theta^2)\sqrt{\frac{\lambda_\beta \mu_\beta}{f'(\beta)}} \pm i(1 - \theta^2)\sqrt{\frac{\lambda_\gamma \mu_\gamma}{f'(\gamma)}}\right\}\sqrt{\nu_{a\beta\gamma}} = 0. \qquad (2)$$

Hence the values of θ are independent of ν, being, in fact, the parameters of the generators of (μ) which meet in a point λ on UV or of the generators of (λ) which meet in a point μ, as can be seen at once from (7), § 2.

The equation of the surface generated by these generators when λ and μ are fixed and ν is variable, is given by eliminating ν between the equations $ax + by + cz + dw = 0$ and $\nu \div \frac{U}{V}$. Hence, from (1), it is

$$\frac{x}{\sqrt{f'a}}\sqrt{\lambda_a \mu_a (V - aU)} \pm \frac{y}{\sqrt{f'\beta}}\sqrt{\lambda_\beta \mu_\beta (V - \beta U)} \pm \frac{z}{\sqrt{f'\gamma}}\sqrt{\lambda_\gamma \mu_\gamma (V - \gamma U)} = 0 \qquad (3)$$

which, when rationalised, gives

$$\Xi \equiv \left\{\Sigma\left(\frac{\lambda_a \mu_a}{f'_a}\right)^2 x^4 (V - aU)^2 - 2\Sigma\frac{\lambda_{\beta\gamma}\mu_{\beta\gamma}}{f'_\beta f'_\gamma} y^2 z^2 (V - \beta U)(V - \gamma U)\right\}^2$$

$$- 64 \frac{\Delta_\lambda \Delta_\mu}{\pi^2} x^2 y^2 z^2 w^2 . (V - aU)(V - \beta U)(V - \gamma U)(V - \delta U). \qquad (4)$$

as the surface generated by the generators of quadrics of the system $\lambda v - \nu$, which lie in the tangent planes to the developable circumscribing (λ) and (μ).

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* De la Gournerie, "Recherches sur les surfaces reglées-tétraèdrales symétriques." Paris, 1867 Compare also Matthews, P.L.M.S.

Now, let the quadric (μ) be the cone (δ). Then Eq. (3) becomes

$$x \cdot \sqrt{\beta - \gamma . \lambda - \alpha . V - \alpha U} \pm y \sqrt{\gamma - \alpha . \lambda - \beta . V - \beta U}$$
$$\pm z \sqrt{\alpha - \beta . \lambda - \gamma . V - \gamma U} = 0, \qquad (5)$$

which, when rationalised, is

$$\Psi \equiv \Sigma x^4 (\beta - \gamma)^2 (\lambda - \alpha)^2 (V - \alpha U)^2$$
$$- 2\Sigma y^2 z^2 (\gamma - \alpha)(\alpha - \beta)(\lambda - \beta)(\lambda - \gamma)(V - \beta U)(V - \gamma U). \qquad (6)$$

This system of surfaces constitutes the quadricuspidal surfaces of de la Gournerie.*

Let λ also coincide with δ. (5) now becomes

$$x\sqrt{L(V - \alpha U)} \pm y\sqrt{M(V - \beta U)} \pm z\sqrt{N(V - \gamma U)} = 0,$$

which is the equation of the developable generated by tangents to UV. In fact, the generators now become the generators of quadrics of the system which lie in tangent planes to the cone (δ). But we have seen (§ 3) that these are the tangent lines to UV.

If λ coincides with one of the other cones, say (α), the equation becomes

$$y\sqrt{\gamma - \alpha . \alpha - \beta . V - \beta U} \pm z\sqrt{\alpha - \beta . \alpha - \gamma . V - \gamma U} = 0$$

or

$$y^2\{(\alpha - \beta)x^2 + (\gamma - \beta)z^2 + (\delta - \beta)w^2\} + z^2\{(\alpha - \gamma)x^2 + (\beta - \gamma)y^2 + (\delta - \gamma)w^2\} = 0,$$

which is identical with Φ. In fact, the generators now are those which lie in planes passing through the vertices of the cones (δ) and (α), or through the line $y = 0$, $z = 0$.

SECTION 9.—*The canonical form of uv.*

If v, v' be the roots of

$$u_\lambda = (\beta + \gamma - \alpha - \delta)\lambda^2 - 2(\beta\gamma - \alpha\delta)\lambda + \beta\gamma(\alpha + \delta) - \alpha\delta(\beta + \gamma) = 0,$$

since the quadratic factors $\lambda - \alpha . \lambda - \delta$, $\lambda - \beta . \lambda - \gamma$, of $f(\lambda)$ are both harmonic with u_λ, we have the relations

$$\frac{v' - \alpha}{v - \alpha} + \frac{v' - \delta}{v - \delta} = 0, \qquad \frac{v' - \beta}{v - \beta} + \frac{v' - \gamma}{v - \gamma} = 0. \qquad (1)$$

If we take as fundamental quadrics, instead of U and V, U_0 and V_0, where

$$U_0 = vU - V, \qquad V_0 = v'U - V;$$

and write

$$X^2 = (v - \alpha)x^2, \qquad Y^2 = (v - \beta)y^2, \text{ \&c.},$$

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* De la Gournerie, "Recherches sur les surfaces reglées-tétraèdrales symétriques." Paris, 1867. Compare also Matthews, P.L.M.S,

the curve UV is the intersection of the quadrics

$$U_0 = X^2 + Y^2 + Z^2 + W^2, \quad V_0 = \xi (X^2 - W^2) + \eta (Y^2 - Z^2), \tag{2}$$

where

$$\xi = \frac{v' - a}{v - a} = -\frac{v' - \delta}{v - \delta}, \quad \eta = \frac{v' - \beta}{v - \beta} = -\frac{v' - \gamma}{v - \gamma}, \tag{3}$$

and the discriminant is

$$D(\lambda) = (\lambda^2 - \xi^2)(\lambda^2 - \eta^2). \tag{4}$$

The equations (2) may be called the canonical form of the curve UV.

In the discriminant $D(\lambda)$ the coefficients of λ^3 and λ vanish. These are the invariants Θ, Θ' of the quadrics U_0 and V_0. Hence these quadrics are doubly apolar, and a skew quadrilateral can be inscribed in either, two pairs of opposite edges of which are generators of the other. These quadrics, with the two other pairs which are similarly related to v_λ and u_λ, have been called the Vossian quadrics of the system.*

Conversely, if the discriminant of $\lambda U - V$ have the canonical form (4), U and V are a pair of Vossian quadrics. For the roots of u_λ are then zero and infinity, and these values of λ give the quadrics V and U respectively.

It is convenient to express the coefficients of V_0 in terms of the roots e_1, e_2, e_3 of the reducing cubic of $D(\lambda)$.

From (3) above

$$\frac{\xi + \eta}{\xi - \eta} = \frac{\dfrac{v' - a}{v - a} + \dfrac{v' - \beta}{v - \beta}}{\dfrac{v' - a}{v - a} - \dfrac{v' - \beta}{v - \beta}} = 2 \cdot \frac{vv' - \frac{1}{2}(a + \beta)(v + v') + a\beta}{(v - v')(a - \beta)}.$$

Substituting the values of v, v' from the equation $u_\lambda = 0$,

$$\frac{\xi + \eta}{\xi - \eta} = \sqrt{\frac{a - \gamma \cdot \beta - \delta}{a - \beta \cdot \gamma - \delta}} = \sqrt{\frac{-M}{N}}.$$

If

$$\sqrt{e_1 - e_3} = m, \quad \sqrt{e_1 - e_2} = n, \quad m^2 = -\tfrac{1}{4}M, \quad n^2 = \tfrac{1}{4}N. \tag{5}$$

$$\therefore \quad \frac{m}{n} = \sqrt{\frac{-M}{N}} = \frac{\xi + \eta}{\xi - \eta}, \quad \text{or} \quad \frac{\xi}{\eta} = \frac{m + n}{m - n}.$$

and the equations of UV in its canonical form are

$$U_0 \equiv X^2 + Y^2 + Z^2 + W^2 = 0,$$

$$V_0 \equiv (m + n)(X^2 - W^2) + (m - n)(Y^2 - Z^2) = 0. \tag{6}$$

From (2) and (4), since the coefficients of the discriminant are invariants, it follows that if two quadrics U, V, whose equations are given in any form, are doubly apolar, the canonical form of their curve of intersection can be at once written down in the form (2), where $\pm \xi$, $\pm \eta$ are the roots of the discriminant of $\lambda U - V$.

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* Voss, Math. Ann., Bd. x. See also Kluyver, American Journal of Mathematics, vol. xix.

SECTION 10.—*Elliptic Parameters.*

Let $u = \int_\delta^\lambda \frac{d\lambda}{\sqrt{f(\lambda)}}$ and let $\Omega_t = 4(t - e_1)(t - e_2)(t - e_3)$ be the reducing cubic of $f(\lambda)$. The roots of Ω_t, regarded as a quartic with an infinite root, are homographic with those of $f(\lambda)$, since the anharmonic ratio of both is the same. If λ, t be correspondents in this homography, $(\lambda, a, \beta, \gamma, \delta) = (t, e_1, e_2, e_3, \infty)$;

$$\therefore \quad \frac{\lambda - a \,.\, \beta - \delta}{\lambda - \delta \,.\, \beta - a} = \frac{t - e_1 \,.\, e_2 - \infty}{t - \infty \,.\, e_2 - e_1}; \quad \therefore \quad t - e_1 = \frac{(e_1 - e_2)(\beta - \delta)}{a - \beta} \frac{\lambda - a}{\lambda - \delta}$$

$$= \frac{1}{4}\beta - \delta \,.\, \gamma - \delta \,.\, \frac{\lambda - a}{\lambda - \delta} = \cdot \frac{1}{4}(\gamma - a)(a - \beta)\frac{f'(\delta)}{f'(a)} \cdot \frac{\lambda - a}{\lambda - \delta}.$$

Similarly,

$$t - e_2 = \frac{1}{4}(a - \beta)(\beta - \gamma)\frac{f'(\delta)}{f'(\beta)} \cdot \frac{\lambda - \beta}{\lambda - \delta}, \quad t - e_3 = \frac{1}{4}(\beta - \gamma)(\gamma - a)\frac{f'(\delta)}{f'(\gamma)} \cdot \frac{\lambda - \gamma}{\lambda - \delta},$$

and

$$\frac{d\lambda}{\sqrt{f(\lambda)}} = - \frac{dt}{\sqrt{\Omega_t}}; \quad \therefore \quad u = \int_\delta^\lambda \frac{d\lambda}{\sqrt{f(\lambda)}} = \int_t^\infty \frac{dt}{\sqrt{\Omega_t}} \quad \text{or} \quad t = pu.$$

Hence

$$\frac{x^2}{w^2} = \frac{4(pu - e_1)}{\gamma - a \,.\, a - \beta}, \quad \frac{y^2}{w^2} = \frac{4(pu - e_2)}{a - \beta \,.\, \beta - \gamma}, \quad \frac{z^2}{w^2} = \frac{4(pu - e_3)}{\beta - \gamma \,.\, \gamma - a}$$

is the parametric representation to the coordinates of UV.

Applying this representation to the canonical form (§9 (6))

$$\frac{X^2}{W^2} = - \frac{pu - e_1}{mn}, \quad \frac{Y^2}{W^2} = \frac{pu - e_2}{n(m - n)}, \quad \frac{Z^2}{W^2} = - \frac{pu - e_3}{m(m - n)}.$$

Let

$$\sqrt{pu - e_1} = \frac{\sigma_1 u}{\sigma u} = \theta u, \quad \sqrt{pu - e_2} = \frac{\sigma_2 u}{\sigma u} = \phi u, \quad \sqrt{pu - e_3} = \frac{\sigma_3 u}{\sigma u} = \psi u,$$

we may take the equations

$$\frac{X}{W} = \frac{-i\theta u}{\sqrt{mn}}, \quad \frac{Y}{W} = \frac{\phi u}{\sqrt{n(m - n)}}, \quad \frac{Z}{W} = \frac{i\psi u}{\sqrt{m(m - n)}}, \tag{1}$$

as the parametric representation of the coordinates in the canonical form.

The following relations connect the functions θ, ϕ, ψ. If $l \sqrt{e_2 - e_3}$,

$$\psi^2 - \phi^2 = l^2, \quad \psi^2 - \theta^2 = m^2, \quad \phi^2 - \theta^2 = n^2, \quad m\phi^2 + n\psi^2 = (m + n)(\theta^2 + mn)$$

$$m\phi^2 - n\psi^2 = (m - n)(\theta^2 - mn). \tag{2}$$

Also, since $\phi' u = - 2\theta\phi\psi$,

$$\frac{d\theta}{du} = - \phi\psi, \quad \frac{d\phi}{du} = - \theta\psi, \quad \frac{d\psi}{du} = - \theta\phi. \tag{3}$$

The addition theorem is (Greenhill, p. 268)

$$\theta(u+v) = \frac{\theta v\phi u . \psi u - \theta u\phi v\psi v}{\theta^2 u - \theta^2 v},$$

$$\phi(u+v) = \frac{\phi v . \theta u\psi u - \phi u\theta v\psi v}{\phi^2 u - \phi^2 v}, \qquad (4)$$

$$\psi(u+v) = \frac{\psi v . \theta u\phi u - \psi u\theta v\phi v}{\psi^2 u - \psi^2 v}.$$

The denominators being all equal to $pu - pv$.

The addition of the half periods can be made by contour integration. The following method is due to Mr. R. Russell. It is assumed that e_1, e_2, e_3 are real, and $e_1 > e_2 > e_3$ so that l, m, n are all real. Since $(e_1 e_2 e_3 \infty) = (\infty e_3 e_2 e_1) = (e_3 \infty e_1 e_2)$, if x, ξ_1, ξ_2 be correspondents in the homographic systems determined by the roots of Ω_t taken in these three orders,

$$(x e_1 e_2 e_3 \infty) = (\xi_1 \infty e_3 e_2 e_1) = (\xi_2 e_3 \infty e_1 e_2). \qquad (1)$$

The AR of any four elements in any one of these systems is equal to that of the corresponding four in either of the others. Thus $(x e_1 e_2 \infty) = (\xi_1 \infty e_3 e_1) = (e_3 e_1 \xi_1 \infty)$,

$$\therefore \frac{\xi_1 - e_1}{e_1 - e_3} = \frac{e_2 - e_1}{e_2 - x} = \frac{e_1 - e_2}{x - e_1}, \quad \frac{\xi_1 - e_3}{e_1 - e_3} = \frac{x - e_2}{x - e_1}, \quad \frac{\xi_1 - e_2}{e_1 - e_2} = \frac{x - e_3}{x - e_1}, \qquad (2)$$

and $(x e_1 e_2 \infty) = (\xi_2 e_3 \infty e_2) = (e_3 \xi_2 e_2 \infty)$,

$$\therefore \frac{\xi_2 - e_2}{e_2 - e_3} = \frac{e_1 - e_2}{e_2 - x}, \quad \text{or} \quad \sqrt{e_2 - \xi_2} = \frac{\sqrt{e_1 - e_2 . e_1 - e_3}}{\sqrt{x - e_2}},$$

$$\frac{\xi_2 - e_3}{e_2 - e_2} = \frac{e_1 - x}{e_2 - x}, \quad \text{or} \quad \sqrt{\xi_2 - e_3} = \sqrt{(e_2 - e_3)}\sqrt{\frac{x - e_1}{x - e_2}}, \qquad (3)$$

and

$$\frac{\xi_2 - e_1}{e_2 - e_3} = \frac{e_1 - x}{ex - e_2}, \quad \text{or} \quad \sqrt{e_1 - \xi_2} = \sqrt{e_2 - e_3} . \sqrt{\frac{x - e_3}{x - e_3}};$$

also

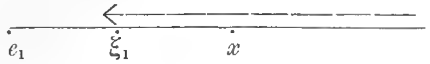
$$\int_\infty^x \frac{dx}{2\sqrt{x - e_1 . x - e_2 . x - e_3}} = \int_{\xi_1}^{e_1} \frac{d\xi_1}{2\sqrt{\xi_1 - e_1 . \xi_1 - e_2 . \xi_1 - e_3}} =$$

$$\int_{e_2}^{\xi_2} \frac{d\xi_2}{2\sqrt{e_1 - \xi_2 . e_2 - \xi_2 . \xi_2 - e_3}} = -u. \qquad (4)$$

Let $-U$ represent the contour integral round any chosen path, starting from ∞, $-\omega_1$ is the linear integral from ∞ to e, $-\omega_2$ is the integral whose path is from ∞ to e_1, round a half circle in the positive direction round e_1 and on to e_2. $\omega_1 + \omega_2 + \omega_3 = 0$.

1°. If $-U$ be the integral round an infinite circle in the positive direction of rotation, the integrand becomes affected by the factor $\varepsilon^{-3i\pi}$, and the integral changes sign. The functions θ, ϕ, ψ are each affected by the factor $e^{+i\pi}$, and also change sign. Hence θ, ϕ, ψ are all odd functions.

2°. For the contour



$-U = -\omega_1 + u$, $U = \omega_1 - u$ from (4). Hence, since $x = pu$ and $\xi_1 = pU$, from (2),

$$\theta(\omega_1 - u) = \frac{mn}{\theta u}, \quad \phi(\omega_1 - u) = \frac{n\psi u}{\theta u}, \quad \psi(\omega_1 - u) = \frac{m\phi u}{\theta u}. \tag{5}$$

3°. For the contour

$$-U = -\omega_2 + e^{-i\pi}\int \frac{d\xi_2}{2\sqrt{e_1 - \xi_2 \,.\, e_2 - \xi_2 \,.\, \xi_2 - e_3}} = -\omega_2 + u, \quad \text{from (4)}$$

$$\therefore \quad U = \omega_2 - u, \quad \xi_2 = pu, \quad \therefore \quad \text{from (3)},$$

since θ, ϕ are each affected by the factor $e^{\frac{i\pi}{2}}$,

$$\theta(\omega_2 - u) = \frac{in\psi u}{\phi u}, \quad \phi(\omega_2 - u) = \frac{iln}{\phi u}, \quad \psi(\omega_2 - u) = l\,.\,\frac{\theta u}{\phi u}. \tag{6}$$

Changing the sign of u in (5) and (6),

$$\theta(\omega_1 + u) = -\frac{mn}{\theta u}, \quad \phi(\omega_1 + u) = \frac{n\phi u}{\theta u}, \quad \psi(\omega_1 + u) = \frac{m\phi u}{\theta u}. \tag{7}$$

$$\theta(\omega_2 + u) = in\,.\,\frac{\psi u}{\phi u}, \quad \phi(\omega_2 + u) = -i\frac{ln}{\phi u}, \quad \psi(\omega_1 + u) = l\,.\,\frac{\theta u}{\phi u}. \tag{8}$$

Also, since $\omega_3 + u = -(\omega_2 + \omega_1 - u)$, substituting from (8) and (5)

$$\theta(\omega_3 + u) = -im\frac{\phi u}{\psi u}, \quad \phi(\omega_3 + u) = il\frac{\theta u}{\psi u}, \quad \psi(\omega_3 + u) = -\frac{lm}{\psi u}. \tag{9}$$

Writing $\omega_1 + u$ for u in (7), $\omega_2 + u$ for u in (8), $\omega_3 + u$ for u in (9),

$$\begin{aligned}
&\theta(2\omega_1 + u) = \theta u, &&\phi(2\omega_1 + u) = -\phi u, &&\psi(2\omega_1 + u) = -\psi u;\\
&\theta(2\omega_2 + u) = -\theta u, &&\phi(2\omega_2 + u) = \phi u, &&\psi(2\omega_2 + u) = -\psi u;\\
&\theta(2\omega_3 + u) = -\theta u, &&\phi(2\omega_3 + u) = -\phi u, &&\psi(2\omega_3 + u) = \psi u.
\end{aligned} \tag{10}$$

Thus $2\omega_1$ is a period of θ, $2\omega_2$ a period of ϕ, $2\omega_3$ a period of ψ.
The double periods $4\omega_1$, $4\omega_2$, $4\omega_3$ are periods of all three.
As u tends to zero. θ, ϕ, ψ tends to unity. Hence we have

$$\begin{aligned}
&\theta\omega_1 = o, &&\phi\omega_1 = n, &&\psi\omega_1 = m;\\
&\theta\omega_2 = in &&\phi\omega_2 = o, &&\psi\omega_2 = l;\\
&\theta\omega_3 = im &&\phi\omega_3 = il, &&\psi\omega_3 = o.
\end{aligned} \tag{11}$$

The functions of the half angles will also be required.

Starting with the formula

$$p\tfrac{1}{2}u = pu + \sqrt{pu - \varepsilon_2 \,.\, pu - \varepsilon_3} + \sqrt{pu - \varepsilon_3 \,.\, pu - \varepsilon_1} + \sqrt{pu - \varepsilon_1 \,.\, pu - \varepsilon_2}\,;^{*}$$

$$\left.\begin{aligned} \theta\tfrac{1}{2}u &= \sqrt{p\tfrac{1}{2}u - \varepsilon_1} = \sqrt{\theta^2 + \phi\psi + \theta\phi + \theta\psi} = \sqrt{\theta + \phi \,.\, \theta + \psi}\,; \\ \phi\tfrac{1}{2}u &= \sqrt{\phi + \theta \,.\, \phi + \psi}\,; \\ \psi\tfrac{1}{2}u &= \sqrt{\psi - \theta \,.\, \psi - \phi}. \end{aligned}\right\} \quad (12)$$

From the addition theorem (4), since

$$l = \sqrt{\psi^2 - \phi^2}, \quad m = \sqrt{\psi^2 - \theta^2}, \quad n = \sqrt{\phi^2 - \theta^2},$$

$$\theta(\tfrac{1}{2}u + \omega_1) = \frac{\theta\omega_1\phi\tfrac{1}{2}u\psi\tfrac{1}{2}u - \theta\tfrac{1}{2}u\phi\omega_1\psi\omega_1}{\theta^2\tfrac{1}{2}u - \theta^2\omega_1} = -\frac{mn}{\theta\tfrac{1}{2}u} = -\frac{\sqrt{\psi^2 - \theta^2 \,.\, \phi - \theta^2}}{\sqrt{\phi + \theta \,.\, \psi + \theta}}\,;$$

or

$$\left.\begin{aligned} \theta(\tfrac{1}{2}u + \omega_1) &= -\sqrt{\psi - \theta \,.\, \phi - \theta}. \end{aligned}\right.$$

Similarly

$$\left.\begin{aligned} \phi(\tfrac{1}{2}u + \omega_1) &= \sqrt{\phi + \theta \,.\, \psi + \phi}, \\ \psi(\tfrac{1}{2}u + \omega_1) &= \sqrt{\psi - \theta \,.\, \psi + \phi}. \end{aligned}\right\} \quad (13)$$

$$\left.\begin{aligned} \theta(\tfrac{1}{2}u + \omega_2) &= i\sqrt{\psi + \theta \,.\, \phi - \theta}, \\ \phi(\tfrac{1}{2}u + \omega_2) &= -i\sqrt{\phi - \theta \,.\, \psi - \phi}, \\ \psi(\tfrac{1}{2}u + \omega_2) &= \sqrt{\psi + \theta \,.\, \psi - \phi}. \end{aligned}\right\} \quad (14)$$

$$\left.\begin{aligned} \phi(\tfrac{1}{2}u + \omega_3) &= -i\sqrt{\psi - \theta \,.\, \phi + \theta} \\ \phi(\tfrac{1}{2}u + \omega_3) &= i\,.\sqrt{\psi - \phi \,.\, \phi + \theta} \\ \psi(\tfrac{1}{2}u + \omega_3) &= -\sqrt{\psi - \theta \,.\, \phi - \theta} \end{aligned}\right\} \quad (15)$$

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* This formula can be readily derived from Hermite's transformation (Greenhill, p. 150). If $z = -\dfrac{H_x}{\Omega_x}$, where $\Omega_x = 4x^3 - g_2x - g_3$, roots e_1, e_2, e_3, and H_x is the Hessian of Ω_x, regarded as a quartic $\dfrac{dz}{\sqrt{\Omega_z}} = \dfrac{dx}{2\sqrt{\Omega_x}}$, or, if $z = pu$, the roots of the quartic in x, $H_x + z\Omega_x = 0$ are $p\tfrac{1}{2}u$, $p(\tfrac{1}{2}u + \omega_1)$, $p(\tfrac{1}{2}u + \omega_2)$, $p(\tfrac{1}{2}u + \omega_3)$.

If we solve this quartic, which is

$$x^4 - 4zx^3 + \tfrac{1}{2}g_2x^2 + (2g_3 - zg_2)x + \frac{g_2^2}{16} + zg_3 = 0, \quad (a)$$

by Euler's method, assuming

$$x = z + \sqrt{t_1} + \sqrt{t_2} + \sqrt{t_3}, \quad t_1, t_2, t_3$$

are the roots of Euler's cubic

$$t^3 + 3Ht^2 + (3H^2 - \tfrac{1}{4}I)t - \frac{G^2}{4} = 0,$$

the roots of which are

$$z - e_2 \,.\, z - e_3, \quad z - e_3 \,.\, z - e_1, \quad z - e_1 \,.\, z - e_2.$$

∴ the roots of (a) are

$$z \pm \sqrt{z - e_2 \,.\, z - e_3} \pm \sqrt{z - e_3 \,.\, z - e_1} \pm \sqrt{z - e_1 \,.\, z - e_2}.$$

The signs of the square roots are determined by making $u \to 0$, thus $p\tfrac{1}{2}u \to \dfrac{4}{u^2}$, $pu \to \dfrac{1}{u^2}$;

∴ the square roots are all positive for the root $p\tfrac{1}{2}u$.

From (12), putting $u = \omega_1, \omega_2\ \omega_3$ successively,

$$\left.\begin{aligned} \theta\tfrac{1}{2}\omega_1 &= \sqrt{mn}, \\ \phi\tfrac{1}{2}\omega_1 &= \sqrt{n(m+n)}, \\ \psi\tfrac{1}{2}\omega_1 &= \sqrt{m(m+n)}. \end{aligned}\right\} \quad (16) \qquad \left.\begin{aligned} \theta\tfrac{1}{2}\omega_2 &= i\sqrt{n(n-il)}, \\ \phi\tfrac{1}{2}\omega_2 &= e^{\frac{i\pi}{4}}\sqrt{ln}, \\ \psi\tfrac{1}{2}\omega_2 &= e^{\frac{i\pi}{4}}\sqrt{l(n-il)}. \end{aligned}\right\} \quad (17)$$

$$\left.\begin{aligned} \theta\tfrac{1}{2}\omega_3 &= -i\sqrt{m.m-l} \\ \phi\tfrac{1}{2}\omega_3 &= -\sqrt{l(m-l)}, \\ \psi\tfrac{1}{2}\omega_3 &= -\sqrt{lm}. \end{aligned}\right\} \quad (18)$$

SECTION 11.—*Representation of Connectors by Points on a Quartic Curve.*

It is known from the theory of the plane cubic that a 1–2 correspondence exists between points on the Hessian of a cubic and tangents to the Cayleyan. If we project on an arbitrary plane from a point on the curve UV, the curve projects into a cubic which is the Hessian of three cubics, whose Cayleyans are the envelopes of the projections of the connectors of the three systems. It might be expected then that a correspondence of the same type would exist between the connectors and the points of UV as exists between tangents to the Cayleyan and points on the Hessian. We will now show how this correspondence can be determined analytically.

If (p, q, r, s, t, u) be the coordinates of the connector passing through $A\ (x, y, z, \omega)$, their values are (§ 6 (1)), $0,\ zx,\ -xy,\ 0,\ yw,\ zu,$ and A lies on the surface

$$\Phi \equiv (\gamma - \alpha)\, z^2x^2 + (\beta - \delta)\, y^2w^2 + (\beta - \alpha)\, x^2y^2 + (\gamma - \delta)\, z^2w^2.$$

Hence q, t, r, u satisfy the equations

$$\Gamma \equiv 2\,(qt + ru) = 0, \quad -r \equiv (\gamma - \alpha)\, q^2 + (\beta - \delta)\, t^2 + (\beta - \alpha)\, r^2 + (\gamma - \delta) u^2 = 0. \quad (1)$$

The coordinates of a connector then are four quantities connected by two quadric relations, just as the coordinates of a point on the curve UV are, so that if Γ and r be regarded as two quadrics, their curve of intersection Γr is a quartic curve, the points on which may be taken to represent the connectors in the first correspondence.

The discriminant of $\lambda\Gamma - r$ is

$$(\lambda^2 - M)(\lambda^2 + N) = \Delta(\lambda) = 0, \quad (2)$$

the roots of which are

$$\pm\sqrt{M}, \quad \pm\sqrt{-N}, \quad \text{or} \quad \pm 2im, \quad \pm 2in. \quad (\S\ 9\ (5)$$

Since it is in the canonical form, Γ and r are a pair of Vossian quadrics of the system (§ 9), and their equations can be reduced to the canonical form by direct transformation. Working with the canonical form of UV, let $q = ZX$, $t = YW$, $r = -XY$, $u = ZW$, and apply to Γ, r the linear transformation

$$\sqrt{2}Q = q + it, \quad \sqrt{2}i\Gamma = q - it, \quad \sqrt{2}R = r + iu, \quad \sqrt{2}iU = r - iu; \qquad (3)$$

the canonical form of Γr is then given by the equations

$$\Gamma_0 \equiv Q^2 + T^2 + R^2 + U^2 = 0, \quad r_0 \equiv 2m(Q^2 - T^2) + 2n(R^2 - U^2)^* = 0. \qquad (4)$$

Thus, if $\mu + \nu = 2m$, $\mu - \nu = 2n$, we can pass from the one system to the other by replacing m, n, by μ, ν.

If, E_1, E_2, E_3 be the quantities corresponding to e_1, e_2, e_3,

$$\sqrt{E_1 - E_3} = \mu, \quad \sqrt{E_1 - E_2} = \nu, \quad E_1 = \frac{\mu^2 + \nu^2}{3} = \frac{2(m^2 + n^2)}{3} = 2e_1, \qquad (5)$$

$$E_2 = E_1 - \nu^2 = 2e_1 - (m - n)^2 = -(e_1 - 2\sqrt{\eta_1}), \text{ where } \eta_1 = e_1 - e_2 \,.\, e_1 - e_3$$

$$E_3 = E_1 - \mu^2 = 2e_1 - (m + n)^2 = -(e_1 - 2\sqrt{\eta_1}),$$

and the elliptic parameter for Γr is Pu, where the zeros of $P'u$ are E_1, E_2, E_3. If

$$\overline{P}u = pu + piu + \omega_1) - e_1 = pu + \frac{\eta_1}{pu - e_1},$$

then

$$\overline{P}u = \overline{P}iuew_1) = \overline{P}(u + \omega_3 - \omega_2) = \overline{P}(u + 2\omega_2).$$

Hence $\overline{P}u$ is an even doubly periodic function of u, whose periods are

$$2\overline{\Omega}_1 = \omega_1, \quad 2\overline{\Omega}_2 = \omega_3 - \omega_2, \quad 2\overline{\Omega}_3 = 2\omega_2,$$

It has one double pole in its parallelogram of periods at $u = 0$, and no other pole, and it tends to $\frac{1}{u^2}$ as u tends to zero. Hence it is identical with the Weierstrassian p-function, which has the same periods.

If $\overline{E}_1$, $\overline{E}_2$, $\overline{E}_3$ be the roots of $\overline{P}u' = 0$, since $pi\omega_1 = e_1 + \sqrt{\eta_1}$,

$$\overline{E}_1 = \overline{P}\overline{\Omega}_1 = e_1 + \sqrt{\eta_1} + \frac{\eta_1}{\sqrt{\eta_1}} = e_1 + 2\sqrt{\eta_1} = -E_3.$$

$$\overline{E}_2 = \quad -(\overline{E}_1 + \overline{E}_3) \quad = e_1 - 2\sqrt{\eta_1} = -E_2.$$

$$\overline{E}_3 = \overline{P}\overline{\Omega}_3 = e_2 + e_3 - e_1 \quad = -2e_1 \quad = -E_1.$$

Hence (Halphen, t. I, p. 32) $\overline{P}u = -Piu$.

The equation (6) is the expression in Weierstrass notation of Landen's first transformation.

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* We are using the symbols U, V here to denote coordinates of a connector. This is not likely to lead to confusion.

If u', v' be the original and transformed arguments in Jacobi's notation, k, l the original and transformed moduli,

$$u' = mu, \quad k' = \frac{n}{m}, \quad v' = \sqrt{\overline{E}_1 - \overline{E}_3}\,u = \sqrt{E_1 - E_3}\,u = (m+n)\,u$$
$$= \left(1 + \frac{n}{m}\right)u' = (1 + k')u'.$$

$$l = \sqrt{\frac{\overline{E}_2 - \overline{E}_3}{\overline{E}_1 - \overline{E}_3}} = \frac{m-n}{m+n} = \frac{1-k'}{1+k'}. \quad \overline{P}u' - \overline{E}_3 = \frac{pu - e_2 \,.\, pu - e_3}{pu - e_1}, \quad \text{from (6)},$$

$$\therefore\ sn\,(v', l) = \sqrt{\frac{\overline{E}_1 - \overline{E}_3}{\overline{P}u - \overline{E}_3}} = \frac{(m+n)\,\theta u}{\phi u \psi u} = (1 + k')\,\frac{sxu'cuu'}{duu'}.$$

which is Landen's first transformation. (v. Greenhill, p. 318.)

Since $\quad \overline{P}u = - Piu, \quad \overline{P}\Omega_3 = - Pi\Omega_3 = - E_1 \ \therefore\ Pi\overline{\Omega}_3 = E_1.$

Similarly, $\qquad Pi\overline{\Omega}_2 = E_2, \quad Pi\overline{\Omega}_1 = E_3.$

Hence, if $2\Omega_1$, $2\Omega_2$, $2\Omega_3$ be the periods of Pu,

$$\Omega_1 = i\overline{\Omega}_3 = i\omega_3. \quad \Omega_2 = i\overline{\Omega}_2 = \tfrac{1}{2}i\,(\omega_3 - \omega_2), \quad \Omega_3 = i\overline{\Omega}_1 = \tfrac{1}{2}i\omega_1. \qquad (6a)$$

If Q, R, U, T are the coordinates of the connector passing through the point on UV whose argument is u, transformed by the substitution (3)

$$\frac{Q}{T} = i\,\frac{q + it}{q - it} = i\,\frac{ZX + iYW}{ZX - iYW} = i\,\frac{\theta\psi - im\phi}{\theta\psi + im\phi}, \quad \text{from §10 (1)},$$

$$\frac{R}{T} = i\,\frac{r + iu}{q - it} = -\,i\,\frac{XY - iZW}{ZX - iYW} = \sqrt{\frac{m}{n}}\,.\,\frac{\theta\phi - in\psi}{\theta\psi + im\phi}. \qquad (7)$$

$$\frac{U}{T} = \frac{r - iu}{q - it} = \frac{XY + iZW}{ZX - iYW} = -\,i\,\sqrt{\frac{m}{n}}\,\frac{\theta\phi + in\psi}{\theta\psi + im\phi},$$

where θ, ϕ, ψ are written for brevity for θu, ϕu, ψu.

Regarding Q, R, U, T as the coordinates of a point on Γr whose argument is U, these ratios can be written down at once from (3) by substituting v for u, μ, ν for m_1n, and Θv, Φv, Ψv for θu, ϕu, ψu, where

$$\Theta v = \sqrt{Pv - E_1}, \quad \Phi v = \sqrt{Pv - E_2}, \quad \Psi v = \sqrt{Pv - E_3}.$$

Thus,

$$\frac{Q}{T} = \frac{-\,i\Theta v}{\sqrt{\mu\nu}}, \quad \frac{R}{T} = \frac{\Phi v}{\sqrt{\nu\,(\mu - \nu)}}, \quad \frac{U}{T} = \frac{-\,i\Psi v}{\sqrt{\mu\,(\mu - \nu)}}. \qquad (8)$$

Equating these values

$$\Theta v = -\sqrt{\mu\nu}\,.\,\frac{\theta\psi - im\phi}{\theta\psi + im\phi},$$

$$\Phi v = \sqrt{\nu\,(\mu + \nu)}\,.\,\frac{\theta\phi - in\psi}{\theta\psi + im\phi}, \qquad (9)$$

$$\Psi v = \sqrt{\mu\,(\mu + \nu)}\,\frac{\theta\phi + in\psi}{\theta\psi + im\phi}, \quad \text{since} \quad \frac{m}{n} = \frac{\mu + \nu}{\mu - \nu}.$$

Differentiate the first of these equations with respect to u, taking into account the relations of § 10 (3),

$$\Theta' v \frac{dv}{du} = -\Phi v . \Psi v \frac{dv}{du} = -\sqrt{\mu\nu} \frac{d}{du} . \frac{\theta\psi - im\phi}{\theta\psi + im\phi}$$

$$= \sqrt{\mu\nu} . \frac{((\theta^2 + \psi^2)\phi - im\theta\psi)(\theta\psi + im\phi) - ((\theta^2 + \psi^2)\phi + im\theta\psi)(\theta\psi - im\phi)}{(\theta\psi + im\phi)^2}$$

$$= 2im\sqrt{\mu\nu} \frac{\theta^2\phi^2 + \phi^2\psi^2 - \theta^2\psi^2}{(\theta\psi + im\phi)^2} = i(\mu + \nu)\sqrt{\mu\nu} . \frac{\theta^2\phi^2 + n^2\psi^2}{(\theta\psi + im\phi)^2}$$

$$= i\Phi v . \Psi v \text{ from (9). Hence, } \frac{dv}{du} = -i, \quad iv = u + c, \qquad (10)$$

when $u = 0, \quad \Theta v = -\sqrt{\mu\nu}, \quad \Phi v = \sqrt{\nu(\mu + \nu)}, \quad \Psi v = \sqrt{\mu(\mu + \nu)}$,

$\therefore$ (§ 10 (16)) $v = 2\Omega_1 - \frac{1}{2}\Omega_1, \quad c = 2i\Omega_1 - \frac{1}{2}i\Omega_1 = \frac{3}{2}i\Omega_1 = -\frac{3}{2}\omega_2,$ from (6a)

$$\therefore \quad iv = u - \tfrac{3}{2}\omega_2 \quad \text{or} \quad i(v + 2\Omega_1) = u + \tfrac{1}{2}\omega_2. \qquad (11)$$

There is a certain latitude admissible in this transformation. Thus we may take any of the quantities $QTR\sigma$ as corresponding to W, and may multiply r by any constant factor, with corresponding alterations in the values of μ and ν. Thus, by an imaginary transformation, taking $\mu + \nu$, $\mu - \nu$ as the roots of the discriminant $A(\lambda)$, $-2iu$, $-2im$, and the coordinate U as corresponding to W.

PROCEEDINGS

OF THE

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SECTION B.—BIOLOGICAL, GEOLOGICAL, AND CHEMICAL SCIENCE.

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PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY

PAPERS READ BEFORE THE ACADEMY

I.

THE PROBLEM OF THE BRAY SERIES.

By GRENVILLE A. J. COLE, F.R.S., M.R.I.A.,
Director of the Geological Survey of Ireland.

Read May 23. Published August 12, 1921.

I.—The Relations of the Series to its Surroundings.

The folded and crushed slates and quartzites that are so well known in the promontories of Bray and Howth, near Dublin, have not been traced down to their foundations. They appear to be of estuarine origin, formed near a shore where Oldhamia, the ally of Monocraterion,[1] and Eldonia,[2] which is possibly a Holothurian, found nourishment on the mud-flats, and were occasionally overwhelmed by incursions of quartz sand. The intense disturbance of these strata, of very unequal "competence," was well indicated by John Kelly[3] in 1853, who recognized that the quartzites showed traces of stratification, but that they were not "in their original position with regard to the adjacent rocks." He held that they had been "protruded through enormous fissures made in the overlying graywacke by volcanic or other expansive power from below." J. B. Jukes,[4] while rejecting this extreme view, pointed out that the beds of sand were probably very irregular to begin with, and that they had been disturbed and "enormously contorted"

[1] G. A. J. Cole, "On Oldhamia and Histioderma," Irish Naturalist, vol. x, p. 83 (1901): G. F. Matthew, "Monocraterion and Oldhamia," *ibid.*, p. 135.

[2] W. J. Ryan and T. Hallissy, "Preliminary notice of some new fossils from Bray Head," Proc. R. Irish Acad., vol. xxix B, p. 246 (1912).

[3] "On the Quartz Rocks of the northern part of the county of Wicklow," Journ. Geol. Soc. Dublin, vol. v, p. 237 (1853).

[4] Annual Address, Journ. Geol. Soc. Dublin, vol. vi, p. 91 (1854).

at successive periods, and likewise broken through by faults. In the official memoir to sheets 102 and 112 (1861), and in that to sheets 121 and 130, published after Jukes's death in 1869, too little attention is given to Kelly's account of the dislocations at Howth and of the anomalous position of Carrickgollogan,[5] which certainly resembles a "protrusion." Jukes and Du Noyer[6] remark, however, that at Howth the contortions make it "frequently difficult to determine even the limits of the quartz rock beds." Gerrard A. Kinahan[7] furnished an excellent map showing how the quartzite bands had become broken up at Bray Head, and floated apart, as it were, in the shales; and W. J. Sollas[8] emphasized in detail their sedimentary origin and their frequent dislocation. He pointed out how the previously crumpled strata must have been "caught in a post-Ordovician squeeze," and he compared the horizontal faults indicated by him on Howth with the far more extensive thrust-planes that had been recognized only a few years before in the Caledonian structure of Sutherland. He also drew renewed attention to the Armorican folding as adding further complications to the district.[9]

The floor on which the Bray Series was accumulated is nowhere visible. Granitoid or schistose rocks probably contributed to its materials, and minute detrital flakes of mica occur in the coarser bands in the shale series at Carrickgollogan. The upper limit of the series has been the subject of some questioning. J. B. Jukes and A. Wyley[10] concluded that an unconformity occurred at the base of the Ordovician system throughout the county of Wicklow, though their most striking piece of evidence,[11] seen at Moneystown, seems equally compatible with a fault. Jukes[12] believed that he could trace an unconformity in Ireland's Eye between black slates, regarded by him as Silurian, and the slates and quartzites of the Bray Series.

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[5] The name is thus spelt on the Ordnance Survey 6-inch map, though geologists have sometimes written it with one l. Kelly calls the mass Shankill, correcting "Shankhill," a common and faulty spelling known to Jukes. Carrickgollogan stands in the south of Shankill townland, and Shankill village lies north-east of it. The crest was once known, fairly enough, as Shankill Hill.

[6] Mem. 102 and 112. p. 42.

[7] "Notes on the Geology of Bray Head," Journ. R. Geol. Soc. Ireland, vol. vi, p. 188 (1882).

[8] "On the Structure and Origin of the Quartzite Rocks in the neighbourhood of Dublin." Sci. Proc. R. Dub. Soc., vol. vii, p. 184 (1892); and "The Geology of Dublin and its Neighbourhood," Proc. Geol. Assoc., vol. xiii, p. 98 (1893). Compare E. Greenly, Mem. Geol. Surv., "Geology of Anglesey," p. 193 (1919).

[9] Compare Jukes, Journ. Geol. Soc. Dublin, vol. vi, p. 38 (1856), and Mem. 102 and 112, p. 22 (1861).

[10] "On the Structure of the North-Eastern part of the County of Wicklow," Journ. Geol. Soc. Dublin, vol. vi, p. 28 (1856).

[11] *Ibid.*, p. 34.

[12] *Ibid.*, p. 43; and Mem. 102 and 112 (1861).

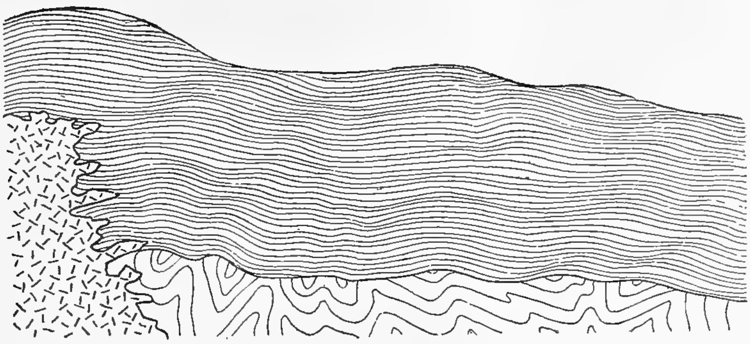

Fig. 1.

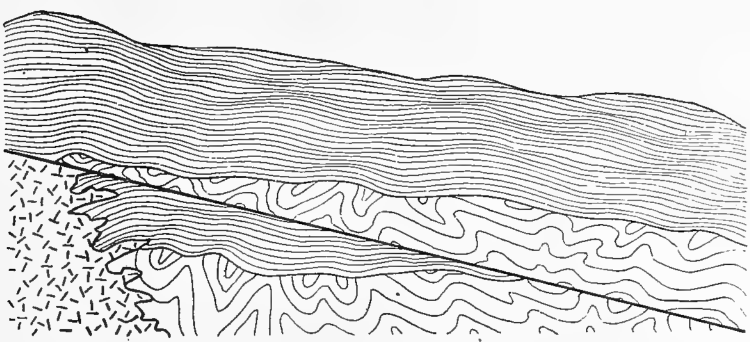

Fig. 2.

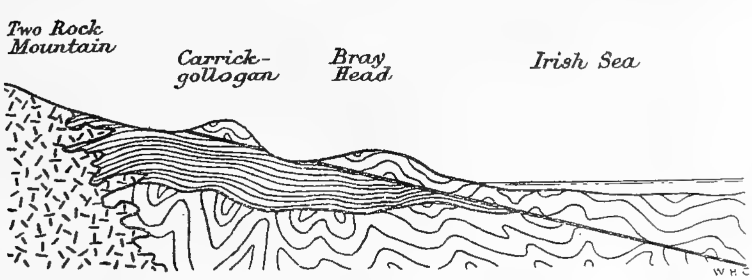

Fig. 3.

- Suggestion as to the relations of the Bray Series to adjacent rocks near Dublin.

Fig. 1.—Generalized section at the epoch of invasion by the Caledonian granite of the Leinster Chain.

Fig. 2.—Relations of the rocks after the occurrence of movement along a thrust plane later in the Caledonian epoch.

Fig. 3.—Origin of the existing features by denudation.

G. H. Kinahan,[13] from his experience over a wide area, supported the view of a general unconformity; but he pointed out the absence of basal conglomerates in the counties of Dublin and Wicklow, except at Moneystown Hill, where the evidence is none too clear. He records a basal Ordovician conglomerate lying on the upturned edges of the altered rocks near Greenore, south-east of Wexford town, and two other instances on the south coast of the county of Wexford. In other cases, he speaks of the Ordovician shales as "plastered against" protrusions of the older rocks. Though the statement is not distinctly made, this suggests the occurrence of Cambrian bosses as horsts among Ordovician strata.

The conception of a general unconformity at the upper limit of the Bray Series was adopted by myself[14] and by W. J. Sollas.[15] In the present paper I venture to urge that the evidence of it has been destroyed in the counties of Dublin and Wicklow by thrusting of post-Ordovician and possibly of Armorican date.

In the Geological Survey memoir on "The Geology of the country around Dublin" (1903), which includes a revision of that previously published on sheet 112 (102 and 112), G. W. Lamplugh[16] cast, as it seems to me, unnecessary doubt on the stratigraphical value of the organisms of the Bray Series. At the same time he published A. M'Henry's views on the absence of an unconformity between that series and the Ordovician shales. M'Henry at that time urged that the Bray Series was of younger age than the Ordovician, and was in reality Gotlandian (Upper Silurian of the Survey). F. W. Egan is cited as an adherent of the same opinion; but those who followed contemporaneously the "Silurian revision" undertaken at that time by the Geological Survey in Ireland will remember that a zeal for sweeping changes, and a particular affection for the Llandovery Series, were apt to outrun the evidence that could be established in the field. Lamplugh showed much hesitation as to M'Henry's views; he was willing, however, to discard the unconformity, and to place (p. 8) the grey slates of Ireland's Eye with the Bray Series. He aptly compared the latter with the lower part of the Skiddaw Slates Series of the Isle of Man, which lies in the same geographical province. On p. 74 of the Memoir of 1903, M'Henry remarks on the close resemblance of the slates of Ireland's Eye, which were held by Jukes to be Ordovician, with those associated with the Bray Series in the counties of Wicklow and Wexford.

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[13] "On Geological Unconformalities," Journ. R. Geol. Soc. Ireland, vol. vii, p. 218 (1889).

[14] "County Dublin," Irish Naturalist, vol. i, p. 32 (1892).

[15] "Geology of Dublin," Proc. Geol. Assoc., vol. xiii, p. 99 (1895).

[16] Mem. of 1903, p. 7.

In a notice of the memoir of 1903,[17] I expressed my frank opinion of M'Henry's proposition, unsupported by palæontological evidence, as to the Gotlandian age of both the Bray Series and the greater series of shaly rocks flanking the Leinster chain on either side. The possible continuity of these two series, which was suggested by Lamplugh, left another problem still unsolved. Why is the Bray Series in the counties of Dublin and Wicklow not invaded by the Leinster granite, while the Ordovician shales have yielded a conspicuous marginal belt, where abundant veins of granite and eurite penetrate an aureole of mica-schist?

Sollas,[18] with characteristic ingenuity, suggested in 1893 that the granitic mass was a laccolitic intrusion, with an Ordovician cover and the Bray Series as a floor. The gneisses of Carnsore, in the south of the county of Wexford, appear, however, to be of composite origin, and to result from the intrusion of granite into slates of the Cambrian series. Sollas's explanation might none the less hold good for the main field of intrusion.

Is not, however, the solution to be found in the horizontal movements that Sollas recognized in Howth? J. F. Blake[19] and other authors have emphasized the resemblance of the Bray Series to the rocks near Holyhead, in Anglesey. E. Greenly, in describing the "Gwna Group" in his fine and recent memoir,[20] recognizes these beds in Howth, and regards them, with Blake, as pre-Cambrian. C. A. Matley[21] has shown how the green rocks of what Greenly now styles the Mona complex override Ordovician strata as the result of thrusting. The thrusts do not affect the Carboniferous beds.[22] Matley states that they occurred between Upper Ordovician and Upper Old Red Sandstone times; they are thus, with extreme probability, of Caledonian age. Matley,[23] again, indicates similar thrusts and inversions of older rocks on Llandilo strata at Mynydd Garn, in N.-W. Anglesey; and Greenly presents a large body of detailed evidence, bringing his experience of mapping in the Scottish highlands to bear on his twenty years' work on the Mona complex and its environment. When it again becomes possible to carry on systematic field-work in southern Ireland, the solution of the relations of the Bray Series to the rocks that flank the Leinster granite will probably be found on the lines indicated by Matley for the rocks across the Channel.

[17] Irish Naturalist, vol. xii, p. 119 (1903).

[18] Proc. Geol. Assoc., vol. xiii, p. 104.

[19] "The Monian System of Rocks," Quart. Journ. Geol. Soc. London, vol. xliv, p. 534 (1888.) See also R. I. Murchison, "Siluria," p. 165 (1854).

[20] "Geology of Anglesey," p. 896 (1919).

[21] "The Geology of Northern Anglesey," Quart. Journ. Geol. Soc. London, vol. lv, p. 636 (1899).

[22] *Ibid.*, p. 667.

[23] "The Geology of Mynydd Garn," *ibid.*, vol lvii, p. 20 (1901).

II.—The Case of Carrickgollogan.

The quartzite cone of Carrickgollogan, with its associated green shales, similar to those that include Oldhamia at Bray Head, appears on the map of the Geological Survey (sheet 121) as an inlier among Ordovician rocks. Jukes and Wyley[24] say that it is "surrounded [bounded?] on one side by mica schist, and on the other by black slate, both of which we believe to be Silurian." This conclusion resulted from the preliminary survey, on which the map issued in 1855 was based. A "historic series" of proofs and successive standards for each one-inch sheet has now been arranged in the office of the Geological Survey, and it has been possible to trace the various developments that led to the revision of sheet 121 in 1865. It has long been known that such revisions occurred in many sheets issued by the Irish Survey, without any change being made in the original engraved date. The proofs dated in manuscript, and the copies of sheet 121 issued after 1865, are now the only clue to the sequence of various copies of the MS. six-inch Geological sheet, Co. Dublin, 26, which includes the Carrickgollogan area.

By collating these documents, some facts of interest come to light. A. Wyley mapped the ground in the first instance in 1853, and recognized the "Cambrian look" of the green shales along the south side of the quartzite boss. On its north side, and south of the second quartzite band, he noted that they were "not at all micaceous." This is evidently an expression of his surprise that they were not altered by the granite. On another copy of this six-inch sheet, Wyley (or Du Noyer?) adds that the shales may be "protected by the quartzite bed." A fine-grained granite dyke occurs in the mica-schists close at hand, and the margin of the main granite of Ballycorus and the Scalp lies only 700 yards (640 m.) away.

When Jukes approved and passed the reduction of the lines to the one-inch scale on February 7th, 1854, the long thin band of shale on the south was inserted as Cambrian, and the whole elliptical Cambrian area was shown as cut off at its south-west end by a fault extending from the district of the Great Sugarloaf. No authority for this fault exists on any six-inch MS. map, though at Carrickgollogan it is quite a local probability. G. V. Du Noyer examined the ground in detail in 1860, and evidently was puzzled by the apparent superposition of the block of Carrickgollogan on Silurian schists and slates. The notes on his revised map show that he found "no evidence to prove the quartz rock of Carrickgollogan 'Cambrian,'" and he states that it rests "in a hollow of the bedded Silurian slates." M'Henry does not seem

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[24] *Op cit.*, Journ. Geol. Soc. Dublin, vol. vi, p. 40 (1856)

to have been aware of this important note, which would have greatly supported the arguments now quoted from him alone. Du Noyer clearly recognized that the inlier of Carrickgollogan might be an outlier, and he notes at one point north of the main quartzite "dark grey soft shales undoubtedly Silurian." The shales here, however, have always seemed to me "undoubtedly" of Cambrian type, and Mr. P. B. Roberts, when working with me on the hill in 1921, secured at this point, from a new trial-hole made for water, a sample of folded compact shale precisely like the typical strata of Bray Head.

Du Noyer's difficulty clearly arose from the apparent superposition of the Cambrian rocks on their surroundings; but superposition would have rendered the absence of granite veins and of metamorphism all the more unaccountable. On 17th November, 1865, Jukes approved a revision for the one-inch map, in which the fault disappeared, while the main quartzite ridge was broken, as in Du Noyer's six-inch map, in its centre. The colouring of the area as of Cambrian age was properly retained. At some later date, the thin band of shale shown on the south was reduced at its eastern end—I think in error—and it remains thus shown in present issues. Without any strong reason, as far as field observation goes, and without authority from the six-inch map, the removal of the fault was accompanied by the carrying of the Cambrian colouring further west, beyond the track leading to Barnaslingan townland.

The fault originally inserted on the map had been connected with the broad structure of the country, and did not help local difficulties of interpretation. The brief description in the memoir to sheet 121, p. 23 (1869), does not refer to the discussions that must have taken place during ten years in the office of the Survey. Both Jukes and Du Noyer seem to have maintained a mutually tolerant attitude; but this unfortunately left the shrewd questionings of Du Noyer to be revived by others after a lapse of twenty years. J. F. Blake[25] remained puzzled, and says that the mass of Carrickgollogan "comes in in defiance of stratigraphy." He remarks that, if the rocks are disposed according to their visible "banding," they "must be faulted on all sides." There is nothing in the form of the Cambrian exposure to exclude faulting. I began to map the boundaries on the plateau south of the Ballycorus lead-mine for my own information sixteen years ago, and it seemed natural[26] in 1908 to describe the Carrickgollogan series as an inlying mass, "probably bounded by faults."

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[25] "The Monian System of Rocks," Quart. Jour. Geol. Soc. London, vol. xlix, p. 535 (1888).

[26] British Association "Handbook to the Dublin District," p. 8.

There was here no suggestion that it might rest upon a fault-plane. The problem of its relations with the Leinster granite still remained. This, however, becomes simple if we dismiss the horst theory, the theory of protrusion, accept Du Noyer's view of the local sequence, and regard the whole Bray Series in the County of Wicklow as imported into the region by thrusting from the east. In 1914, writing on East Leinster for the Cambridge Geographies, I suggested that the Cambrian series had been banked up thus against the Leinster chain, and that Carrickgollogan, though technically an inlier, should be regarded as an outlying "klip." Events since then have delayed publication, and the passage is only now in type. The idea may have occurred to several geologists, but it removes so many difficulties that it seems well to inquire what its acceptance will involve.

III.—The Wider Problem.

The Bray Series, like the Mona Complex,[27] must have been formed on a floor of still older crystalline rocks. Whether it is of Cambrian age or not, Upper Cambrian strata probably once extended over it. These may have been removed by denudation, as in Anglesey,[28] in early Ordovician or late Cambrian times. Since Arenig strata occur in Anglesey, a Cambrian date seems likely for this considerable epoch of erosion. Then followed the Ordovician overlap, and the marine Arenig strata, with *Clonograptus flexilis*, recognized by Dr. Gertrude L. Elles[29] at Courtown, in the north of the county of Wexford, were no doubt deposited in continuity with those of Wales. The sea-floor sank, and Gotlandian (Upper Silurian) strata followed in regular succession. The next break was caused by the mountain-building of the Caledonian epoch. The Leinster chain rose, and the granite cauldron in its core produced considerable metamorphism of the encasing Ordovician rocks. The part of the Bray Series that we know, which is probably only the upper section of a contorted system, lay, however, well beyond the zone of danger. The late Cambrian denudation had swept away, not only its cover, but also its westward prolongations. When the Caledonian crumpling first began to rear it from its bed, this residue of the upper mass still lay eastward of the cauldron, though the western part of its foundation was no doubt traversed by the granite-magma as it rose into the Ordovician arch. The granite came into place very largely by corrosive action; but in time it cooled, and no longer sent out veins into its walls. The Caledonian earth-movements continued, and a thrust-plane broke the crest of the range in the North

[27] E. Greenly, "Geol. of Anglesey," p. 169 (1919).
[28] *Ibid.*, p. 402.
[29] Letter in Irish Naturalist, vol. xix, p. 244 (1910).

Wicklow and Dublin district, and traversed the Bray Series in the region of the Irish Sea. The Ordovician and Gotlandian covering of the granite core moved north-westward, and the upper part of the Bray Series, sliced off from its foundations, followed across the flanking slates, and even across the metamorphic aureole.[30] The north-western front of the overthrust complex, and the scarp that probably was formed by it, disappeared through denudation in early Devonian times. It is interesting to reflect that some of the quartzite pebbles in the Old Red Sandstone conglomerates at Portraine and west of Rathcoole may have been derived from a block of the Bray Series towering high above the surface revealed to us at the present day.

Denudation, however, continued. Even in early Carboniferous times granite and schist were exposed, and their fragments are seen in the limestone at Rathfarnham and Blackrock. The Bray Series, in its new location, became truncated and dissected. Its edge was worked back eastwards, and at some epoch, pre-Carboniferous or post-Carboniferous, the boss of Carrickgollogan was, by subaerial action, severed from the block of Bray.

One consideration leads on to another. What becomes of the granite of Dunleary and Killiney when it enters the estuary of the Liffey? The great bar of crystalline rock, continuous down to the valley of the Nore, rises here 500 feet (150 m.) above the sea, under which it disappears. Its north-easterly strike aims across the bay, and, if we continue the margins of its outcrop, we embrace the crumpled block of Howth. Is Howth also a klip, and do the granite and the flanking Ordovician strata pass beneath it, reappearing on the north in Portraine, at Balbriggan, and in Rockabill?

The low-lying country between Dublin and Galway has always suggested a band of weakness; and the north coast of Galway Bay has all the appearance of a fault-line. Hence the Leinster granite may well be cut off by a Caledonian fault in Dublin Bay. But the searchlight of geological imagination may play even on tectonics. It must be confessed that a boring of 2,000 feet, starting on the Sutton strand, might prove more convincing and effective.

In this paper I have not touched the question of the southern boundary of the Bray Series near Wicklow town, or the long ridge of Carrick Mountain, which resembles Carrickgollogan in its strike and form. It is clear that the

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30 This suggestion receives very welcome support from Prof. Olaf Holtedahl's recent paper on "The Scandinavian 'Mountain Problem'" (Quart. Journal Geol. Soc. London, vol. lxxvi, p. 387, 1921). Holtedahl reasons that, in the long time over which the Caledonian deformation extended, an igneous mass, the intrusion of which occurred in the earlier part of the period of crust-movement, may have become "dead," and even subject to weathering, before the final thrusting took place.

Bray Series was remoulded by the Caledonian folding, equally with the stubborn pre-Cambrian floor of Donegal. It is here suggested that the later stages of that folding are responsible for some of the anomalies recognizable in the field.

Finally, it is obviously tempting to ascribe the overthrusting of the Bray Series on the Leinster chain to an epoch when the chain had already suffered denudation—that is, to the Armorican folding. The relations, however, of the Carboniferous limestone to the Howth block seem to be those of simple overlap, and Greenly,[31] whose work has been so frequently of service in this discussion, remarks that "in the Carboniferous rocks of Anglesey there is a total absence of the isoclinal, shearing, or thrusting structures that recurred so persistently in all the older periods." Isoclinal folding from the south is well known at Loughshinny and at Clondalkin in the county of Dublin; and the Armorican overfolding in southern Ireland, accompanied by faulting along the strike, is far more extensive than Jukes represented in his cautious longitudinal sections. But the importation of the Bray Series after it had acquired a cover of Devonian and Carboniferous rocks would, I think, have involved greater disturbance of the Carboniferous strata in the Dublin district than that of which we now have evidence. I should have liked to put forward an Armorican date for the importation, but a late Caledonian date seems to present fewer difficulties.

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[31] "Geol. of Anglesey," p. 682 (1919).

II.

THE COLLEMBOLA OF SPITSBERGEN AND BEAR ISLAND.

(Results of the Oxford University Expedition to Spitsbergen, No. 18.)

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AND

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By the favour of Professor E. B. Poulton, F.R.S., of the Hope Museum of Zoology, and Mr. C. S. Elton, of New College, Oxford, we have had the privilege of studying the Collembola or Springtails collected by members of the Oxford University Expedition to Spitsbergen, who made extensive collections and observations on the archipelago during the summer of 1921. The localities whence these specimens came are Klaas Billen Bay, Advent Bay, Cape Boheman, and Gips Valley, on the west coast of the large Western Island of the archipelago; Prince Charles Foreland, a long narrow islet lying alongside the western coast of this island; and Bear Island, situate somewhat remote from the main Spitsbergen group, nearly 200 miles to the south. The value of this collection is much enhanced by the careful records, not only of the exact localities whence the insects came, but also of the nature of the habitat in which each gathering was secured. These ecological notes, which will, we understand, be further elucidated by members of the expedition, give especial value to the collections. Spitsbergen and Bear Island have been already partly explored faunistically, and we are able to add only two species to the recorded list of Collembola, one of these being new to science. Of the twenty-one species previously known to inhabit Spitsbergen and Bear Island, eight are represented in the present collection.

Very little has been added to our knowledge of the Collembola of Spitsbergen since the publication of the papers of Schäffer and Skorikow, which both appeared in the year 1900. In these, references will be found to previous literature on the subject. In the present paper we give in the first place a list of the species collected by the Oxford University Expedition, with details of localities, habitat, and dates of capture, adding a few notes as to the general range and geographical importance of the species in each case. It is unnecessary to incorporate similar details with regard to species not represented in the present collection, but a tabular list of all Collembola recorded from Spitsbergen and Bear Island is given, in which the known distribution of each through the different islands of the archipelago is indicated, as well as its range in other Arctic districts, in Europe, and in America. It is interesting to find that of the twenty-three Spitsbergen and Bear Island species, fifteen inhabit Great Britain, while two—*Achorutes viaticus* and *Archisotoma Beselsi*—are found far to the south in Antarctic or sub-Antarctic regions. As regards local distribution in Spitsbergen itself, five species of the ten collected by the Expedition come from Prince Charles Foreland, the westernmost island of the group. Almost all previous records of Spitsbergen Collembola are due to investigations on the large and often-visited West Island.

List of Oxford University Expedition's Collection.

PODURIDAE.

Achorutes Templeton.

Hypogastrura Börner.

Achorutes viaticus Tullberg.

This common and well-nigh cosmopolitan insect is abundant on Spitsbergen, and occurs also on Bear Island. The Spitsbergen localities are Advent Bay (many specimens on surface of pools in boggy tundra near coast, 4th July, 1921), Klaas Billen Bay (a dozen on side of Mount Terrier at 2,800 feet, 29th July, 1921; two among moss on edge of salt marsh near Bruce City, 13th August, 1921; many on surface of brackish tidal pool in salt marsh, Bruce City, 13th August, 1921), and Prince Charles Foreland (in enormous numbers among decaying seaweed on shingly shore, inner side of Richard Lagoon, 9th July, 1921; one specimen in moss on scree-slope at 300 feet, mouth of Glen Mackenzie, and four shaken from plants on rocky hill, 6th July, 1921). On Bear Island *A. viaticus* occurred at Walrus Bay (a single specimen, 15th June, 1921, and many on marshy area, 13th August, 1921) and on the south-western shore (six under stones near Elassia Lake, 17th April, 1921).

A. viaticus has long been known as a member of the Spitsbergen and Bear Island fauna (Schäffer, 1900, p. 243). It has a wide range on the archipelago, being recorded by Skorikow (1900, pp. 203-4) from Amsterdam Island, at the far north-western corner of the Western Island, from Whales Point on Stans Foreland (Edge Island), and from Barents Island to the south-east, as well as from King Karl Islands to the eastward. Its general range extends over the Arctic regions, Europe, America southwards to Tierra del Fuego (Schäffer, 1897), and on to the sub-Antarctic Macquarie Island, south of New Zealand (Carpenter, 1909; Tillyard, 1920).

Xenylla Tullberg.

Xenylla humicola (Fab.).

This species, ranging from the Arctic regions to Europe, the Azores, and North America, was first described from Greenland specimens. It is found both on Spitsbergen and Bear Island, but it is apparently much scarcer than *Achorutes viaticus.* All the Spitsbergen specimens are from Prince Charles Foreland (one in moss on scree-slope at 300 feet, mouth of Glen Mackenzie, 6th July, 1921 ; two under stones on low hill near coast, 10th July, 1921). Bear Island : south-west (four specimens under stones near Elassia Lake, 12th June, 1921); Walrus Bay (five specimens among flowers of *Saxifraga oppositifolia,* 14th June, 1921); south centre of island (four specimens under plants and stones on green hillock on barren, shattered Tetradium limestone, 14th June, 1921).

Xenylla humicola was first recorded from Bear Island by Tullberg (1876, p. 89), and from Spitsbergen by Schäffer (1900, p. 242), and by Skorikow (1900, p. 202), who gives Anderson's Bay in Barents Land as the locality. It has a wide Arctic, European, and North American distribution.

Onychiurus Gervais.

Lipura Burm.

Aphorura MacGill.

Onychiurus armatus (Tullb.) var. **arcticus** Tullb.

This is another widely distributed insect, which occurs both on Spitsbergen and Bear Island. Spitsbergen: Klaas Billen Bay (twelve specimens among moss and Carex on edge of salt marsh, near Bruce City, 13th August, 1921); Gips Valley (among shingle under stones on raised beach near coast, 26th June, 1921). Bear Island: south inland region (eleven specimens by shaking plants in a rich sheltered nook among rocks, 14th June, 1921); Walrus Bay (four specimens, 15th June, 1921; one under stones on top of low hill, 22nd June, 1921).

Linnaniemi (1912, p. 87) is doubtless justified in regarding Tullberg's *Lipura arctica,* described (1876, p. 39) from Spitsbergen specimens, as a variety of the European *Onychiurus armatus.* Wahlgren (1899, p. 337) records both typical *armatus* and *arcticus* from Bear Island, as well as *O. neglectus* (Schäffer), which is doubtfully distinct. The majority of the specimens in the present collection are from 2·5 to 3 mm. in length, considerably larger than typical European *armatus,* but not quite equal in size to the Spitsbergen forms (4 mm. long) described by Tullberg. Skorikow (1900, p. 201) records the species from Horn Sound (towards the southern extremity of the West Island) and from Stans Foreland (Edge Island); he mentions also its occurrence at Advent Bay and Dickson Bay, which, like Klaas Billen Bay, open into the great Ice Fiord of the West Island.

ENTOMOBRYIDAE.

Isotominae.

Folsomia Willem.

Folsomia sexoculata (Tullberg).

This springtail was found at a single locality only on the archipelago. Klaas Billen Bay (four specimens among moss and Carex at edge of salt marsh, near Bruce City, 13th August, 1921). It is known to occur in eastern Greenland and on Jan Mayen (Linnaniemi, 1912, p. 111), as well as in northern Europe (Norway, Finland, Germany, northern England, Scotland, and western Ireland), but it has not previously been recognised as a member of the Spitsbergen fauna.

F. quadrioculata (Tullberg).

This species has been known as a member of the Spitsbergen fauna since the publication of Lubbock and Wahlgren's papers (1899). In the present collection it is represented by specimens from Klaas Billen Bay (twenty among moss and Carex at edge of salt marsh, near Bruce City, 13th August, 1921, and four in damp moss by boulders on raised beach, Bruce City, 4th August, 1921). It has been recorded from the western and eastern coasts of the West Island by Skorikow (1900, p. 206), as well as from King Karl's Islands. Wahlgren (1900*b*, p. 5) noticed its presence on Bear Island. It has a wide distribution in northern and central Europe (including Great Britain), and extends into Greenland and North America (Linnaniemi, 1912, pp. 111–13).

Archisotoma Linnaniemi.

Proisotoma Börner (in part).

Archisotoma Beselsi (Packard).

Isotoma Beselsi Packard (1877).

I. spitzbergenensis Lubbock (1899).

I. arctica Stscher (1899).

I. janmayensis Wahlgr. (1900*a*).

This well-known and most characteristic Spitsbergen insect is abundant in the collection. Prince Charles Foreland (in large numbers among decaying seaweed on shingle shore, inner side of Richard Lagoon, 9th July, 1921). Klaas Billen Bay (sixteen specimens on surface of tidal pools near Bruce City, 13th August, 1921; twelve specimens at low water-mark, Cape Scott, 10th August, 1921). Lubbock's types of *I. spitzbergensis* came from Dixon Bay, which, like Klaas Billen Bay, opens into the great Ice Fiord.

Archisotoma is one of the most distinct and interesting forms of the order, belonging essentially to the tide-mark fauna, and with a range around the North Atlantic coasts, both east and west. It may probably be regarded as belonging to the same American-West European geographical group as the sponge *Heteromeyenia Ryderi* and the well-known American plants of western Ireland; its presence in Greenland and Jan Mayen, and its apparent absence from the Asiatic Arctic districts, are suggestive in this connexion. It reappears far southwards in Tierra del Fuego; and a closely allied species *A. Brucei* (Carpenter, 1906) inhabits the South Orkneys in the Antarctic Ocean.

Agrenia Börner.

Agrenia bidenticulata (Tullberg).

Isotoma lanuginosa Carl (1889).

This distinct northern and Alpine springtail is sparingly represented in the collection. Prince Charles Foreland (two specimens among decaying seaweed on shingle shore, inner side of Richard Lagoon, 9th July, 1921; four specimens on snow slope, side of hill, 10th July, 1921); Cape Boheman (three specimens on surface of pond in rocks of tundra near coast, 12th July, 1921); Klaas Billen Bay (two specimens on side of Mount Terrier, height 2,800 feet, 29th July, 1921). *A. bidenticulata* is recorded by Skorikow (1900, p. 205) from the southern end of West Island (Horn Sound, Batty Bay, and Whales Bay), as well as from Genevra Bay, east of the Island, and from King Karl Islands.

Agrenia bidenticulata has a wide range in the Arctic, including Franz Josef Land and Greenland; but it is apparently unknown on the American continent. In Europe it is found in Norway and Finland; and one may detect it beneath stones in the bed of mountain streams in the Irish and North British highlands. Apparently absent from the central European plain, it reappears in the Swiss Alps, on the edge of the melting snows in springtime (Carl, 1899, pp. 307–10).

Isotoma Bourlet.

Isotoma viridis Bourlet.

This widespread insect was found by the Expedition at a larger number of localities than any other, though it is apparently less abundant in individuals than *Proisotoma Beselsi.* It occurs on Bear Island as well as on the Spitsbergen archipelago (*sens. str.*); Tullberg (1876) recorded it from both many years ago. All the specimens collected are of the "self-coloured" aspect regarded as "typical" for this species; but the colour of individuals varies from bright green to dark olive, or from clear violet to deep blue-black. Prince Charles Foreland (near Point Carmichael, Freshwater Bay, a dark green specimen among moss on the shingle of raised beach, at 40 feet elevation, 4th July, 1921; a dark violet specimen at same locality on sand; two violet specimens at 1,300 feet level on Lordstair's Heights, 4th July, 1921; two violet specimens among *Dryas octopetala* and under stones on top of low hill near coast, 10th July, 1921). Cape Boheman (a violet specimen on plants among rocks on dry tundra, 12th July, 1921). Gips Valley (a violet specimen among stones and moss on a warm slope, near coast, 26th June, 1921). Klaas Billen Bay (four dark green specimens among plants and under shingle of raised beach near Bruce City, 11th August, 1921). Bear Island (five dark olive green specimens at Walrus Bay, 15th June, 1921, four dark violet under shaly stones on hill slope, and two green among moss in dry gully at Walrus Bay, 22nd June, 1921; four dark violet specimens under stones by stream in gully in dolomite, Walrus Bay, 22nd June, 1921; two of same form on rocks by stream in Tetradium limestone, south centre of island, 11th August, 1921; two blue-black specimens under stones near Elassia Lake, south-west of island, 17th June, 1921. Skorikow (1900, p. 204) records *I. viridis* from Horn Sound towards the northern extremity of the West Island.

This springtail, one of the commonest members of the British and Irish fauna, has a very wide range in the Arctic regions, Europe, and North America.

Isotoma multisetis sp. nov. (figs. 1–5).

Length, 2·5 mm. Feelers half as long again as head; their segments as 7 : 12 : 13 : 14. Eight ocelli on each side; post-antennal organ elongate-oval; longer than diameter of front ocellus (fig. 2). Foot-claw and empodial appendage (fig. 3) untoothed or with only a trace of teeth. Mucro of spring (fig. 4) with three teeth (a terminal and two dorsal). All abdominal segments (in some specimens the thoracic segments also) with long feathered bristles (fig. 5).

Colour, yellowish, verging towards orange or olive-green, with dark segmental margins.

Locality, Bear Island. Types in Hope Museum, Oxford.

This species, nearly allied to *I. viridis* Bourlet, may be distinguished by the greater number of feathered bristles (which extend to the anterior segments), the more elongate and relatively narrower post-antennal organ, the absence of teeth on the foot-claws, the smaller size, and the apparently constant coloration. The dark segmental margins and abundant bristly covering enable the observer easily to recognize insects of this species among a number of *I. viridis*.

It was collected by the Expedition on Bear Island only: Walrus Bay (one specimen under stone on slope of hill, 22nd June, 1921; three specimens 15th June, 1921); Elassia Lake (two young specimens under stone, 12th June, 1921); south central region (one specimen on green hillock—Skua's nesting-hump—on shattered barren Tetradium limestone, 14th June, 1921).

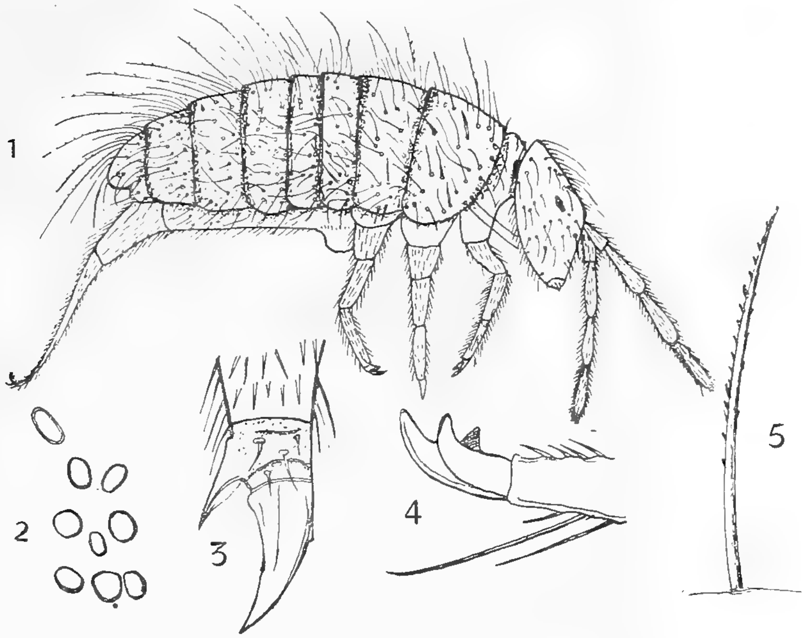

FIG. 1.—*Isotoma multisetis*, side view. × 30.
FIG. 2.—Ocelli and post-antennal organ of left side. × 200.
FIG. 3.—Tip of foot with claw and empodium. × 540.
FIG. 4.—End of dens and mucro, side view. × 750.
FIG. 5.—Feathered bristle from abdomen. × 400.

SMINTHURIDAE.

Sminthurides Börner.

Sminthurides Malmgreni (Tullberg).

This species—the only member of its family known to inhabit Spitsbergen—was first recorded from the archipelago by Tullberg (1876). It was found by the Oxford Expedition at Klaas Billen Bay (one specimen on surface of freshwater pool in raised beach near Bruce City, 29th July, 1921) and on Bear Island (six specimens under stones near Elassia Lake, 17th June, 1921). It has apparently not been previously noticed on Bear Island. The specimens are referable to the dark violet "type form" of the species, which is especially characteristic of Arctic regions, but some of the Bear Island examples were red when alive. In the temperate portions of its range—Great Britain, Germany, and Switzerland—it is represented by the prettily variegated form *elegantula* (Reuter).

Species of Collembola.	Spitsbergen.							Bear Island.	Novaya Zemlya.
	Prince Charles Foreland.	West Island.	Barents Island.	Edge Island.	King Karl Islands.	North-East Island.	Giles or White Island.		
Achorutes viaticus Tlb.,	×	×	×	×	×	—	—	×	×
A. hyperboreus (Boh.),	—	×	—	—	—	—	—	—	—
A. Tulbergi Schäf.,	—	×	×	—	—	—	—	—	×
A. longispinus Tlb.,	—	×	×	×	—	—	—	—	×
Xenylla humicola (Fab.),	×	—	×	—	—	—	—	×	×
Anurida granaria (Nic.),	—	×	—	—	—	—	—	—	—
Onychiurus armatus (Tlb.),	—	—	—	—	—	—	—	×	—
var. arcticus Tlb.,	—	×	—	×	—	—	—	×	×
O. neglectus (Schäf.),	—	—	—	—	—	—	—	×	—
O. groenlandicus (Tlb.),	—	×	×	—	—	×	—	—	—
Tetracanthella pilosa Schött,	—	×	—	—	—	—	—	×	—
Folsomia sexoculata (Tlb.),	—	×	—	—	—	—	—	—	—
F. quadrioculata (Tlb.),	—	×	—	—	×	—	—	×	×
F. binoculata (Whl.),	—	—	—	—	—	—	×	—	—
F. fimetaria (Lin.),	—	×	—	—	—	—	—	—	—
Archisotoma Beselsi (Pack.),	×	×	—	—	—	—	—	—	—
Proisotoma Schötti (D. Torre),	—	×	—	—	—	—	—	—	—
Agrenia bidenticulata (Tlb.),	×	×	—	×	×	—	—	—	×
Isotoma viridis Bourl.,	×	×	—	—	—	—	—	×	×
I. multisetis (Carp. & Phil.),	—	—	—	—	—	—	—	×	—
I. violacea Tlb.,	—	—	×	—	—	—	—	—	—
Lepidocyrtus lanuginosus (Gm.),	—	×	—	—	—	—	—	—	—
Sminthurides Malmgreni (Tlb.),	—	×	—	×	—	—	—	×	×
Sminthurinus niger (Lubb.),	—	—	—	—	—	—	—	×	—

Franz Josef Land.	Jan Mayen Island.	Greenland.	N. Siberia.	Scandinavia.	Finland.	Germany.	Switzerland.	Great Britain.	Ireland.	N. America.	S. America.	Antarctic.
—	—	×	×	×	×	×	×	×	×	×	×	×
—	—	—	—	—	—	—	—	—	—	—	—	—
×	—	—	×	—	—	—	—	—	—	×	—	—
×	—	—	×	×	×	—	—	×	×	×	×	×
—	×	×	×	×	×	×	—	×	×	×	—	—
×	×	×	×	×	×	×	×	×	×	×	—	—
—	×	—	×	×	×	×	×	×	×	×	×	—
—	×	×	×	×	×	—	—	—	—	—	—	—
—	×	—	—	—	—	×	—	—	—	—	—	—
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—	—	—	×	×	×	×	—	×	—	—	—	—
—	—	—	×	×	×	×	×	×	×	—	—	—
—	—	—	—	×	×	×	×	×	—	—	—	—
—	—	×	×	×	×	×	—	×	×	—	—	—

Tabular Summary of Distribution.

In the foregoing table (pp. 18–19) an attempt is made to show the distribution of the species of Collembola known to inhabit Spitsbergen and Bear Island, both as regards the various islands of the archipelago and generally. In a few cases where no more definite locality than "Spitsbergen" is recorded for a species, it is taken for granted that the insects were collected on the frequented West Island. The other regions included show generally the range of the Spitsbergen springtails; and in the selection preference has been given to countries the Collembolan fauna of which is fairly well known.

Distributional Notes.

A glance at the tabular list of Spitsbergen Collembola shows that most of the species have a wide range in the Arctic regions and in temperate Europe. *Achorutes viaticus* is probably well-nigh cosmopolitan. A few species are seen to be exclusively or characteristically Arctic: *Achorutes hyperboreus* (this form, however, has not been recognized by modern workers at the group; and it may be founded on aberrant *A. viaticus*), *A. Tullbergi*, *Tetracanthella pilosa*, *Onychiurus arcticus*, and *O. groenlandicus*. It will be noticed that *Achorutes longispinus*, *Archisotoma Beselsi*, and *Agrenia bidenticulata* are common to the Arctic regions, to our own islands, and to Scandinavia and Finland, while apparently absent from the central European lowlands; the two former of these three insects are found also in America, while the other is represented on the Swiss mountains. Such distribution, showing affinity between the fauna of America and that of the Arctic regions and northern and western Europe, has been noticed in many groups. It supports the view that land connexions probably existed to the north of the Atlantic in Tertiary and Pleistocene times; and the discontinuous range of such insects as the three mentioned above suggests for them a comparatively high antiquity. This is especially true of *Archisotoma Beselsi*, a most distinct and apparently archaic type of its family, which ranges as far south as Tierra del Fuego, and is represented by a closely allied species on the South Orkneys in the Antarctic Ocean. Belief in the "accidental" passage, over wide sea-channels, in high latitudes, of these minute and frail insects is not easy of acceptance; and the fact that at least two species of Collembola now inhabit the Antarctic continent helps us to consider the probability of the survival of some members of the order in the Arctic regions, even through the period of severest glaciation.

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III.

NOTE ON AZEOTROPIC MIXTURES.

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[Read November 13. Published December 22, 1922.]

More than sixty years ago Roscoe found that a certain mixture of hydrochloric acid and water distilled, without change of composition, at a constant temperature higher than the boiling point of either component. He showed that the composition of the mixture of constant boiling point varied with the pressure under which the distillation was carried out. Roscoe afterwards obtained similar results with a number of other acids.

Shortly afterwards Berthelot noticed that a particular mixture of ethyl alcohol and carbon disulphide boiled at a constant temperature lower than the boiling point of either pure substance; and Chancel observed that propyl alcohol and water formed a mixture of minimum boiling point.

Since then a very large number of binary mixtures of minimum boiling point and a much smaller number of mixtures of maximum boiling point have been discovered, notably in recent years by Lecat.[1]

The term "azeotropic mixtures" was proposed by Wade and Merriman,[2] and adopted by Lecat for mixtures of constant boiling point.

Benzene and ethyl alcohol and ethyl alcohol and water respectively form mixtures of minimum boiling point, whilst benzene and water are practically non-miscible; and it was observed by the author in 1902 that when any mixture of the three liquids is distilled through a very efficient still-head, a ternary azeotropic mixture of constant composition comes over at a temperature lower than the boiling point of any one of the three binary mixtures or of any of the single substances.

Ternary azeotropic mixtures of several of the lower alcohols of the ethyl alcohol series with benzene and water and with *n*-hexane and water were

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[1] "La Tension de Vapeur des Mélanges de Liquides ; L'Azéotropisme," Brussels, 1918.
[2] Trans. Chem. Soc., 1911, 99, 1004.

afterwards obtained and examined by Miss Fortey and the author; later, several such mixtures were obtained in the Trinity College laboratory, and recently the number of known mixtures has been greatly increased by the researches of Lecat.

No ternary azeotropic mixture of maximum boiling point has yet been discovered.

The question whether any two or three given liquids are likely to form a binary or ternary azeotropic mixture, respectively, is of interest, and in a few instances it now seems possible to answer the question with a fair degree of confidence.

Alcohols and water.—The higher monhydric aliphatic alcohols are either partially miscible or non-miscible with water; and, adopting Lecat's term "heterogeneous mixtures" for pairs of partially miscible or non-miscible mixtures, it may be stated at once that all the higher alcohols of this series form binary (heterogeneous) azeotropic mixtures of minimum boiling point with water. The behaviour of the lower homologues with water has been investigated, and it is certain that methyl alcohol is the only one that does not form an azeotropic mixture with water.

Since the alcohols of the methyl alcohol series may be regarded as compounds of alkyl radicals, C_nH_{2n+1}, with hydroxyl, OH, it follows that the smaller the alkyl group the greater must be the relative influence of the hydroxyl group on the properties of the compound, and the closer must be the relationship to water; and this conclusion is confirmed by the decreasing miscibility of the alcohols with water as the molecular weight increases, and in many other ways. Thus methyl alcohol, ethyl alcohol, and the two propyl alcohols are miscible with water in all proportions, whereas only one of the four isomeric butyl alcohols is infinitely miscible, and all the amyl alcohols are only partially miscible with water.

It is, however, not only the molecular weight, but also the constitution of the alcohol that has to be considered; thus, of the four butyl alcohols, the primary alcohol derived from normal butane has the highest boiling point, 116·9°, and it is this alcohol which is the least soluble in water. On the other hand, the boiling point of the tertiary alcohol, derived from isobutane, is the lowest, 82·55°, and it is this alcohol which is miscible with water in all proportions.

The boiling point of the tertiary alcohol is only a few degrees higher than that of ethyl alcohol, 78·3°, and is much lower than that of normal propyl alcohol, 97·2°, and in many of its properties tertiary butyl alcohol resembles ethyl alcohol more closely than the isomeric butyl alcohols. It may, in fact, be concluded that, for many purposes, it is rather the boiling point than the molecular weight of the alcohol that may usefully be taken into account in considering the relationship of the alcohols to water.

It may, however, be noted that the boiling point of secondary butyl alcohol, 99·6°, is only 2·4 degrees higher than that of normal propyl alcohol, but that the butyl alcohol is only partially miscible with water, whilst the propyl alcohol is infinitely miscible.

Alcohols and hydrocarbons.—Considering next the relationship of the alcohols to a hydrocarbon, such as normal hexane, it will be obvious that as the magnitude of the alkyl group increases, the influence of the hydroxyl group must become relatively smaller, and the alcohol must approximate more and more closely in its properties to the hydrocarbon. It is found, indeed, that methyl alcohol is only partially miscible with normal hexane at ordinary temperatures, whereas those of the higher alcohols which are liquid at ordinary temperatures are miscible with this hydrocarbon in all proportions. It is found also that several of the lower alcohols form azeotropic mixtures of minimum boiling point with hexane, whilst the higher alcohols do not. Only a few of the alcohols have, however, been distilled with hexane, and it is of interest to consider which of the other alcohols are likely to form azeotropic mixtures with this paraffin.

The aromatic hydrocarbons, benzene and toluene, behave in a very similar manner to hexane, but they are miscible in all proportions with methyl alcohol, as well as with the higher liquid alcohols.

Benzene, like hexane, forms azeotropic mixtures of minimum boiling point with the lower alcohols, but not with the higher ones; but here, again, there are several alcohols which have not yet been investigated.

Before considering the properties of mixtures of toluene with the alcohols it may be well to point out that the normal relation between the boiling points and the molecular composition of mixtures of two liquids is expressed by a curve, and that the smaller the difference between the boiling points of the two liquids the smaller is the curvature. If the two liquids had the same boiling point, the relation would be expressed by a straight line; and it is obvious that, for such a pair of liquids, the slightest deviation from normality would involve the existence of a mixture of minimum or maximum boiling point. Conversely, since the normal curvature is always slight, the greater the difference between the boiling points of the two liquids the greater must be the deviation from normality for an azeotropic mixture to be capable of formation.

Now, although the deviation from normality for toluene and methyl alcohol is greater than for toluene and ethyl alcohol, yet the difference in boiling point for the former pair, 45·9 degrees, is considerably greater than for the latter, 32·3 degrees. Also the boiling point of the toluene-ethyl alcohol azeotropic mixture is only 1·6 degrees lower than that of the alcohol. It would not be possible to say off-hand whether toluene and methyl alcohol would be likely to form an azeotropic mixture or not, and this question will be discussed later.

Alcohols, hydrocarbons, and water.—It has been stated that methyl alcohol does not form an azeotropic mixture with water, and it is found that no ternary azeotropic mixture is formed with methyl alcohol, water, and either hexane, benzene, or toluene.

Five alcohols of the methyl alcohol series have been observed to form ternary azeotropic mixtures of minimum boiling point with normal hexane and water; four certainly, and one (secondary butyl alcohol) probably with benzene and water, and five with toluene and water.

The alcohols which it is advisable to consider are given in the table (p. 26), the capital letters, A, W, H, B, and T, referring to the alcohol, water, hexane, benzene, and toluene respectively. The boiling points of the pure alcohols and of the known binary and ternary azeotropic mixtures are given under the respective headings. The boiling points of the heterogeneous mixtures of the hydrocarbons and water and of the hydrocarbons themselves are:—

Hexane and water (H.W.), 61·55°.
Benzene and water (B.W.), 69·25°.
Toluene and water (T.W.), 84·1°.
Hexane, 68·95°.
Benzene, 80·2°.
Toluene, 110·6°.

In the three graphs (figs. 1 to 3) the boiling points of the known binary and ternary azeotropic mixtures are plotted against those of the alcohols.

Little need be said about the boiling points of the alcohol-water mixtures. If the A.W. curves were extrapolated, they would intersect the horizontal line representing the boiling point of methyl alcohol at a temperature higher than 64·7°, showing that no azeotropic mixture of this alcohol with water is possible. On the other hand, the curve clearly approaches, but would not intersect, the vertical line representing the boiling point of water; in other words, all the higher alcohols form azeotropic mixtures with water.

Alcohol.	Boiling Points in Centigrade Degrees.							
	A.	A.W.	A.H.	A.B.	A.T.	A.H.W.	A.B.W.	A.T.W.
Methyl, ...	64·7	None	50·0	58·35	None	None	None	None
Ethyl, ...	78·3	78·15	58·7	68·25	76·7	56·6	64·85	74·55
Isopropyl, ...	82·45	80·37	61·0	71·9	80·6	58·2	66·5	76·2
Tertiary Butyl, ...	82·55	79·9	63·7	73·95	?	58·9	67·3	—
n-Propyl, ...	97·2	87·7	65·65	77·1	92·6	59·95	68·5	80·05
Secondary Butyl, ...	99·6	88·5	67·5	79	—	61·1	?	—
Tert. Amyl (5) $(CH_3)_2C(OH)C_2H_5$, .	102·0	87 ?	68·5	?	99·2	—		82
Isobutyl, ...	108·0	89·9	68·1	79·85	101·15	None		83
Amyl (8) $(CH_3)_3C.CH_2OH$, . .	112 ?	—			—			
Amyl (6) $(CH_3)_2CH.CH(OH).CH_3$, .	113	—			—			
n-Butyl, ...	116·9	92·25			105·5			
Amyl (3) $C_2H_5CH(OH).C_2H_5$, . .	117	—			—			
Amyl (2) $CH_3CH(OH)CH_2.C_2H_5$, .	119	—			—			
Amyl (4) $C_2H_5CH(CH_3).CH_2OH$, .	128	—			—			
Amyl (7) $(CH_3)_2CH.CH_2.CH_2OH$, .	131·8	95·15			110·5			
n-Amyl (1) $CH_3.CH_2.CH_2.CH_2.CH_2OH$,	137·9	—						
n-Octyl, ...	178·7	98						

The alcohol-hexane curve (fig. 1) would intersect the vertical line representing the boiling point of hexane, 68·95°, at a temperature of about 112°. It is quite possible that amyl alcohol (8), the primary alcohol derived from tetramethyl methane,[1] may form an azeotropic mixture with hexane, but it is much less probable that amyl alcohol (6) would form such a mixture, and it may be regarded as cer ain that none of the alcohols with higher boiling points would do so.

From the alcohol-hexane-water curve it is obvious that methyl alcohol could form no ternary azeotropic mixture, since the boiling point would be

[1] There appears to be no recorded determination of the boiling point of this alcohol, but the b.p. of normal amyl alcohol is 101·7 degrees higher than that of normal pentane, and of symmetrical isoamyl alcohol (7) 103·5 degrees higher than that of isopentane. It may therefore be conjectured that the b.p. of amyl alcohol (8) is about 102·5 degrees higher than that of tetramethyl methane, 9·5°.

much higher than that of the binary alcohol-hexane mixture. The A.H.W. curve, as drawn, intersects the vertical H.W. boiling point line at about 109°, but the observed boiling points are not sufficiently numerous or regular to allow of the curve being extrapolated with much confidence. If the curve were correctly drawn, it would appear that isobutyl alcohol should form a ternary azeotropic mixture, but, according to Lecat, it does not. Probably, therefore, the curve should be somewhat flatter. It seems probable that tertiary amyl alcohol (5) should form a ternary mixture, but the boiling point of the binary A.H. mixture is slightly higher than that of the isobutyl alcohol-hexane mixture, and the matter can only be decided by experiment.

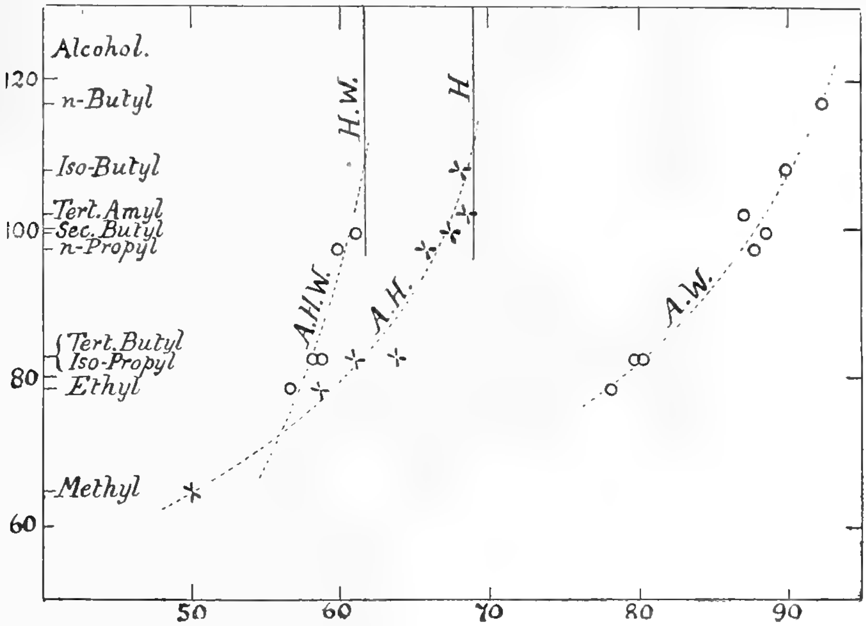

FIG. 1.

It is certain, at any rate, that no alcohol boiling at a temperature higher than 108° can form a ternary mixture with hexane and water.

The benzene mixtures have been more thoroughly investigated than any others. The point of intersection of the A.B. curve (fig. 2) with the vertical benzene boiling-point line is at about 109°. Isobutyl alcohol, and all alcohols of lower boiling point, should, apparently, form binary mixtures with benzene; but, as with hexane, the tertiary amyl alcohol mixture, if it actually exists, has a slightly higher boiling point than the isobutyl alcohol mixture. It is uncertain whether it has really been obtained. No alcohol boiling at a higher temperature than 108° should form a binary mixture with benzene.

It is clear that methyl alcohol cannot form a ternary azeotropic mixture with benzene and water. The point of intersection of the A.B.W. curve with the vertical B.W. boiling-point line appears to be at about 101°. It is uncertain whether secondary butyl alcohol (b.p. 99·6°) forms a ternary mixture; it is almost certain that tertiary amyl alcohol (b.p. 102°) does not. Alcohols of higher boiling point cannot form ternary azeotropic mixtures with benzene and water.

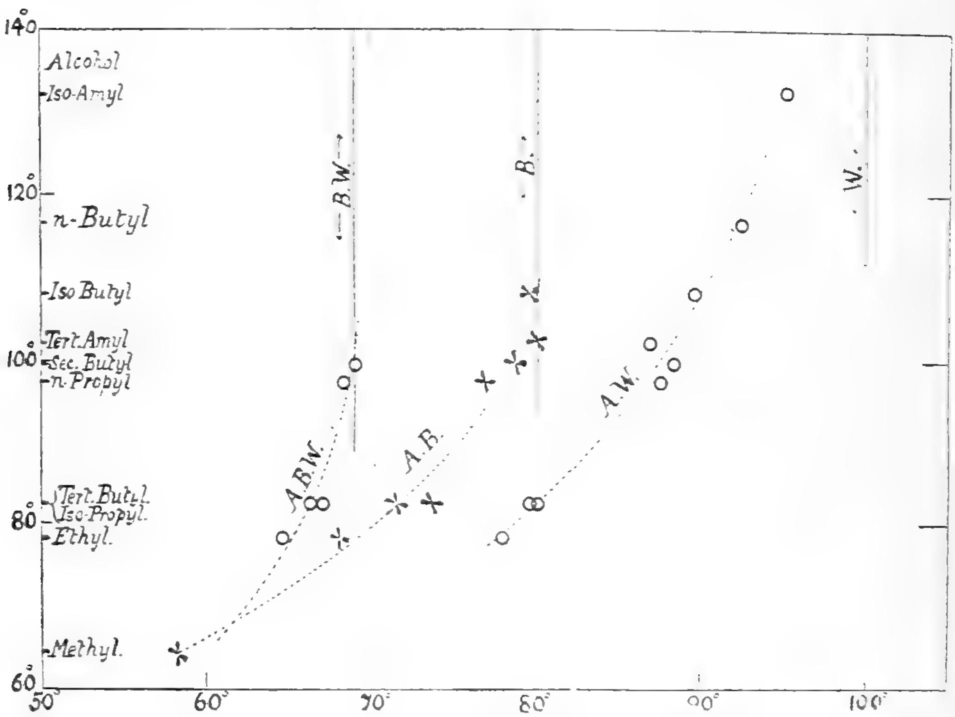

FIG. 2.

The toluene-alcohol curve (fig. 3) is not very suitable for extrapolation to lower temperatures. As drawn, it might appear to indicate the existence of a methyl alcohol-toluene binary azeotropic mixture. A somewhat better, but still not very satisfactory, indication can be obtained by plotting the known differences between the boiling points of the alcohols and of the binary alcohol-toluene mixtures against the boiling points of the alcohols. The curve so obtained leaves it doubtful whether a binary methyl alcohol-toluene mixture should be formed. No azeotropic mixture has actually been obtained, but the boiling-point molecular composition curve for methyl alcohol and toluene is extremely flat for mixtures rich in alcohol; and it would be exceedingly difficult to separate pure methyl alcohol from the mixture by distillation, whereas toluene could easily be separated from a strong solution. The case is doubtless similar to that of a mixture of acetic acid and water, from which it is practically impossible to separate pure water, but easy—from strong solutions—to separate pure acetic acid by distillation.

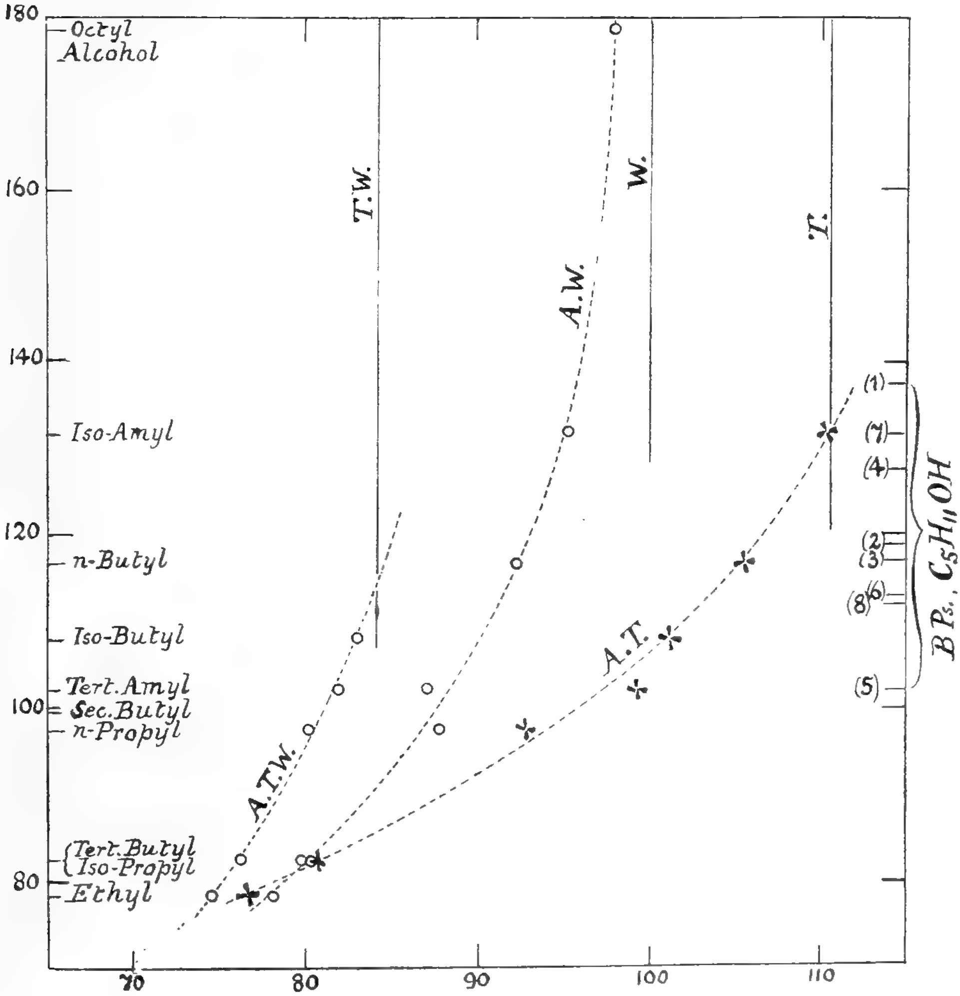

FIG. 3.

The upper limit of the curve, where it intersects the vertical toluene boiling-point line, is at about 132°, or just about the boiling point of symmetrical isoamyl alcohol (7). According to Lecat, this alcohol does form a mixture of minimum boiling point with toluene, but the boiling point of the azeotropic mixture is only 0·1 degree lower than that of toluene.

It seems safe to predict that all the isomeric amyl alcohols, with the exception of the normal alcohol (1), can form such mixtures. There is no doubt that the secondary and tertiary butyl alcohols could do so.

Methyl alcohol, of course, forms no ternary azeotropic mixture with toluene and water. The upper limit of the A.T.W. curve is at about 114°, and it is therefore quite possible that amyl alcohol (6), b.p. 113°, and probable that amyl alcohol (8) can form a ternary azeotropic mixture, and it is certain that the secondary and tertiary butyl alcohols can do so. On the other hand, it is most probable that *n*-butyl alcohol and amyl alcohol (3), and certain that all alcohols of still higher boiling point, cannot form such mixtures.

Lecat has prepared and examined a number of binary aud ternary azeotropic mixtures formed by the hydrides of benzene [cyclohexane, C_6H_{12}, b.p. 80·75°; cyclohexene, C_6H_{10}, b.p. 82·75°; and cyclohexadiene, 1:3, C_6H_8, b.p. 80·8°] with the lower alcohols, and with the lower alcohols and water. The results are very similar to those with benzene.

IV.

THE ACTION OF SULPHUR CHLORIDE ON AMMONIA AND ON ORGANIC BASES.

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The general similarity in chemical properties between sulphur and oxygen is too well known to require anything other than a brief reference. The elements form an analogous series of compounds in the fields of both organic and inorganic chemistry; and the consideration of these striking analogies fostered the hope that it might be possible to prepare a series of nitrogen sulphides corresponding to the oxides of oxygen. It was also hoped to isolate some nitrogen-sulphur compounds parallel to the oxy-acids of nitrogen.

A memoir of Gregory[1] appeared in the "Journal de Pharmacie," in which he affirmed that he had isolated a new compound to which he assigned the formula NS. Soubiernan[2] also described the preparation of the same compound, and later work by Fordos and Gelis[3] showed that this sulphur nitride may be prepared by the action of ammonia on sulphur chloride dissolved in carbon disulphide. They also pointed out that Gregory's compound was probably contaminated by sulphur, as the amethyst coloration, which he stated his compound gave on treatment with alcoholic potash, is not given by pure nitrogen sulphide, but is readily obtained when the compound is mixed with sulphur. Upwards of forty years afterwards, Schenck[4] reviewed the methods for preparing nitrogen sulphide, and showed that the substance did not possess the simple formula previously accepted but existed as the polymer N_4S_4. In the same year Muthmann and Clever[5] prepared a second sulphide of nitrogen by heating N_4S_4 with carbon disulphide under a pressure of five atmospheres, and established the formula N_2S_5 for the compound. More recently, Burt[6] has succeeded in transforming the orange-coloured sulphur nitride N_4S_4 into a blue-coloured variety of the same empirical formula.

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[1] Journal de Pharmacie, 1836, **22**, 301.
[2] Annalen der Chemie, 1838, **67**, 71.
[3] Annalen der Chemie, 1851, (3) **32**, 385.
[4] *Ibid.*, 1896, **290**, 171.
[5] Zeitschrift anorg. Chemie, 1896, **13**, 200.
[6] Trans. Chem. Soc., 1910, **97**, 1171.

As far as we have been able to trace, the nitrogen sulphides described above are the only compounds of this class hitherto isolated. The action of ammonia on sulphur chloride was, therefore, further examined by us, in the hope of supplementing the number of nitrogen sulphides already known. Owing to the vigorous nature of the reaction between sulphur chloride and the base, a diluent liquid is necessary. After preliminary experiments with carbon disulphide, benzene,[1] light petroleum, carbon tetrachloride, and chloroform, the latter solvent was selected on account of its high state of chlorination and its volatility. Sulphur monochloride was used in the work, as it is least likely to exert a chlorinating or oxidising effect on any of the reaction products. In order to determine the course of the reaction, a solution of ammonia in chloroform was prepared, and the strength of the solution determined. A stream of dry ammonia gas was passed into a litre of the solvent at 10° until no further absorption of the base occurred. Titration showed that the chloroform contained 30·6 grams of ammonia per litre (1·8 N). This solution was slowly added to 34 grams of sulphur monochloride, dissolved in 500 c.c. of ice-cold chloroform, until a permanent alkalinity was developed. The mixture was mechanically stirred during the reaction, and on the average 370 c.c. of the ammonia solution were required for combination with the amount of sulphur chloride used. The main products of the reaction were found to be ammonium chloride, sulphur and nitrogen sulphide (N_4S_4), and the quantities of sulphur chloride and ammonia employed lead to the equation given below. 370 c.c. of 1·8 N ammonia correspond to 0·666 gram-molecules of the base, and this reacts with 0·5 gram-molecules (34 grams) of sulphur monochloride. It therefore follows that four molecules of ammonia combine with three molecules of sulphur monochloride, hence the equation—

$$12SCl + 16NH_3 = N_4S_4 + 12NH_4Cl + 4S_2.$$

As no nitrogen was evolved during the reaction, it is of interest to compare this equation with that given by Ruff and Geisel[2] for the action of sulphur tetrachloride on ammonia—

$$12SCl_4 + 16NH_3 = 3N_4S_4 + 48HCl + 2N_2.$$

From the equations it is seen that when acting on ammonia the various chlorides of sulphur behave as a mixture of SCl_3 with sulphur or chlorine. If the state of chlorination is greater than in SCl_3, oxidation by the

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[1] Francis (Trans. Chem. Soc., 1904, **85**, 259, 1535; 1905, **87**, 1836) obtained a good yield of N_4S_4 by passing ammonia into a solution of sulphur dichloride in benzene. See also Davis, *ibid.*, 1905, **87**, 1831.

[2] Berichte d. Deutsch. Chem. Gesell., 1904, **37**, 1573.

excess chlorine results in the liberation of free nitrogen, while if the state of chlorination is lower free sulphur is found as a reaction product.

In order to obtain the nitrogen-sulphur compounds formed in the above reaction, the experimental methods are somewhat modified. Ammonia dissolved in chloroform is added to an ice-cold solution of sulphur chloride in the same solvent until a permanent alkalinity is developed. The solvent is then filtered to remove the precipitated sulphur and ammonium chloride, and the residue well washed with chloroform. A further quantity of sulphur chloride is added to the combined filtrates, and the ammonia solution again added until alkalinity develops. The process is repeated until traces of nitrogen sulphide are noticed in the precipitate, when the filtrates are distilled until about three-quarters of the solvent is removed. The concentrated solution is now treated with an excess of methylated spirit, which precipitates most of the nitrogen sulphide together with sulphur. On treatment of the precipitate with carbon disulphide, fairly pure nitrogen sulphide (N_4S_4) is obtained. After concentrating the alcoholic filtrate, and allowing it to cool at intervals, various forms of crystals separate out at the different stages. Nitrogen sulphide and sulphur are first obtained, but later characteristic square laminae form. Subsequently a red oil separates, which solidifies to a low melting solid (10–11°), and is identical with the sulphide of nitrogen (N_2S_5) described by Muthmann and Clever. By careful fractional crystallisation of the alcoholic filtrate the compound which crystallises in the form of square plates may be obtained fairly free from sulphur, and it may be further purified by repeated crystallisation from carbon disulphide. The compound, for which we propose the name *hexasulphamide*, appears to have the formula S_6NH_2, and a comparison of its properties with those of the compound SNH obtained by Wölbling[1] by the reduction of nitrogen sulphide may be of interest :—

SNH.	S_6NH_2.
Yellow leaflets.	Colourless, square plates.
M.P. 152°.	M.P. 105°.
Not acted on by cold KOH.	Not acted on by cold aqueous KOH or HNO_3.
Acted on by HNO_3.	
Heated gives NH_3.	Heated gives NH_3.

[1] Zeitsch. anorg. Chem., 1908, 57, 281.

Hexasulphamide is insoluble in water, and in aqueous acids and alkalis, but is soluble in organic solvents such as carbon disulphide, alcohol, and chloroform. Chlorine oxidises it to N_4S_4, and alcoholic potash gives an intense violet-red coloration, which disappears after a time, a persulphide being formed.

The large sulphur content of the compound is remarkable, and as the melting point might suggest that the substance was a sample of impure sulphur, the melting point of a mixture of the substance with sulphur was taken and found to be 98°. The percentages of nitrogen and sulphur in the compound were determined, and found to agree with the theoretical values for hexasulphamide. The sulphur was oxidised to sulphate by careful heating with a large excess of sodium peroxide in a nickel crucible, and weighed as barium sulphate. The nitrogen was estimated by combustion with copper oxide in an atmosphere of carbon dioxide according to Dumas' method. Boiling with sodium hydroxide solution does not liberate all the nitrogen as ammonia.

0·1385 gram gave 0·9285 gram of $BaSO_4$, whence S = 92·0 per cent.

0·1400 gram gave 0·9403 gram of $BaSO_4$, whence S = 92·2 per cent.

0·3591 gram gave 17·1 c.c. N_2 at 12,755 mm., whence N = 6·5 per cent.

0·5020 gram gave 26·2 c.c. N_2 at 11,755 mm., whence N = 6·4 per cent.

S_6NH_2 requires S = 92·3 per cent.; N = 6·7 per cent.

As has already been mentioned, hexasulphamide behaves in a similar way to a mixture of nitrogen sulphide and sulphur, or the red nitrogen sulphide (N_2S_5) on treatment with alcoholic potash: in all cases a violet-red or amethyst coloration is developed, which disappears after some time. No explanation has up to the present been advanced to account for this colour development, but it is conceivable that it is connected with the formation of a salt of a nitrogen-sulphur acid—

$$S_6NH_2 + KOH = S_6NHK + H_2O.$$

Colour development in the case of hexasulphamide is not limited to the action of potash, for the amethyst coloration is produced by alcoholic solutions of the organic bases. The tint in these cases is, as a rule, not so deep as that obtained with alcoholic solutions of potassium hydroxide. If the solutions of the different bases are weak, some time elapses before the colour develops, and the time is found to vary with the dilution of the solution and the nature of the base. The figures in the following table show the time that elapses before the colour develops. 5 c.c. of N/3 solutions of the bases were used in each case :—

N/100 S_6NH_2	Potassium Hydroxide.	Methylamine and Ethylamine.	Dimethylamine, Diethylamine, and Piperidine.
1 c.c.	150 seconds.	210 seconds.	240 seconds.
2 c.c.	80 ,,	120 ,,	125 ,,
3 c.c.	50 ,,	85 ,,	95 ,,
4 c.c.	35 ,,	60 ,,	70 ,,
5 c.c.	20 ,,	55 ,,	60 ,,

The view that the colorations referred to above are due to the formation of a salt of a nitrogen-sulphur acid led to attempts to prepare such an acid by the action of sulphuretted hydrogen on solutions of nitrogen sulphide, nitrogen sulphide and sulphur, and the red sulphide of nitrogen. In no case was any such product isolated, for either the original materials were obtained on crystallisation, or, if the reaction had proceeded far, ammonium polysulphide was formed. It was thought that the organic derivatives might be more stable, as such derivatives of carbonic acid and sulphurous acid are obtained as stable compounds. In accordance with this view, the action of nitrogen sulphide (N_4S_4) on ethyl mercaptan was examined, but no derivative of the desired nature was isolated. On adding ethyl mercaptan to the sulphur nitride a vigorous reaction takes place, considerable heat is developed, and ammonia is evolved. A deep-red liquid—which is probably a solution of the nitrogen sulphide in the mercaptan—is formed in the first stages of the reaction, but on further addition of the thioalcohol the colour disappears, and the end products are a pale-yellow liquid and a small amount of a white solid. The latter appears to be sulphur, and is generally found to an extent of 3–4 per cent. of the amount of nitrogen sulphide used. To trace the other products of the reaction, a weighed amount of nitrogen sulphide was placed in the reacting vessel, and the mercaptan was slowly run in. A flask (C) contained a known volume of N/1 sulphuric acid, and the ammonia formed in the reaction was absorbed in this medium. During the reaction a small amount of a white, evanescent solid collected on the sides of the reacting vessel and in the tube leading to C. (A small amount of this was collected in separate experiments, but it was too unstable to be fully examined. It decomposes rapidly in air, giving off ammonia.) When the reaction was over, the reacting vessel was heated to 50° in order to decompose any of the unstable white solid, and a current of air was drawn through the apparatus to carry over the last traces of ammonia. Titration of the acid showed that almost 90 per cent. of the nitrogen of nitrogen sulphide is liberated as ammonia by the action of methyl mercaptan.

0·7440 gram N_4S_4 gave 0·2434 gram NH_3, or 88·5 per cent. of the calculated amount.

1·0004 gram N_4S_4 gave 0·3697 gram NH_3, or 89·8 per cent. of the theoretical amount.

On fractional distillation of the residual liquid obtained in the experiment, a small fraction was obtained at 35°, which was obviously unchanged ethyl mercaptan. A trace of ethyl sulphide distilled at 91·5°, but the main fraction was collected at 150-153°. On further fractionation it was found that this consisted almost entirely of ethyl disulphide (b.p. 151·5–152°). The distillate on reduction by zinc and hydrochloric acid was converted into ethyl mercaptan. Nitrogen sulphide, therefore, reacts with ethyl mercaptan mainly in accordance with the equation—

$$12C_2H_5SH + N_4S_4 = 6(C_2H_5)_2S_2 + 4NH_3 + 2S_2.$$

The action of sulphur chloride on a number of organic bases was examined, and the derivatives formed appear to be characteristic for the different types of bases. Thus sulphur chloride when added to solutions of the aliphatic bases in chloroform or ether gives white precipitates of the hydrochloride of the bases, the sulphur compound of the base remaining in solution. This reaction has already been investigated by Michaelis[1] and his collaborators, and dithioamines have been isolated. Diethylamine, for example, gives rise to dithiodiethylamine $S_2(NEt_2)_2$, and piperidine is converted into dithiopiperidine.

The alkyl substituted aromatic bases approximate to the aliphatic type, giving white or faintly coloured precipitates on treatment with sulphur chloride in ethereal or benzene solution. Derivatives of such a type have previously been isolated, dithiodimethylaniline, $Me_2N.C_6H_4\text{–}S\text{–}S\text{–}C_6H_4NMe_2$, being prepared from dimethylaniline.[2]

The primary aromatic amines, on the other hand, give coloured precipitates when a few drops of sulphur chloride are added to a solution of the base in ether, chloroform, or benzene. (The precipitates are actually colourless, being the hydrochlorides of the bases, but appear coloured on account of the tints developed in the solutions.) The results obtained with the bases at

[1] Berichte d. Deutsch. Chem. Gesell., 1895, **28**, 165.

[2] Merz. and Weith, Berichte d. Deutsch. Chem. Gesell., 1885, **19**, 157.

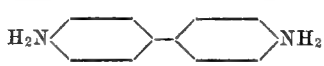
our disposal are given in the table below, and from these it appears that sulphur chloride might with advantage be employed as a reagent for the qualitative examination of organic bases.

Primary Aromatic Amines.

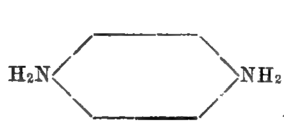
Substance.	Solvent.	
	Benzene.	Chloroform.
Aniline.	Red-yellow precipitate.	Red-brown precipitate.
o-Toluidine.	Scarlet ,,	Red-brown solution.
p-Toluidine.	Red ,,	Red precipitate.
α-Naphthylamine.	Maroon ,,	Chocolate precipitate.
β-Naphthylamine.	Scarlet ,,	Orange ,,
Benzidine.	Green-blue ,,	Dirty apple-green precipitate, fading to dirty white.
m Phenylene diamine.	Yellow ,,	
p-Phenylene diamine.	Green-blue ,,	

It seems probable that the colours obtained in the above reactions are connected with the orientation of the amino groups in the molecule. Compounds like benzidine and *p*-phenylene diamine, for example, in which the amino groups occupy similar positions, give similar colorations, whilst *m*-phenylene diamine gives a precipitate of a different tint.

(Benzidine) . . .

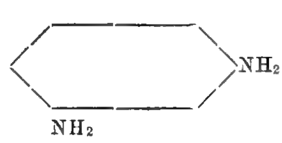


(*p*-phenylene diamine)



Green-blue precipitate

(*m*-phenylene diamine)



Yellow precipitate

The nature of the products formed in the reactions with primary amines has already received some attention. Edeleano[1] examined the action of

[1] Bull. Soc. Chim., 1891, (3) 5, 175.

sulphur chloride on aniline in chloroform solution at 50°, and obtained thio-aniline. More recently, Coffey[1] has made a fuller study of this case, and showed that at low temperatures the reaction takes place quantitatively, according to the equation—

$$3C_6H_5NH_2 + S_2Cl_2 = C_6H_5NS_2 + 2C_6H_5NH_2, HCl.$$

The work described in this paper was undertaken before Coffey's publication appeared, and we are able to confirm his results, as a similar reaction takes place with *m*-toluidine, which we selected as a typical case. To isolate the products of the reaction 19·3 grams (3 mols.) of the base were dissolved in 150 c.c. of anhydrous ether, and the solution cooled in a freezing mixture to below - 15°. 8·1 grams (1 mol.) of sulphur monochloride dissolved in 30 c.c. of dry ether were slowly added from a dropping funnel, the mixture being mechanically stirred during the reaction. The solution becomes coloured, and toluidine hydrochloride separates out. Additional ether is added to the mixture after half of the sulphur chloride has been introduced as the separated hydrochloride makes stirring somewhat difficult. After all the sulphur chloride has been added, the mixture is kept in the freezing mixture and stirred for an hour. It is then filtered, and the hydrochloride washed with ether. The solvent is removed from the combined filtrates in an evacuated desiccator, and a reddish-brown solid soon begins to separate. The first fractions of this are rejected, and the part which separates out subsequently is kept in a vacuum desiccator for a further forty-eight hours to remove all traces of ether, and is then analysed. It is pure *N-dithiotoluidine.* (Found N = 8·1 per cent. : $C_7H_7NS_2$ requires N = 8·3 per cent.)

The substance appears to polymerise on keeping, especially if exposed to air. It becomes oily, and the solubility in ether decreases.

Hydrogen chloride gas decomposes a solution of dithiotoluidine in dry ether, sulphur chloride and the base being formed. The reaction, therefore, is reversible—

$$RNH_2 + S_2Cl_2 \rightleftarrows RNS_2 + 2HCl.$$

Aqueous hydrochloric acid also decomposes it, a mauve-coloured dye-stuff and black tarry products being formed. The nature of these was not further examined.

Colours were also obtained by the action of sulphur chloride on other aromatic compounds containing the NH_2 group, and it is hoped to determine the course of the reaction in these cases later. Some of the results obtained are shown in the table opposite.

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[1] Rec. Trav. Chim., 1921, (4) 50, 745.

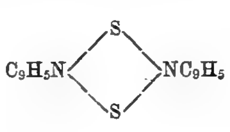
Substance.	Coloration
Phenylhydrazine.	Red-brown precipitate (in benzene). Yellow precipitate (in chloroform).
Benzylphenylhydrazine.	Chocolate precipitate (in benzene). Yellow precipitate (in chloroform).
Diazoaminobenzene.	Yellow precipitate (in benzene). Yellow-brown precipitate (in chloroform). Orange-red precipitate (in carbon disulphide).
Aminoazobenzene.	Chocolate precipitate (in benzene). Maroon precipitate (in chloroform). Magenta, with a metallic sheen (in carbon disulphide).

Aromatic compounds containing an acid group in the molecule do not produce coloured precipitates with sulphur chloride. For example, sulphanilic acid and the three amino-benzoic acids give at the most a slight white precipitate on treatment with the reagent. The nitranilines behave in a similar way. When the hydrogens of the amino group are replaced, as in acetanilide, *p*-acetotoluidide, formanilide, &c., no reaction takes place: this is to be expected in the light of the course of the reaction already established in the case of the parent bases.

Colour production is also inhibited when the NH_2-group is part of an acid amide. No colour is formed in such cases, even when the sulphur chloride is added direct to the solid amide. Urea, thiourea, and their substituted derivatives also behave in this way.

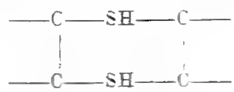
Substances containing a tertiary nitrogen atom as a ring member give precipitates in benzene solution with sulphur chloride: these are white and are soluble in chloroform. Such results have been obtained with pyridine, collidine, quinoline, and α- and β-picoline.

Edinger[1] has investigated this reaction in the case of quinoline and methylquinoline. The product obtained on heating these substances with sulphur chloride in a sealed tube consists of a mixture of chlorinated compounds and a substance $C_{18}H_{10}N_2S_2$, to which he ascribes the constitution

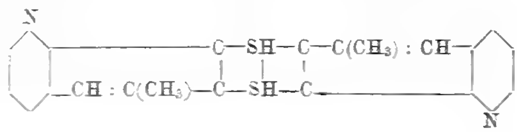


[1] Berichte d. Deutsch. Chem. Gesell., 1896, **29**, 2456; 1897, **30**, 2418; J. pr. Chem., 1896, [2] **54**, 340.

He later finds grounds for supposing that the sulphur atom in such compounds is tetravalent, existing as a ring member of the type



the formula for the methylquinoline derivative being



We wish to take this opportunity of expressing our thanks to Dr. P. J. Brannigan and Dr. E. W. McClelland for help received during the work.

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[1] J. pr. Chem., 1902, [2], 66, 209.

V.

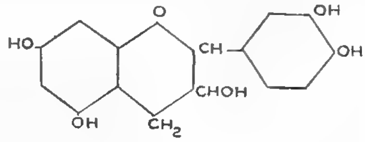
THE CONSTITUTION OF CATECHIN—Part I.

By JAMES J. DRUMM, M.Sc.,
University College, Dublin.

[Read May 28. Published July 17, 1923.]

Although a great many papers have already appeared on the subject of the catechins, the constitution of these bodies has not yet been finally settled. Hitherto the most thoroughly investigated representative of the class has been the principal catechin of Gambir catechu. In the present paper also a few further derivatives of this catechin are described, the preparation and properties of which place the structure of the parent molecule in a new light.

Without attempting a detailed account of the literature of the subject, it may be stated that A. G. Perkin (Jour. Chem. Soc., 1905, 84, p. 87) made the first real attempt to establish a structural formula (I) for catechin.



I.

Perkin's formula (I) represents catechin as a derivative of chromane, and therefore also of $\alpha\gamma$-diphenylpropane.

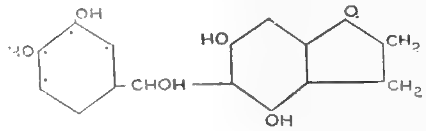
Perkin (Jour. Chem. Soc. 1897, lxxi, p. 1138) has pointed out that there is a close relationship between the nuclear groups of tannins and those of the flavone dyes which occur associated with the tannins in many plants. Thus, quercitin occurs associated with catechin in Gambir catechu, and both contain the catechol and phloroglucinol nuclei.

Ryan and Walsh (Proc. Royal Dublin Society, 1916, xv, p. 114) suggest that the flavone dyes and anthocyanidins are formed in plants from the more widely distributed phlobatannins. Freudenberg (Ber. d. Deutsch. Chem. Soc., Ges., 1920, liii, 1420) shares this view, and considers it extremely unlikely that the structure of the catechins should strongly deviate from the general molecular pattern of the flavones and anthocyanidins, all of which are derivatives of $\alpha\gamma$-diphenylpropane. In fact, the latter worker (Ber. d. Deutsch. Chem. Ges., 1922, lv, 1938) regards the phloroglucinol tannins as being produced in plants from the catechins.

St. von Kostanecki and V. Lampe, however, could not reconcile Perkin's formula (I) with the fact that catechin on bromination forms only a monobromo derivative. Moreover, catechin does not readily split off water, forming a simple anhydride, as the grouping

$$>CH—C(OH)<$$

would seem to require. For these reasons the latter workers (Ber. d. Deutsch. Chem. Ges., 1906, xxxix, 4007) replaced the chromane formula (I) by the coumarane formula (II), which represents catechin as a derivative of diphenylmethane.



II.

Latterly Perkin and Everest also have adopted the coumarane formula (*vide* Text-book on the Natural Organic Colouring Matters, p. 466).

Freudenberg (Ber. d. Deutsch. Chem. Ges., 1920, liii, 1420), however, has pointed out that the earlier work of Perkin and his collaborators (Jour. Chem. Soc., 1902, lxxxi, p. 1164) somewhat annuls the force of the first arguments used by von Kostanecki against the chromane formula (I)—catechin readily forms a disazobenzene derivative. Too much emphasis, therefore, should not be placed on the fact that catechin forms only a monobromo derivative on bromination.

From what follows in the present paper it will be seen that the second of the reasons advanced against the chromane formula also loses its significance; for although a direct elimination of the elements of water from the catechin molecule is not readily accomplished, still this elimination can be achieved by indirect methods in such a way as to yield a simple anhydride containing, in fact, an ethylene linking

$$>C = C<$$

Hence a coumarane formula, which represents catechin as a derivative of diphenyl carbinol, is not necessarily the only formula to be considered.

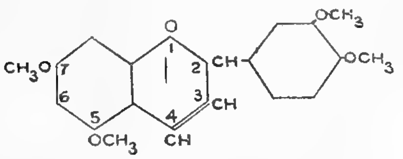
von Kostanecki (Ber. d. Deutsch. Chem. Ges., 1907, xl, 720) by the energetic reduction of catechin tetramethyl ether obtained an oily product which, on further methylation, formed a crystalline pentamethyl ether which melted at 83–84° C. Freudenberg (Ber. d. Deutsch. Chem. Ges., 1920, liii, 1427), in fact, claims to have proved this pentamethyl ether identical with 2·4·6·3′·4′-pentamethoxy-$\alpha\gamma$-diphenyl-propane, thereby establishing an $\alpha\gamma$-diphenyl-propane structure for catechin itself. N. Nierenstein (Jour. Chem. Soc., 1920, cvii, pp. 971–1151), however, challenges Freudenberg's results, and at the same time he himself asserts that he has proved v. Kostanecki's catechin reduction product (just referred to) to be identical with 3·4·2′·4′·6′-pentamethoxy-$\alpha\alpha$-diphenyl-propane. The controversy between these two workers has not yet been finally settled. On completion of the work at present in hand the writer hopes to be able to decide between an $\alpha\alpha$- and $\alpha\gamma$-diphenyl-propane formula for catechin.

When a solution of catechin tetramethyl ether (1 mol.) in carbon disulphide is treated with a molecular equivalent of phosphorus pentachloride, hydrogen chloride is at once evolved, and the corresponding chloride of catechin obtained in very good yield. The reaction may be represented thus :—

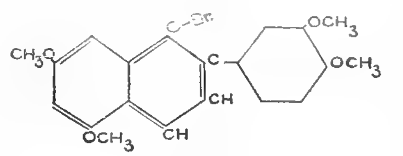
$$C_{19}H_{21}O_5\,(OH) + P\,.\,Cl_5 = C_{19}H_{21}O_5Cl + POCl_3 + HCl.$$

This chloride consists of colourless prisms which melt at 112° C. (when heated rapidly) with evolution of hydrogen chloride. When catechin chloride is heated with pyridine, it loses hydrogen chloride, and yields a colourless crystalline compound melting at 135° C. The results of analysis of this latter compound prove it to have the formula $C_{19}H_{20}O_5$.

It is proposed to name this compound dehydro-catechin tethramethyl ether —formula (III).



III.

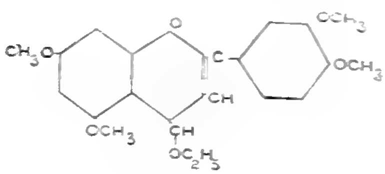


IV.

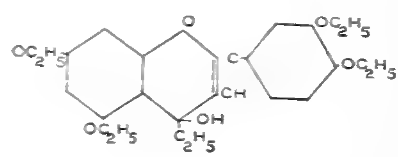
When the solution of dehydro-catechin tetramethyl ether (1 mol.) in chloroform is treated with bromine (2 mols.), hydrogen bromide is evolved, a bright red crystalline solid at the same time separating from the solution. Though analyses of this compound, agreeing closely with one another, could not be obtained, the results, nevertheless, indicated a monobromide structure for the body.

For reasons about to be given, a benzepyranol formula (IV) has been assigned to this bromide. The formation of such a compound from dehydrocatechin tetra-methyl ether necessarily requires the double bond linking in the latter compound (III) to lie between the carbon atoms (3) and (4). A synthesis of the compound 5·7·-dimethoxy-2mp.-dimethoxy phenyl-1·4·-benzopyranol anhydrohydrobromide has been commenced. In this way it is hoped definitely to establish the constitution of the above bromide derivative of catechin.

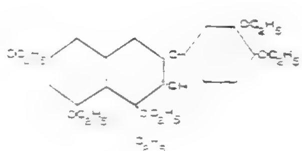
When excess of alcohol is poured on some of the above bromide the red colour gradually disappears, a colourless solution resulting. Addition of hydrochloric acid in excess, however, restores the colour to the solution. By treating the bromide with dilute alcoholic ammonia, and then extracting the mixture with ether, the expected colour-base was obtained on evaporation of the ether. This method was first described by Watson and Senn (Jour. Chem. Soc., 1915, cvii, p. 1483). The colourless base so obtained crystallized from alcohol in colourless prisms, melting at 133° C. The results of analyses of this compound agreed closely with the formula (V).



V.



VI.

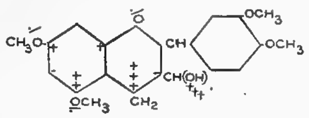


VII.

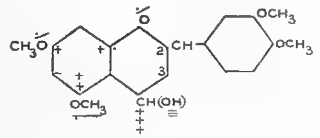
Watson and Senn (*loc. cit.*, p. 1,485) obtained a very closely allied compound as the colour-base of the pyranol salt got from the action of magnesium-ethyl iodide on luteolin tetra-ethyl ether. These authors, in their paper, do not mention any results of analysis of their compound, to which they gave the formula (VI). From the very close analogy of the colour-base (V) with that obtained by Watson and Senn from 5·7-diethoxy-2mp-diethoxy phenyl-1·4-benzopyranol anhydrohydriodide, it would seem that the latter, in reality, had the constitution represented by formula (VII).

The colour-base (V) on treatment with hydrochloric acid immediately regains the bright-red colour of the anhydrohydrochloride. The anhydrohydrochloride was prepared in a pure condition, as described in the experimental part of this paper. The results of analysis of this chloride agreed with the formula 5·7-dimethoxy-2mp-dimethoxy phenyl-1·4-benzopyranol anhydrohydrochloride.

It is obvious that the formula (III) assigned to dehydro catechin tetramethyl ether argues to either of the formulae (VIII) or (IX) for catechin tetramethyl ether.



VIII.



IX.

At the present stage, it does not seem easy to suggest a line of concise experimental investigation such as would admit a final decision between the above two formulae.

The recent theory of induced alternate polarities in carbon compounds advanced by Robinson and Kermack (Jour. Chem. Soc., 1922, cxxi, p. 427), and independently by Lapworth (ibid., p. 416), and now somewhat generally accepted as being at least a "useful system of classification of a wide range of phenomena" in organic chemistry, suggests formula (IX) for the tetramethyl ether of catechin. This theory, at the same time, would emphatically reject formula (VIII), for in the latter formula the (–OH) group attached to carbon atom (3) should exhibit a relatively large induced positive polarity (as illustrated in the diagram); and it is unlikely that, in such a compound, the hydroxyl group would be so easily replaced by the negative chlorine atom, as is the case with catechin tetramethyl ether. In formula (IX), on the other hand, the (–OH) group attached to carbon atom (4) should possess a large induced negative polarity, and this would explain why catechin tetramethyl ether so readily reacts with phosphorus pentachloride, even at ordinary temperatures. Furthermore, the behaviour of the chloride of catechin tetramethyl ether towards ethyl and butyl alcohols rather strengthens these conclusions. This chloride, when boiled for a short time with ethyl or butyl alcohol, yields the corresponding ethyl and butyl catechin tetramethyl ethers respectively. The analogy of such a reaction with that between an acid chloride and an alcohol is seen from the particular example:

$$CH_3-\underset{\underset{\underline{O}}{\|}}{\overset{+}{C}}-\overset{-}{Cl}+C_2H_5-\overset{-}{O}-\overset{+}{H}=CH_3\underset{\underset{\underline{O}}{\|}}{\overset{+}{C}}-\overset{-}{O}C_2H_5+\overset{+}{H}-\overset{-}{Cl}.$$

A compound such as $(CH_3\overset{+}{C}O)\overset{-}{Cl}$, of course, represents the extreme type of negative Cl. (Compare Lapworth, Mem. Manchester Phil. Soc., 1920, lxiv (3), pp. 1–16.)

Experimental Part.

Preparation of chloride of catechin tetramethyl ether.

Seven grams of pure catechin tetramethyl ether were dissolved in 50–60 c.c. of carbon disulphide in a 200 c.c. round flask fitted with a reflux condenser and calcium chloride tube; 5 grams of phosphorus pentachloride were added to the contents of the flask (by disconnecting the condenser for a few moments).

An evolution of hydrogen chloride was immediately observed. The flask was shaken intermittently until all the phosphorus pentachloride had dissolved and the evolution of hydrogen chloride ceased (about ten minutes in all).

The contents of the flask were then thrown into a litre beaker containing 200 c.c. of 10 per cent. sodium carbonate solution with some ice. The contents of the beaker were stirred vigorously until effervescence ceased. The layer of carbon disulphide was separated in a large separation funnel, and was washed again by shaking up with 100 c.c. 10 per cent. carbonate solution. Finally, the carbon disulphide layer was allowed to stand for half an hour in a conical flask over 10 grams of anhydrous potassium carbonate. The carbon disulphide was then decanted off and allowed to evaporate in a dish. When most of the solvent had gone, colourless rhombohedral crystals separated. These were pressed on the filter pump and allowed to stand on a porous plate for half an hour until all the solvent had gone. The compound was recrystallized from ligroin.

The pure compound melted at 112° C. with evolution of hydrogen chloride. The yield of the pure product was 6 grams.

In an estimation of chlorine by Stepanow's method:—

0·4640 grams of chloro-catechin tetramethyl ether required 12·9 c.c. of N/10 $AgNO_3$ for titration, corresponding to 0·0457 grams of chlorine. Therefore Cl for compound is 9·85.

$C_{19}H_{21}O_5Cl$ requires Cl 9·724.

Preparation of ethyl catechin tetramethyl ether.

A solution of 5 grams of chlorocatechin tetramethyl ether in 40–50 c.c. of absolute alcohol was boiled for half an hour in a (100 c.c.) round flask fitted with a reflux condenser. The contents of the flask were then poured into a dish and left aside for a few hours until the separation of felted crystals was complete. The crystals were separated from the mother liquor on a Buchner filter in the usual way. After recrystallizing twice from absolute alcohol and once from ligroin, the melting point of the compound was 123° C. The yield of the pure compound was 2·5 grams.

On analysis :—

(*a*) 0·1352 grams of the substance gave 0·0774 grams of H_2O and 0·3354 grams of CO_2, corresponding to H 6·4, C 67·6 for the compound.

(*b*) 0·1484 grams of the substance gave 0·0874 grams of H_2O and 0·3672 grams of CO_2, corresponding to H 6·5, C 67·3.

$C_{21}H_{26}O_6$ requires C 67·4 and H 6·99.

In an estimation of the molecular weight of the compound by the elevation of the boiling-point, using a Landsberger apparatus :—

0·501 grams of the compound gave (using absolute alcohol as solvent) an elevation of 0·35° C. when the volume of the solution was 7 c.c., and an elevation of 0·20° C. when the volume was 11·5 c.c. The corresponding values for the molecular weight are 319, 340 respectively.

$C_{21}H_{26}O_6$ requires 375.

Ethyl catechin tetramethyl ether is insoluble in caustic potash solution, nor does its solution in alcohol afford any colour reaction with ferric chloride. It dissolves in concentrated sulphuric acid, forming a yellow solution. Phosphorus pentachloride has no action at ordinary temperature on the solution of this compound in carbon disulphide. Ethyl catechin tetramethyl ether is sparingly soluble in ether, easily in chloroform, sparingly in absolute alcohol in the cold, but easily in boiling alcohol.

Preparation of butyl catechin tetramethyl ether.

This compound was prepared by boiling a solution of the chloride in normal butyl alcohol for about ten minutes, as in the case of the corresponding ethyl compound, which latter compound it closely resembles in its properties. It crystallized from alcohol in stout prisms which melted sharply at 79–80° C.

On analysis :—

0·1180 grams of the substance gave 0·2984 grams of CO_2 and 0·0780 grams of H_2O, corresponding to C 68·88, H 7·31 for the compound.

$C_{23}H_{30}O_6$ requires C 68·62, H 7·51.

Preparation of dehydro catechin tetramethyl ether.

Five grams of the chloride of catechin tetramethyl ether were heated for about half an hour with 20 c.c. of pure, dry pyridine in a 100 c.c. round flask fitted with a reflux condenser. It was found convenient to heat the flask in a glycerine bath maintained at a temperature of 130° C., so that the pyridine boiled gently. The contents of the flask were then thrown into 300 c.c. of water and allowed to stand for a few hours. At the end of this time the separated, white, crystalline precipitate was filtered off on the pump, washed with 50 c.c. of normal sulphuric acid, and then with 50 c.c. of water. After two recrystallizations from absolute alcohol, the compound was obtained in glistening white needles, which melted sharply at 133·5–134·5° C.

Dehydro catechin tetramethyl ether is easily soluble in benzene and chloroform, sparingly soluble in ether, ligroin, and cold absolute alcohol. Its solution in alcohol does not give any colouration with a solution of ferric chloride. It dissolves in cold concentrated sulphuric acid, forming a deep orange solution. The yield of the pure compound was 4 grams.

On analysis:—

0·1666 grams of the substance gave 0·4238 grams of CO_2 and 0·0924 grams of H_2O, corresponding to C 69.37, H 6·21.

$C_{19}H_{20}O_5$ requires C 69·48, H 6·14.

The action of bromine on dehydro catechin tetramethyl ether.

6·6 grams of pure dehydro catechin tetramethyl ether were dissolved in 60 c.c. of chloroform at room temperature, and to this solution 32 c.c. of a second chloroform solution containing 3·2 grams of bromine were added. Fumes of hydrogen bromide were immediately evolved, the solution simultaneously assuming a wine-red tint. After about an hour the separation from the solution of a red crystalline precipitate was complete. The solid product was filtered off on the pump, allowed to stand for a few hours on a porous plate, and finally kept for two days in a vacuum desiccator over powdered caustic soda. Accurate analyses of the compound for Br. could not be obtained, though the results pointed to the formula $C_{19}H_{19}O_5Br$. for the compound. As already pointed out in the earlier part of this paper, this bromide was assumed to be the anhydro salt of a tetramethoxy benzopyranol; accordingly, it seemed feasible to try to isolate and obtain the corresponding colour-base in a pure condition. The method of Watson and Senn (Jour. Chem. Soc., 1915, cvii, p. 1477), for the isolation of colour-bases from their corresponding benzopyranol anhydro-salts, was successfully tried.

The bromide was added to 50 c.c. of 80 per cent. alcohol, and 20 c.c. of concentrated ammonia (s. g. 0·880) added; 100 c.c. of a saturated solution of ammonium chloride were then mixed with the solution, and the whole subsequently extracted with three successive volumes (100 c.c. each) of ether. The combined ether extracts were allowed to stand for an hour over anhydrous potassium carbonate, and the ether afterwards distilled off on a water-bath. The white crystalline residue was then recrystallized, once from chloroform and twice from absolute alcohol. The compound was then obtained as colourless glistening needles, which melted sharply at 133–134° C., and was free from traces of halogens. On pouring dilute hydrochloric acid on some of the crystals, the latter at once assumed a beautiful red tint, due to their transformation into the corresponding anhydrochloride. This base is sparingly soluble in ether, easily soluble in chloroform, somewhat sparingly soluble in cold, though readily soluble in hot absolute alcohol. The base does not give any colouration with ferric chloride, and is insoluble in cold caustic potash solution. It dissolves in concentrated sulphuric acid, giving an orange-coloured solution which does not exhibit any fluorescence.

On analysis:—

0·1728 grams of the substance gave 0·4270 grams of CO_2 and 0·1020 grams of H_2O, corresponding to C 67·36, H 6·61.

0·1424 grams of the substance gave 0·3530 grams of CO_2 and 0·0824 grams of H_2O, corresponding to C 67·6, H 6·46.

$C_{21}H_{24}O_6$ requires C 67·70, H 6·50.

$C_{19}H_{20}O_6$ requires C 66·25, H 5·85.

Preparation of the anhydrohydrochloride of the colour base.

Two grams of the base were dissolved in 20 c.c. of chloroform, 50 c.c. of chloroform, previously saturated with hydrogen chloride, were then added to the solution, and the whole allowed to stand in a shallow evaporation dish. After a few hours the separation of a carmine-red crystalline solid from the solution was complete. The crystals were separated on a Buchner funnel, and washed once with 10 c.c. of chloroform. The chloride was then dried for ten minutes at a temperature of 75–80° C. in an air oven, and, finally, it was allowed to stand for two days over powdered caustic soda in a vacuum desiccator. The yield of pure substance was 2 grams. It melted at 126–128° C.

The chloride is only sparingly soluble in the ordinary solvents. When alcohol is poured on the crystals the red colour quickly disappears, indicating alcoholysis of the salt to the base. Excess of hydrochloric acid restores the red colour. The chloride is somewhat soluble in hot dilute hydrochloric acid, forming a coloured solution which possesses feeble dyeing properties.

In an estimation of chlorine in the compound by the method of Stepanow:—

0·4340 grams of the chloride required 12·35 c.c. of N/10 $AgNO_3$, corresponding to chlorine 10·09 for the compound.

$C_{19}H_{19}O_5Cl$ requires chlorine 9·78.

In conclusion, the author wishes to express his thanks to Professor H. Ryan, D.SC., for his valuable advice and helpful criticisms, and to the Department of Education of An Saorstáit for a grant in aid of the investigation.

UNIVERSITY COLLEGE, DUBLIN,
May, 1923.

VI.

PASTEUR CENTENARY CELEBRATION,
26th February, 1923.

1.—LOUIS PASTEUR,

By WILLIAM ROBERT FEARON, Sc.D., F.T.C.D.

I.

This afternoon we have assembled for the purpose of recalling to mind the achievements and example of a man whose life-work has rendered him famous among the men of his generation and ours; and whose genius is intimately associated with the present progress of knowledge in science, medicine, and the industries.

Although the name of Louis Pasteur belongs to so many departments of learning, his life was in no wise divided or dispersed. Begun in simplicity and obscurity—"the small hidden spring of a large river"—it was continued and directed with an exactness of purpose that makes it read like an epic rather than a record of mortal accomplishment.

He was born at Dôle on December 27th, 1822. His father, Jean Joseph Pasteur, who had served under Napoleon as a Sergeant-Major, and had been awarded the Legion of Honour, soon afterwards moved to Arbois and settled as a tanner. In the midst of these quiet surroundings the youth of Pasteur was spent.

He entered the École Normale of Paris in 1843; where he came under the influence of great and inspiring teachers, notably the chemist Dumas, and here, while yet in the spring-time of his life he made his first discovery—the exact nature of the mysterious *racemic acid*, which had been found in the wine vats in Alsace twenty-five years previously, and which had baffled the best intellects of French chemistry.

From a careful examination of the crystalline forms of this acid and its salts, Pasteur found that it was really a mixture of two substances; one, the familiar tartaric acid of antiquity, the other a new form of tartaric acid hitherto unsuspected.

This discovery, of great interest in the theory of chemistry, was the first demonstration of the two great qualities which characterized Pasteur's later investigations: namely, exact observation and great experimental skill in manipulation.

This early discovery brought him no money, but brought him friendships, which were of greater worth, and also indirectly led him to wider fields of research and harvests beyond his anticipation.

These were the studies of fermentations. In them every aspect of Pasteur's genius is displayed, and in them he first definitely out-topped the men of his time and anticipated in himself the future development of humanity.

II.

Fermentation is a process older than civilization. Certain materials when left to themselves are found to undergo a spontaneous and often profound chemical change which alters their whole character.

Since times forgotten, man has availed himself of these natural changes in the preparation of wine and beer, in the manufacture of vinegar, in the making of butter and cheese.

The causes of these changes or fermentations were quite unknown, and their occurrences were sometimes so capricious as to appeal to a sense of the supernatural, such as the influence of a comet on a vintage or a thunderstorm on a dairy. The current scientific notions of the nature of fermentation had hardly advanced beyond the time when Lemery—some two hundred years previously—had written :

> "Fermentation is an Ebullition raised by the Spirits that endeavour to get out of a Body ; meeting with the gross Earthy Parts that oppose their passage, they swell and rarefy the Liquor until they find a way out."

In the middle of the nineteenth century, ferments were considered to be dead chemical substances in the process of decay, and fermentation itself was thought to be akin to oxidation.

Pasteur's interest in fermentation probably went back to the days when he played in his father's tan-yard in Arbois.

In 1854 he was appointed Dean of the Faculty of Science newly instituted at Lille. He at once realized that the work of his department should be brought into touch with the important industries of the district, notably the manufacture of alcohol from grain and from beet-sugar.

These fermentation industries were often visited by strange and quite inexplicable diseases. The wrong substances were produced, and the good were rendered useless. Acids appeared, and wines went sour. Beer developed unpleasant flavours. Pasteur approached the problem with the help of the microscope, and soon detected a difference in the shape of the particles of the ferment in the normal fermentations and the abnormal fermentations.

In good beer the yeast was round ; in beer that had gone sour the particles of the ferment were narrow and elongated, very like the particles found in sour milk.

After a long and careful research, Pasteur showed that these unknown ferments were really living organisms, low forms of vegetable life growing freely in the liquids, and causing the characteristic fermentation changes as a result of their growth.

The alcohol in wine or beer is produced from the sugar of the grape (or the starch of the barley or potato after it has been changed into sugar) by the working of a living organism—yeast. The formation of acids in the manufacture of vinegar or the souring of wine is due to the action of a different living organism. Pasteur clearly established that these fermentations were intimately associated with the presence of certain low forms of life; and that when a fermentation failed, it was because the organism responsible for the change was either absent altogether or unable to grow properly.

He studied and isolated the ferment which causes milk to turn sour, and is now familiar to science as the *Lactic Bacillus*.

These results, part of which was first published in 1857, were revolutionary in their consequences. Dr. Horace Brown, a great authority on the fermentations, wrote of them:

> "The current of my thoughts was entirely changed by the perusal of the earlier work of Pasteur. . . . . Few here can realize what it meant to have the vague and utterly sterile ideas of the Liebig school replaced by the clear and logical demonstration that fermentations are phenomena correlative with the vital action of specific organisms."

Thus was demonstrated a great scientific discovery of the last century: Fermentation is one of the manifestations of life. It has been abundantly shown that this applies to all the natural fermentations known to man. Pasteur was the first scientific vitalist in that he replaced the confused notion of obscure and indefinite chemical forces by the clear notion of definite living organisms. Looking back from the quiet haven of established and accepted knowledge, it is easy to underestimate the importance of this discovery; but to anyone acquainted with the desolate confusion of ideas which existed at the time of Pasteur's researches, his work rises like a lighthouse above an uncharted and unresting sea—a lighthouse set upon the rock of truth, which for Pasteur was as the Rock of Ages.

III.

In 1859 Pasteur's eldest daughter died. One of his letters written at that time contains the following sentence:—

> "Let us think of those who remain, and try as much as lies in our power to keep from them the bitterness of life."

It was impossible for a great observer like Pasteur to contemplate the phenomena of fermentation and of micro-organic life without thinking of the problems of human life itself, of pain and disease, and the bitterness of apparently useless suffering. But the way of approach to the scientific study of human ailments was extraordinarily hard for Pasteur. He was not qualified (in the academic sense) to practise medicine. His presence, as a mere chemist, was acutely resented by the physicians and surgeons of Paris. Greater than all these was the almost complete lack of knowledge about the immediate cause of diseases themselves. Indeed, it was sometimes doubted if diseases had a definite cause; they may have arisen spontaneously, or as the result of a vast number of indefinable conditions. "Treat the patient and not the distemper" was a catch-cry of the period.

Before approaching the study of diseases, Pasteur had carried out an original and startling experiment on the fermentation of ammonium salts of tartaric acid. This fermentation he found to be due to the growth of a mould, *penicillium glaucum.* When he added some of this mould to a solution of the racemic acid, which he had previously shown to be a mixture of two substances, the mould grew, and fermented the solution just as if it were simple tartaric acid. However, on examining the mixture, he found that the organism had somehow separated the racemic acid into its two constituents, and had fermented or eaten up one of them, leaving the other form untouched. In other words, this minute vegetable had, in the course of some hours, performed the chemical operation of analysing or resolving racemic acid into its two constituents—an operation which had taken Pasteur several years of research to accomplish and explain.

This work has been extended and amplified by many subsequent investigators; and fermentation by living organisms, or their equivalents, *enzymes,* is now widely employed in biological chemistry as a means of separating sugars and other substances.

The power of the mould to attack one component of the racemic acid in preference to the other was shown by Pasteur to be due to the fact that the component destroyed was of frequent natural occurrence, and hence more familiar to the mould. This was one of the first examples of an intentional bacteriological operation. Pasteur also brought about the formation of butter-milk by inoculating fresh milk with the lactic bacillus, which he had previously isolated from sour milk. In this he reproduced the change that takes place everywhere in the dairies of the world, only instead of the lactic bacillus being borne to the milk by the uncertain winds, it was brought by the more certain test-tube. The rule of man had been extended into the realm of the invisible. Another Gulliver had come to Lilliput, but instead of being taken captive by the pigmy inhabitants, he assumed kingly state. "He was king for a day, and he has left us his kingdom for ever."

IV.

We can say that before every great discovery a period of myth and superstition existed in which the natural events are interpreted by allegory or empirical dogma. Later on, when science possesses some of the necessary implements of knowledge, there are numerous tentative speculations advanced—speculations which are frequently incorrect because the means employed are inadequate to meet the difficulties of the investigation, or because the problem is very complex and requires a preliminary process of analysis. The inquiry into the origin and nature of micro-organisms is probably the best example of this gradual emergence of scientific knowledge from unscientific speculation.

The mathematician and alchemist Athanasius Kircher (1641) is generally credited with the first rational presentation of the belief in a world of invisible living organisms influencing the material welfare of men and lower animals:

> "It is so true that the air, the water, the earth, all swarm with innumerable very minute insects, that now-a-days it can be proved by the human eye. It has been universally known that worms are produced in putrifying bodies: but only since the wonderful invention of the microscope has it been possible to recognize that all putrifying substances teem with an innumerable swarm of beings invisible to the naked eye."

The opinions of Father Kircher were accepted by the great naturalist Linnaeus and by his pupil Nyssander, who made them the basis of a *germ theory* of disease; according to which each infective disease was due to a particular micro-organism or germ. This is all the more interesting as it was formulated in the entire absence of any precise experimental proof.

A tremendous controversy slowly developed as to the existence and significance of micro-organic life. Good experimental work and bad reasoning joined issue with unsound investigation and brilliant guess-work. Some seekers denied completely the very existence of these germs; others, with a touch like King Midas of old, found them wherever they chose to lay their hands. The controversy was still further obscured by acrimonious metaphysical disputes about the immortality of animals and the origin of life.

Linnaeus, on his part, simplified the whole problem by grouping all germs, infusoria, and the like into the class *Chaos* in his great treatise "*Systema Natura.*" He also displayed a marked lack of confidence in the results of microscopical observation.

Before micro-organisms could be studied with satisfaction it was necessary to obtain a clear notion as to their limitations. Did they only arise from other living organisms or did they spring up from dead material under favourable conditions? There was a wide-spread belief in the spontaneous generation of life.

Organic fluids such as milk, meat-broth, hay-infusion, when exposed to air or when closed up in flasks were found after a day to be full of a variety of living organisms. The problem of the origin of life in some way resembled the problem of fermentation, but it was infinitely more complicated. The friends of Pasteur advised him to avoid it. "You will never find your way out of it," said Biot, "and will only waste your time."

All the same, Pasteur solved the problem, as far as it can be solved by the methods of physics and chemistry. He employed the same weapons of research as he had successfully used in the work on fermentation; these were: a systematic use of the microscope, a patient and exquisite skill in manipulation, the establishment of the fact before the theory, and, lastly, a love of the truth for its own sake and not for any fame that might chance to come with it.

Pasteur, suspecting that the air carried the infections which manifested themselves as living organisms in the flasks of the upholders of the spontaneous generation theory, began his research by a bacteriological examination of the atmosphere. If it were the primary source of micro-organisms, it should be possible to remove them by filtering through wool or other material. If the organisms already existed in the culture-fluids, it should be possible to destroy them by heat without altering materially the nutrient material in the fluid. Results from experiments carried out in towns where the air is impure should differ from experiments carried out in mountain air.

He devised a series of experiments which completely refuted the claims of the spontaneous generation school, and at the same time marked out the boundaries of the modern science of bacteriology. He demonstrated the almost universal distribution of germs, and the impossibility of keeping any material free from infection, unless by a systematic process of sterilization and isolation. In the Pasteur Institute at Paris are still preserved flasks and tubes, prepared and sealed by Pasteur over fifty years ago, containing organic fluids which have undergone no fermentation changes whatsoever.

To quote his own words from his Sorbonne lecture of 1864:

> "I have excluded from my flasks of organic fluids, and am still excluding from them, the one thing which is past man's making; I have excluded from them the germs which float in the air; I have excluded from them life."

Subsequent discussions on spontaneous generation have been little more than sparks among the ashes of a great controversy.

V.

In his attempts to extend the empire of science into the foreign and hostile land of medicine, Pasteur found a strong-hearted ally in Surgeon Lister of Glasgow, whose sense of the impotence of many remedial measures then practised led him to break away from the contemporary doctrine that wound-putrefaction was due to simple exposure to the air, and to seek to sterilize the wounds by methods derived from Pasteur's experiments.

Lister's means were crude, and his antiseptics were faulty—often so strong that they destroyed the good and bad tissues alike, or so weak that their action was ineffective. However, as Mr. Stephen Paget has expressed it: "His methods were fallible, but he had got hold of principles that were infallible." Thus was the reign of antiseptic surgery begun.

Pasteur's studies in human pathology were made easier for him owing to the recognition of his great discoveries in connexion with the diseases of silk-worms, which had threatened ruin on the industries in the south of France, and had resulted in a loss of one hundred million francs in the single year 1865.

At the request of his old teacher and friend, Dumas, Pasteur went to Alais, and settled in the centre of the ruined districts. His work was completely successful from the scientific and from the industrial aspects. He isolated the organisms of two distinct diseases, hitherto considered as one, and invented a method of detecting and separating diseased stock, which has been adopted in all countries where the silk-worm is cultivated. This triumph was won at the expense of over three years' unremittent work and a severe penalty.

In 1868 Pasteur was struck down with semi-paralysis, and while still convalescent, the Franco-Prussian War of 1870 brought him sorrow keener than death itself. Shall we not cry, "Happy are the dead?" he wrote to one of his friends; and to another, "How fortunate you are to be young and strong! Why cannot I begin a new life of study and work? Unhappy France, dear country, if I could only assist in raising thee from thy disasters!"

After the war of 1870, Pasteur turned his whole attention to industrial chemistry. "Our misfortune," he wrote, in the preface to his famous treatise on Brewing, "prompted me with the idea of these researches. I undertook them, immediately after the war in 1870, with the determination of perfecting them, and thereby benefiting a branch of industry wherein we are undoubtedly surpassed by the Germans."

This task completed, he returned to the study of infective diseases. As his grandson, M. Vallery-Radot, has written: "Infinitely small organisms appeared to Pasteur as the terrific disorganizers of living tissues. . . . Might there not exist a particular germ in connexion with each infective disease, just as every fermentation is caused by a special ferment?"

In 1873 he was elected a member of the French Academy of Medicine, and thereby strengthened his position.

Widespread epidemics of anthrax had been carrying off enormous numbers of sheep and cattle in France; whilst in Russia some 56,000 head of cattle were destroyed in two years. A rod-shaped organism had been found in the blood of animals killed by anthrax, but the discoverer, Davaine, had been unable to convince agriculturalists of its connexion with the disease. Once more Pasteur's technique was equal to the occasion. He isolated and cultivated the bacillus, and showed beyond question that it was the cause of the disease. Then, seeking for a remedy, he found that if sheep were inoculated with cultures of the bacillus grown artificially at blood-temperature (36° C.) all the sheep died; but if the bacillus were grown at a somewhat higher temperature (42° C.), and kept for fourteen days, the sheep, after inoculation, developed a very mild form of anthrax, from which they recovered, and were then found to be immune from the ordinary fatal form of anthrax. The introduction of the weakened form of the anthrax bacillus into the sheep's body leads to the production of defensive substances which are able to repel a subsequent invasion of the disease, just as if the sleeping garrison of some outpost was roused by the detonation of a harmless firework, and so prepared for an attack by more deadly agents.

Pasteur presented his results in a famous paper read before the Academy of Science in 1881. The work was received with some show of hostility by the orthodox veterinary surgeons present, so a demonstration on a large scale was arranged by the Melun Agricultural Society. Fifty sheep were infected with the most virulent form of anthrax; twenty-five of them had previously been rendered immune by the Pasteur method. Two days later all the unvaccinated sheep were dead—the others were in perfect health.

This work formed the foundation of the modern vaccine treatment of disease, whereby a defence-mechanism is built up in the subject through repeated injections of a weakened form of the disease. The process of weakening the virulence of a disease germ by chemical or other methods is still termed *Pasteurisation*.

VI.

The winter of his life found Pasteur engaged in the development of bacteriology and preventive medicine. His last scientific conflict was with an invisible foe—the ultra-microscopic organism which gives rise to rabies (or hydrophobia). Up to the present time the actual cause of this fearful disease is absolutely unknown. A large number of organisms have at one time or another been isolated as the excitants of the disease, but none has stood the tests of extensive investigation. The virus of the disease can pass through filters capable of retaining known germs, and hence the infective organism must be capable of existing in a very minute form at one period of its life-history.

The infective agent, whatever its nature, is found in the saliva of animals stricken with the disease, and hence is most frequently conveyed by bites of rabid animals. It is also found concentrated in the brain and spinal cord.

Pasteur first showed that when an extract made from the brain-matter of a mad dog was injected into the nervous system of a healthy dog, the dog developed rabies after an incubation period of fourteen days.

If the healthy dog were inoculated with the virus by means of a wound on the surface of its body, a much longer and more variable period intervened before the disease appeared.

Pasteur then discovered that by drying the spinal cords taken from rabid animals for varying lengths of time he could prepare a series of viruses of gradually decreasing strengths. If a spinal cord were dried for fourteen days or longer, it lost all its toxic properties.

By these means he was able to obtain a series of vaccines or preparations of attenuated virus just as he had succeeded in the case of anthrax.

By injecting small quantities of this attenuated virus in gradually increasing strengths each day, Pasteur was able to build up a defence mechanism which rendered an animal completely immune from rabies. Owing to the long incubation period of the disease, at least fourteen days from infection, it was possible to construct this wonderful defence while the organisms of the disease were actually in the animal's body. Hence, Pasteur's treatment is really prophylactic, and not in any way curative. If the symptoms of rabies have already set in, Pasteur's treatment is of no avail, and no remedy has yet been found. The disease is invariably fatal. This fact is of great importance in considering the applications and results of the Pasteur method.

Much doubt was expressed at first as to the value of Pasteur's treatment for rabies; partly owing to ignorance of the pathology of the disease, and partly owing to faulty application of the treatment. At the present time there can no longer be any doubt that it is efficacious and of vast service to humanity.

Such adverse criticism as survives has been estimated by Sir Almroth Wright, who, in reply to a recent attack on Pasteur, has written : . . . "Fresh seeds of error will infallibly be sown so long as mankind accepts as instructors in medicine those who are prepared to teach without adequate study, without sense of responsibility, without equipment of intellectual morality, and without reverence for the work of Pasteur, and gratitude for that of Jenner and Lister."

Long before Pasteur died every civilized country was working along the lines laid down by his teaching; and when he died, in 1895, his name was great upon the lips of men. But whether we honour him as a great chemist, or as a biologist, or a bacteriologist, or an inspired teacher, or as a man of noble character and lofty faith, we must always remember that France has first claim to him, for "that which put glory of grace into all that he did," as Bunyan says of Greatheart, "was that he did it for pure love of his country."

VII.

Many of the pupils of Pasteur are still with us. The schools that he established and the methods that he introduced are part of our heritage.

In our own country (Ireland) the principles of Pasteur have been applied to medicine and agriculture with success. As an instance—you may read in the records of the Department of Agriculture how, in the first year of its existence in Ireland (1900), it was confronted by a disease causing extensive mortality among the calves in the dairying districts of the south. This disease, generally called *white scour*, was of unknown origin, and yielded to no remedy.

M. Nocard, one of Pasteur's pupils and colleagues, then head of the Veterinary College at Alfort, near Paris, was invited to Ireland by Mr. T. P. Gill, the Secretary of the Department, and the consent of the French Government was obtained. M. Nocard was installed in a farm-laboratory in the centre of the affected district; and he carried out the investigations with a speed and skill worthy of a pupil of Pasteur. After eight weeks the germ had been discovered and isolated, a successful treatment devised, and a scheme of prevention drawn up. Nocard's remedies were adopted by the Department, with the result that calf mortality through *white scour* was completely overcome.

There is an old French proverb: "Glory is the sunlight of the dead." It is over twenty-five years now since all Europe laid its wreaths on the grave of Pasteur; but he is living yet, and will continue to live, in the work of the lesser men whom he inspired, "and glory is the least of things that follows this man home."

2.—LOUIS PASTEUR AS CHEMIST.

By PROFESSOR SYDNEY YOUNG, D.Sc., F.R.S., President.

It is unquestionably on account of Pasteur's magnificent services to mankind that his name will be honoured as long as our civilization lasts; but even if his only researches had been those on chemistry and fermentation, he would always be counted amongst the greatest men of science of the nineteenth century.

It was Delafosse, at the École Normale, who first directed Pasteur's attention to crystallography and molecular physics, and after becoming assistant to Balard, Pasteur repeated the work of de la Provostaye on the crystalline form of the tartrates.

The existence of small facets or hemihedral faces on quartz crystals had previously been noticed by Haüy, who classified the crystals as right-handed or left-handed, according to the position of the facets. Again, Biot had observed that some quartz crystals turned the plane of polarization of polarized light to the right, others to the left. Finally, Sir John Herschel had suggested a relationship between the two phenomena—a relationship which had been confirmed by experiment.

Pasteur was the first to observe similar small facets on crystals of tartaric acid and of its salts, and he took up with enthusiasm the study of these crystals. He also prepared and crystallized the sodium-ammonium salt of the optically inactive form of tartaric acid known as racemic acid, and found that the crystals were of two kinds, each with hemihedral faces, and related to each other as an object is to its image in a mirror. The crystals of one kind were identical with those of the sodium-ammonium salt of ordinary, optically active tartaric acid; the crystals of the other kind had never before been observed, and Pasteur concluded that they must be those of the salt of a hitherto unknown acid. If, then, ordinary tartaric acid turns the plane of polarization in one direction—it is now said to be dextro-rotatory—it might be expected that the new acid would turn the plane in the opposite direction.

In order to test the correctness of this conclusion, Pasteur, with extraordinary care and perseverance, picked out crystals of each kind from the mixture, keeping them separate. He then made aqueous solutions of each kind of crystal, and was delighted to find that the two solutions did, indeed, turn the plane of polarization in different directions. Pasteur had, in fact, proved that racemic acid is a mixture of equal quantities of dextro- and laevo-tartaric acid, the one tending to turn the plane to the right, the other to the left to an equal extent, with the result that racemic acid does not affect polarized light.

Pasteur's discovery was received with scepticism by the Academy of Sciences until the observations had been verified, step by step, by Biot, who, doubtful at first, finally congratulated Pasteur with effusion on his brilliant discovery.

Pasteur arrived at the conclusion that the differences in optical properties and in crystalline form were, in all probability, due to a different arrangement of the atoms in the molecule, the arrangement being dissymmetric in the same way that the crystals are dissymmetric. He thus laid the foundation for the great branch of the science afterwards named stereochemistry, and for the notion of the asymmetric carbon atom, and of the arrangement of the atoms in space.

Pasteur continued his researches while professor of chemistry at Strasbourg, and he there succeeded in converting ordinary tartaric acid, on the one hand, into inactive racemic acid, and, on the other hand, into a new inactive acid which he called mesotartaric acid. He showed that this acid, unlike racemic acid, cannot be resolved into isomeric active acids.

The method of resolving racemic acid into dextro- and laevo-tartaric acid first adopted by Pasteur, was extremely laborious; but he found that if, instead of preparing the sodium-ammonium salt, he neutralized the acid with an optically active base, the separation of the optical isomers was greatly facilitated, because their properties—solubility and so on—differ far more widely than those of salts formed with inactive bases.

Some little time afterwards, Pasteur happened to hear of an observation by a German firm of chemical manufacturers that some solutions of commercial calcium tartrate containing organic matter had undergone fermentation in warm weather with loss of material. Thinking the observation important, Pasteur added a little albumen to a solution of a salt of ordinary tartaric acid, and found not only that fermentation took place, but also that the solution became turbid owing to the growth of minute living cells ; he was further able to prove that it was to these cells that the fermentation was due.

Repeating the experiment with a salt of racemic acid, he found that the solution, optically inactive at first, gradually became more and more strongly laevo-rotatory until the fermentation finally ceased. He found, in fact, that the organism used the dextro-acid as a food, but left the laevo-acid untouched. He thus discovered a third method of obtaining an optically active acid from the inactive racemic acid. These three methods are the only ones that have since been employed for the purpose of resolving racemic compounds.

Two years later the Rumford medal was conferred on Pasteur by the Royal Society "for his discovery of the nature of racemic acid, and its relations to polarized light."

3.—LE FRANÇAIS DANS PASTEUR.

By PROFESSOR ROGER CHAUVIRÉ.

Français, et parlant en français devant vous d'un grand Français, souffrez que je le revendique comme Français. Inhabile et incompétent à juger de ses mérites scientifiques, qui viennent d'être lumineusement exposés, je chercherai en lui les traits proprement nationaux, par où il se rapproche de maint petit bonhomme obscur que j'ai vu, là-bas au vieux pays, vivre, peiner, grandir dans l'effort, et qui, moins le génie—*longo, sed proximus intervallo*—me semble son proche parent.

I.—Pasteur me semble le type du *bourgeois français.*

Un "middleman" est un homme qui, par ses moyens, tient le milieu entre le grand et l'homme du peuple. Un bourgeois est d'abord un "middleman," et il est quelque chose de plus. L'essentiel en lui, c'est la notion d'une hiérarchie dans les valeurs sociales, et le désir d'y garder son rang ou de s'y élever, à tout prix. A ses yeux, les professions libérales sont supérieures au travail manuel parce qu'elles engagent l'intelligence ; aux affaires, parce qu'elles supposent un désintéressement relatif. De cette notion, illusoire ou non, d'une certaine noblesse sociale résulte chez nous l'afflux des valeurs dans l'armée, la magistrature, l'université, l'art, la science : ces hommes, sensibles à l'honneur d'être et de rester des bourgeois, sont l'armature de la France. Pasteur en est un.

II.—Le père de Pasteur est un petit commerçant, mais distingué, cultivé, et cherchant toute sa vie à se cultiver.

Pasteur est *enraciné* dans sa province natale : son attachement à Arbois, à la maison de famille, aux amis d'enfance.

Enraciné dans la famille. Ce qu'est la famille française, intime, tendre, jalouse parfois jusqu'à la tyrannie, chargée—à l'exclusion de l'école ou de l'université—de l'éducation de l'enfant. Admirables parents qu'a eus Pasteur : amour, vénération, reconnaissance, qu'il leur a portés. Son affection pour ses sœurs. Sa femme, Marie Pasteur, dévouée comme une ombre, enterrée à ses pieds, *socia rei humanae atque divinae.* Son gendre Vallery-Radot, consacrant sa vie à la gloire de Pasteur. Ainsi, à la française, Pasteur reste toute sa vie dans les liens étroits de la famille.

Enraciné dans le métier. Il accepte toutes les tâches, si étroites, spéciales, hétéroclites soient-elles, sachant bien que d'une expérience à sujet limité, comme celle sur le champignon du vinaigre, mais bien faite, peuvent sortir des conséquences infinies. Travailler, c'est son éternel conseil, jeune à ses sœurs, mourant aux élèves qui le veillent. Ce travail bien fait, fini, poussé *ad unguem*, est sa passion (notes à l'Académie), et le fini du travail est un trait communément reconnu à nos artisans. Un précédent orateur a dit, et c'est bien remarquable, qu'aucune expérience de Pasteur n'a eu besoin d'être revue ni corrigée. Patience et mesure toute françaises de cette œuvre, qui s'édifie lentement par un effort continu, comme ces fortunes françaises, moyennes et solides, fruit du travail, de l'épargne, et de l'horreur du risque.

Enraciné dans sa religion. Ferme résistance à l'agnosticisme des savants ses contemporains (Sainte-Beuve, Renan, Ch. Robin, Cl. Bernard, Marcellin Berthelot).

Enraciné dans la cité. Sa conduite en 1871 : il renvoie son titre de docteur *honoris causa* à l'université de Bonn. Le pourquoi de son acte : sa passion patriotique.

III.—Mais ne prenons pas Pasteur pour un conservateur aveugle, enfermé dans la tradition de son pays ou de sa classe. Les idées héritées auxquelles il se tient fermement, son esprit critique les vérifie, et, assuré de la durée ou de sa vie de travail ou de sa race, dont il n'est qu'un moment, il les tempère par une mesure et une sagesse toute françaises.

Sa religion n'est pas automatisme. Il la base sur cette idée très forte des limites de la science expérimentale, lesquelles il serait contraire à la méthode d'outrepasser, et sur le fait de l'instinct religieux. Il craint que le préjugé antireligieux n'entame l'impartialité de Charles Robin.

Son patriotisme n'a rien d'agressif ; et cela encore est une idée française, née de la Révolution, que l'intérêt des patries se concilie, en dernier ressort, avec celui de l'humanité. Ce qui le soulève contre la Prusse en 1871, c'est moins l'intérêt national que celui de la justice. "Je crois invinciblement que la paix et la science triompheront de l'ignorance et la guerre, que les peuples s'entendront non pour détruire, mais pour édifier."

IV.—Dernier trait bien français et bien bourgeois: Pasteur est foncièrement *idéaliste.* Certes Pasteur se réjouit d'être utile; sinon, il manquerait de cette sagesse et pondération françaises que nous louons en lui. Enorme enrichissement de la France et de l'humanité qui résulte de ses travaux désintéressés. C'est sa valeur utilitaire qui lui a valu la grande popularité.

Mais lui-même sait bien que ce n'est là que la face obscure de son génie. La face rayonnante, ce par quoi il est vraiment grand, c'est l'élargissement de la connaissance humaine, fût-ce sans applications prochaines, la découverte de la dissymétrie moléculaire et des infiniment petits. Et lui-même n'a considéré la science que comme une des catégories de l'idéal: "Heureux celui qui porte en soi un Dieu, un idéal de beauté, et qui lui obéit: idéal de l'art, idéal de la science, idéal de la patrie, idéal des vertus de l'Evangile." Et à son père: "Regarder en haut, apprendre au delà, chercher à s'élever toujours, voilà ce que tu m'as enseigné."

V.—Tel fut ce bourgeois français, de vieille race pure. Et naturellement, je ne prétends pas que toute notre bourgeoisie soit telle. Mais le type de Pasteur est son idéal, l'image de ce qu'elle aimerait être. Elle pense qu'une civilisation ne se mesure pas au poids de charbon ou d'acier qu'elle produit, mais à l'affinement des cœurs et des cerveaux. Il peut y avoir des barbares puissants et des sauvages couverts d'or. Mais la vraie civilisation est affaire non de quantité, mais de qualité. C'est par cette conviction profonde, par cette invincible aspiration que Pasteur apparaît si proprement français.

VII.

NOTES ON THE HUMAN OVARY, WITH SPECIAL REFERENCE TO A CORPUS LUTEUM OF OVULATION.

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(Plates III–V.)

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Contents.

I.—Introductory.

The study of the formation of the human gametes, and of the structure of the principal or primary sex organs, is one of interest to all biologists, and especially to medical men. For many years I have been working on animal gametogenesis,[1] but hitherto have been obliged to confine myself to the study of these processes in the lower organisms, mainly because it is difficult to get surgeons who are sufficiently interested to carry out the instructions necessary to get first-class fixation of human material; few medical men understand that ten minutes after cessation of the circulation extensive changes have

[1] "The Cytoplasmic Inclusions of the Germ Cells," in ten parts, Quart. Jour. Micr. Sci., 1917–1922.

begun to take place in the cells of an extirpated part of the body. Material removed from a patient has therefore to be transferred rapidly to the fixing fluids.

In Dublin recently I was able, through the co-operation of the well-known gynæcologist, Dr. Bethel Solomons, to obtain two human ovaries which were fixed immediately after removal. It is a pleasant duty for me to thank Dr. Bethel Solomons for his interest in my work, and for his scientific co-operation, which has enabled me to be the first person to obtain human ovaries fixed by these special modern methods of micrology.

Dr. Bethel Solomons has kindly supplied me with the following facts about the patient from whom the ovaries were procured:—

> "Miss———, single, aged 41 years, was admitted to Mercer's Hospital at the end of the year 1923. Slight dragging pain in back, fatigue on exertion, difficulty in micturation, heavy menstruation, and leucorrhœa. General appearance—red-faced, masculine growth of hair on face, pronounced beard and moustache, evidently accustomed to shaving; masculine arrangement of femoral and pubic hair. Large fibroid uterus reaching to umbilicus, ovaries apparently normal. Operation carried out for supravaginal hysterectomy with removal of uterus and ovaries. Tumours filled whole pelvis, pressing on Douglas' pouch."

On pathological examination the tumours were reported to be fibro-myomata. The ovaries were carefully examined by me, and did not appear to exhibit any abnormality.

The ovaries contained at least thirty or forty oocytes. The above description of the patient from whom the ovaries were obtained is given in case such evidence may in some way be of future value.

Medical jurists at one time paid great attention to the presence or absence of the corpus luteum, as indicating whether or not pregnancy had occurred. As Glaister has pointed out, the condition of the uterus is much more important in this matter; but neither the presence of the corpus lutuem, nor the mere macroscopic dissection of the uterus, would reveal whether the early stages of pregnancy had, or had not, occurred. Probably the corpus luteum as a reliable medical index to pregnancy is completely ruled out. Dr. Matthews Duncan states that he has dissected a case of pregnancy in which there was complete absence of corpus luteum. This is a hard saying: minute microscopical examination of both ovaries and retro-peritoneal region would alone enable one to state definitely whether or not luteal tissue was completely absent. It is an extremely difficult matter to remove all genital tissue during such operations. When first discovered, the corpus luteum was supposed to be a sufficient evidence of pregnancy or of previous child-bearing. It is on record that Abernethy and Sir Astley Cooper in a court of law swore away the innocence of a dead woman because one of her ovaries contained a corpus luteum.

The human ovary, like that of most, if not all, mammals, exhibits a cortical and a medullary zone. The young eggs lie strictly within the cortical zone, while both the corpora lutea and the corpora albicantia abut into, or lie mainly within, the medullary zone; most of the corpora albicantia are to be found in the medullary region of the ovary. According to the results obtained by me with orcein, and resorcin fuschsin, no elastic tissue is present in the ovary, with the natural exception of that within the arteries. The walls of the Graafian follicle and of the corpus luteum do not contain elastin fibres. The process of ovulation appears to be brought about by turgor within the antrum folliculi, and not by the collapse of connective tissue or muscle fibres.

I must take this opportunity of thanking various of my friends who have looked at my sections, and given an opinion on doubtful points. Among these gentlemen I must mention especially Professor H. Pringle and Professor A. C. O'Sullivan.

II.—General Outline of the Formation of the Human Corpus Luteum.

The manner of formation of the human corpus luteum has been elucidated by various observers, and is shortly as follows. The Graafian follicle contains a cavity—the antrum folliculi, which, after ovulation has taken place, collapses partly, though not so completely as in some of the lower mammals. The sudden release of pressure within the antrum folliculi, brought about by the partial escape of the liquor folliculi, together with mechanical rupture of certain blood capillaries of the membrana granulosa (vel follicle epithelium of zoologists), causes a slight hæmorrhage into the antrum folliculi. Some lymph probably exudes into this cavity, but in some examples the blood-clot is said to be absent; in this case the cavity of the follicle is completely filled by lymph or tissue exudate, and not by blood. In those cases where the antrum folliculi becomes filled with mixed blood and exudate, the position of the old Graafian follicle is marked outwardly by the presence of a little blood-clot on the surface of the ovary. Human embryologists declare that this cicatricial clot is not always present, but in rats and guinea-pigs taken at the right moment it is always present, so far as my knowledge goes.

Now, just before ovulation, the theca interna becomes organized into a layer of polygonal cells, which lie ready immediately to invade, organize, and vascularize the membrana granulosa cells. Outside the theca interna layer is the fibrous theca externa, or external tunic. Directly ovulation has taken place, the follicle epithelial cells (or membrana granulosa) begin to grow and develop in a remarkable manner, and form large polygonal glandular cells containing the so-called lutein granules, which in nearly all mammals give the corpus luteum a yellow or reddish brick colour. The theca interna cells are assisted in the process of organization of these gland cells by the invasion of large ingrowths from the theca externa: the latter carries big blood-vessels and lymph channels (Pl. III, fig. 3). The luteal cells are almost, if not entirely, follicle-epithelial in origin—but in the human and, in all probability, in some of the lower mammals certain of the theca interna cells are said to become very much like the glandular, true luteal cells in appearance. These are called para-lutein cells. The corpus luteum goes on developing till it is a large structure protruding on the surface of the ovary (Pl. III, fig. 1, lower figure).

Two kinds of corpora lutea are recognized—a corpus luteum spurium, corpus luteum of ovulation, or menstrual corpus luteum, and what is often called a corpus luteum verum, or corpus luteum of pregnancy. According to some observers there are certain marked differences between the two kinds, even in the earlier stages of formation of these bodies, but for the lower mammals Marshall and many other authorities believe that up to a late stage there is no difference beyond size between the two types. This is also my view. The human corpus luteum of menstruation is certainly formed completely so far as the histological arrangements of its elements are concerned. In Pl. III, fig 1, is a section of the corpus luteum of ovulation, showing at *ct* a medullary wedge of connective tissue, which becomes organized within the remains of the old antrum folliculi. (Part of this wedge is photographed on Pl. V, fig. 8, *mx*). At *cc*, is an open space occupied by a coagulable fluid into which, especially from the area *x*, large numbers of leucocytes (Pl. V, fig. 10, *b*) and fibroblasts (*f*) are wandering.

If pregnancy supervenes the corpus luteum grows larger and by the fourth or fifth month is the size of a pigeon's egg. Some time before parturition, the corpus luteum begins to undergo regression changes, ultimately forming a scar-like structure, as does the corpus luteum spurium (fig. 1, *ca*).

According to Villemin, the human menstrual corpus luteum develops for eight to ten days after ovulation, and this is followed by a " période d'état," or period during which neither further development nor regression takes place, lasting five or six days, after which regression sets in.

With this short preliminary sketch we may undertake an examination of the modern literature bearing on our problem.

III.—PREVIOUS WORK.

The well-known Belgian embryologist, Van der Stricht, has carefully studied the corpus luteum of the Vespertillio noctula, one of the bats. These were captured in the evenings, on the outskirts of Ghent. Van der Stricht has made a very extensive collection of the ovaries of several species of bats, and his work is of special importance in any discussion on the corpus luteum. Van der Stricht, with reference to the question of the origin of the luteal cells, writes—"En attendant de nouvelles recherches, surtout chez les grands mammifères, nous restons toujours convaincu de l'origine mixte" (i.e. from both membrana granulosa and theca interna).

The present writer cannot criticise Van der Stricht's opinions, on the basis of the human material he has seen, but, as will be mentioned more fully below, in the case of Ornithorhynchus, there can be no doubt that the luteal cells are derived purely from the membrana granulosa of anatomists (follicle epithelium layer of the zoologist). One must agree that in certain mammals it is very difficult to say whether or not the theca interna cells participate in the formation of the luteal cells. The close approximation to size between follicle epithelial and thecal cells found in many mammals does not apply to Ornithorhynchus. According to Van der Stricht, the corpus luteum of bats is mainly epithelial (granulosa) in origin, though the conjunctive or thecal elements participate, and its products are a serous, "prefatty" (pregraisseux) substance during the histogenic stages of its life-history and a "lipoid" (lipoide) substance during the longer period of gestation. Van der Stricht thus distinguishes two periods of chemical activity in the corpus luteum: his views certainly seem to agree with what Miller finds in the human, where, as I have noted elsewhere, the corpus luteum of pregnancy is supposed to contain neutral fat, which is not present in that of menstruation. Van der Stricht divides theentire life-history of the corpus luteum into three successive phases: (*a*) A phase of genesis, during which the lutein cells form at the expense of the follicular epithelium (granulosa) and of some interstitial cells and conjunctive cells of the theca interna. During this stage the theca interna also forms the vascular framework of the corpus luteum. The fatty granulations are relatively few at this period, within the luteal cells. (*b*) A phase characterized by the extraordinary richness of the fat in the protoplasm of the glandular endocrine cells. At this stage the lutein cells begin to grow greatly in volume, and continue doing so right up to the middle period of gestation. Moreover the whole corpus luteum grows gradually, principally through the accumulation of the various products of secretion. During this period, too, the theca externa may thin out and even disappear at certain places around the corpus luteum. In such cases all sharp delimitation between the corpus luteum and the ovarian stroma, with its rich interstitial glands, is effaced. (*c*) Then follow the stages of involution or atrophy. These changes set in some time before the birth of the embryo, and are characterized by a hypertrophy of the connective tissues of the corpus luteum, spreading from the centre of the organ towards its periphery. Step by step the corpus luteum shrinks till all that is left of it is an almost solid connective tissue nodule, which among human anatomists is called a corpus albicans.

From the work of various observers it does seem probable that there are two periods to be distinguished in the secretory history of the corpus luteum. Most of the authors on this subject seem to agree that the deposition of fat in the luteal cells in its later stages is not a sign of degeneration, but represents a normal function of an endocrine nature. Van der Stricht is very emphatic in disagreeing with Mlle. Niskoubina Nadiejda and Pottet, who claim that the appearance of fat in the human corpus marks the beginning of fatty degeneration.

Van der Stricht says: " Dans le corps jaune de la Chauve-souris, on ne constate point de processus de destruction cellulaire semblable [à glandes sebacées], les éléments glandulaires se montrent merocrines."

This observer, speaking of the physiology of the corpus luteum, makes the following statement: – "Après avoir démontré que le corps jaune de la Chauve-souris fournit au sang de la mère une substance séreuse, prégraisseuse, surtout abondante durant la période de la migration de l'ovule, et un produit lipoide qui remplace graduellement la première, à partir de l'arrêt de l'ovule et de sa fixation dans la corne uterine, il nous semble rationnel de conclure, en admettant l'exactitude des expériences physiologiques des auteurs précédentes, que la sécrétion séreuse exerce son influence sur les transformations uterines de la première phase de la gestation, pendant le deplacement de l'œuf, et que la sécrétion lipoide intervient principalement pour provoquer l'arrêt et la fixation du blastocyste et la formation du placenta."

While I recognize that the physiological function of the corpus luteum may not solely be that of preparing the uterine walls for the implacement of the ovum, it is difficult to understand what cytological evidence this distinguished continental observer has brought forward to support his views as to a primary serous and then a secondary lipoid type of secretion. As will be mentioned below, the work of Allen and Doisy throws quite a bright light on this subject, and I believe that Van der Stricht may have to modify his views.

J. P. Hill and the present writer have given an account, now in press, of the formation of the corpus luteum of Ornithorhynchus, the duck-billed

Platypus. In this form there can be no doubt as to the origin and manner of metamorphosis of the various histological elements of the corpus luteum.

Just as in the higher mammals, there are three layers concerned, the membrana granulosa or follicle epithelium, the theca interna, and the theca externa. The lutein cells come from the follicle epithelium alone, and are always, in the adult corpus luteum, clearly distinguishable from those of the theca interna: therefore the question of the origin of the lutein cells from element other than follicular epithelium, cannot be entertained. In the Platypus, the theca interna cells form or aid in forming lymph channels, blood-vessels, separating tissue, inter-cellular spaces, and their purpose throughout is that of enabling the glandular products of the luteal cells to be carried away, and for the lymph and blood-vessels to penetrate every corner and element of the corpus luteum. *The theca interna cells at no time approach the follicle epithelial (granulosa) cells in size.* We can thus speak dogmatically on this question of the origin of the lutein cells, in so far as the Platypus can be taken as representing the mammalian type.

In the Platypus, up to a late stage, there is a fairly well-marked and constant difference between the cells of the theca interna and those of the theca externa. In the fully formed corpus luteum one does find places where it is not at all easy to discriminate between these two categories of cells, but in certainly the majority of cases which Professor J. P. Hill and I examined, the differentiation was marked. In Ornithorhynchus, the theca externa functions at once as a sheath for the confinement of the corpus luteum, and as a base for the ingrowth of the connective tissue trabeculae carrying in both large blood- and lymph-vessels, and the elements of the theca externa which function for the further opening up of the glandular material.

In our material of Ornithorhynchus we discovered elongate mitochondrial elements within the luteal cells, probably corresponding to the luteal granules of higher forms. This is a matter which, to my mind, still requires a good deal of careful microscopical work, especially from the comparative point of view. The work carried out on Ornithorhynchus should serve as a basis for future researches on the comparative histology of the corpus luteum of mammals and Sauropsida in general.

Apart from the description of the formation of the corpus luteum of the bat by Van der Stricht, and of Ornithorhynchus by J. P. Hill and the writer, one of the most thorough descriptions of the mammalian corpus is that by the American worker, George W. Corner. This paper was published in 1915, and Corner has attempted to describe the minute cytology of the lutein cells. His technique is somewhat inadequate—formalin fixation followed by

Mallory's stain being his favourite method: he used as well two per cent. osmic acid on fresh cells for twenty-four hours in order to study the fat-content of the tissue. He mentions that he tried janus green, intra vitam, for the mitochondria.

In the corpus luteum of the sow, Corner has given a description of two types of cells other than the luteal cells: these new types he calls additional cells, type 1 and type 2.

The American author finds a difficulty in saying whether additional cells, type 2, represent a modification of the lutein cells or of the connective tissue. He thinks that there seem to be transitions in both directions. In one recently ruptured follicle, the theca interna cells nearest the granulosa were, Corner shows, partly composed of cells similar in size, shape, and appearance to the additional cells, type 2.

In the cytoplasm of the sow's lutein cells, Corner recognizes an endoplasm and an exoplasm. The latter is so full of granules and globules of diverse substances that the nucleus of the fresh cell can sometimes hardly be seen. Some of these granules are mitochondria, according to Corner. Other globules are fatty and selectively stained by Suden III and osmic acid. Corner goes on to discuss (and confuse!) the trophospongium of Holmgren, and the inner network of Golgi, and compares certain empty spaces he finds in the luteal cells of the sow, with the Golgi apparatus or the trophospongium. In his figure 7, the canals shown probably have no connexion with the Golgi apparatus: in figs. 5, 6, 9, 11, 13, and 15, Corner draws cells which, unknown to him, show the position occupied by the Golgi apparatus. In a more recent paper, however, he corrects some of his misinterpretations.

Miller denies the presence of neutral fat in the human menstrual corpus luteum.

The various discrepancies between the accounts of these different authors depend largely on mere nomenclature: some workers call everything that goes black in osmic acid, fat. Osmic acid blackens according to no very definite rules, and without more extended experimentation it is impossible to say whether or not neutral fat is present.

Apparently in the sow, horse, cow, and cat, the cells of the corpus luteum do contain a substance which blackens in osmic and Sudan III, and these globules are probably, but not certainly, neutral fat. The presence of neutral fat in the gland cells of the corpus luteum is paralleled by the presence of fat in the cortical substance of the supra-renal.

Miller in 1914 stated that the corpus luteum of human pregnancy differs from that of menstruation or ovulation, in that the former gives no neutral fat-reaction and exhibits no colloid degenerative changes. From an examination of the literature it appears that there is a considerable division of opinion on the subject, and it is evident that differences between the two, excepting that of duration, are often difficult to demonstrate by ordinary examination of fixed material.

Corner claims that he can not only distinguish the corpus luteum of pregnancy from that of menstruation, but that he can distinguish seven clear periods in the history of the corpus of pregnancy. His periods are as follows:—

1. Preparatory.
2. Exoplasmic development, 1st part.
3. Do. do. 2nd part.
4. Transition period.
5. Endoplasmic development, 1st part.
6. Do. do. 2nd part.
7. Beginning of retrogression.

He says: "The corpus luteum, being an organic body, presents considerable variety of structure, so that these periods overlap, and pass gradually into each other . . . . ." So far as the granules within the luteal cells are concerned, Corner mentions that in period 1, there is practically no endoplasm on account of the large numerous exoplasmic vacuoles which exist in the luteal cells, while fat granules are present in great quantity. In period 2, the luteal cells are similar, but the distribution of fat is more general. In period 3, the endoplasmic area around the nucleus is now clearly developed. In period 4, the ring-like vacuoles of the exoplasm have nearly disappeared, and the entire cell becomes gradually occupied by homogeneous cytoplasm.

In the fifth period, or that of endoplasmic development, one gets an increase in the diversity of the cells. Many cells show peripheral canalization, while neighbouring cells may be quite free from such protoplasmic differentiations. The additional cells of Corner are now best developed. In the later stages of the life history of the luteal cells, one or more fat globules much larger than any before noted make their appearance.

From this short account of Corner's work it will be noted that this author, following Cesa-Bianchi, depends principally on what may roughly be called exoplasmic and endoplasmic areas of the lutein cells. Unlike Van der Stricht, this author does not try to describe serous and lipoid periods of secretion.

How far the endoplasmic area of Cesa-Bianchi and Corner is traceable to the change in position, growth, and spreading out of the Golgi elements, has yet to be ascertained. But there is good reason for believing that some of the elongate spaces drawn by Corner are the unstained "ghosts" of the Golgi apparatus, after the latter has spread out from a peri-nuclear to a circum-nuclear position. Moreover, we do not know whether or not the Golgi elements metamorphose into fat, or participate in some way in fat-production: in addition the behaviour of the Golgi elements in the human will probably be found to differ in the luteal cells of the menstrual corpus and of the corpus of pregnancy.

In the material described in this paper, the woman was a virgin, and her last period had taken place from two to three weeks before ovariotomy was carried out. The stimuli bringing about retrogression could not then have developed far at this period of the woman's oestrus cycle. The luteal cells of her corpus showed no signs of senescence. I do not wish to say that cytologically the corpus luteum of pregnancy cannot be differentiated from that of ovulation; but I believe that histologically the two kinds are similar up to the stage when the final disposition of their cellular elements is brought about.

The question of the further development of the intra-cellular organellae of the lutein elements is quite a different problem; and I have some definite evidence in that province to bring forward in this present paper.

In a more recent paper Corner has gone over his previous work, and has re-interpreted some of his older results. He shows that the theca interna cells contain "fat" before invasion of the membrana granulosa sets in, and he declares that there is no evidence that the cells of the theca interna are ever converted into fibroblasts of the usual spindle-cell type, or that they lay down the fibrils of the close-meshed reticulum which is present in the corpus luteum of the sow. Corner believes that the theca interna elements persist as such throughout pregnancy, but could not express a positive opinion because of the confusing resemblance between some of the theca and some of the granulosa derivatives.

Corner's more recent paper is a valuable piece of work, and he has shown clearly that the theca interna cells may approximate very closely to the luteal cells. He mentions slender spindle-shaped cells which insinuate themselves between the granulosa cells. These are possibly the additional cells type 2, of his former paper and the stellate cells of this present paper. Corner could not decide as to their place and manner of origin.

Reading the literature on the corpus luteum granules, it is difficult to find any good evidence for the existence of different types of granulations coinciding with the supposed different functional periods. Corner, who does not insist in his paper on coincidence of cytological structure with physiological action, and Cesa-Bianchi, alone have given any evidence of differential arrangement of intracellular material during different periods. Van der

Stricht, who insists on two clearly marked periods, one of serous secretion, the other of lipoid secretion, gives little or no cytologic evidence for his conclusion.

Van der Stricht draws up a useful comparison between the activity of the suprarenal cells and those of the corpus luteum. It seems to be clear that the mere presence of " fat " within the luteal cells does not necessarily herald disintegration of the corpus luteum; nor is it necessary to believe that one should find a special type of cytoplasmic differentiation to coincide with a different type of physiologic function.

In 1910 Riquier described the Golgi apparatus of the luteal cells of Bos taurus. In many cells, according to this worker, the Golgi apparatus is circum-nuclear in situation, and it does not take direct part in the formation of fat. In the regression stages the apparatus shrinks *pari passu* with the rest of the cell. Riquier used the Golgi method, which distorts the apparatus.

Edgar Allen and Edward Doisy have initiated what may be the forerunner of a great amount of valuable biochemical work on ovarian hormones. From a selected pound of hog ovaries with large Graafian follicles they were able to aspirate through a hypodermic needle at least 100 c.c. of liquor folliculi plus a few follicle cells and an occasional egg. An extract was prepared as follows: fresh liquor folliculi was added to a double volume of 95 per cent. alcohol and allowed to stand until the proteins had coagulated. The coagulum is filtered off, and the filtrate, practically free from protein, contains the active constituent: the alcohol is distilled off, the hormone being thermostable, and the aqueous suspension is extracted with ether. The ether extract is evaporated, the solids are dried in a vacuum desiccator, and the residue is dissolved in a minimal quantity of ether, and a double volume of acetone added: these processes of solution and precipitation are repeated twice. The precipitate (lecithin and kephalin) shows no activity in the test animal, but by boiling out the material gained from the combined evaporated filtrates, with 95 per cent. alcohol, the active substance is obtained free from protein, but contaminated with a little fatty material. The alcohol is now evaporated off, and the minute yield of oily residue is taken up in purified corn oil, or emulsified in dilute sodium carbonate. The subcutaneous injection of either fluid containing the follicular hormone produces no ill-effects on test animals, but brings about the following reactions on spayed animals :—

1. From one to three injections of this extract produces typical oestrual hyperaemia, growth, and hypersecretion in the genital tract, and also growth of the mammary glands. These changes include all the remarkable histological alterations of the oestrus cycle.

2. Such spayed animals, after treatment, will take normal vigorous males. The spayed females take the initiative as usual in the courtship, and do not

repulse the male. Since normal animals only copulate when on heat, the conclusion is drawn that this follicular hormone is the cause of oestrual or mating instincts.

3. Several injections of the extract were made into animals after weaning at the age of three to four weeks. They became sexually mature in two to four days, or at least twenty days to forty days too soon. These experiments were done with controls.

4. Parallel results were *not* obtained with corpus luteum extract and commercial ovarian extracts.

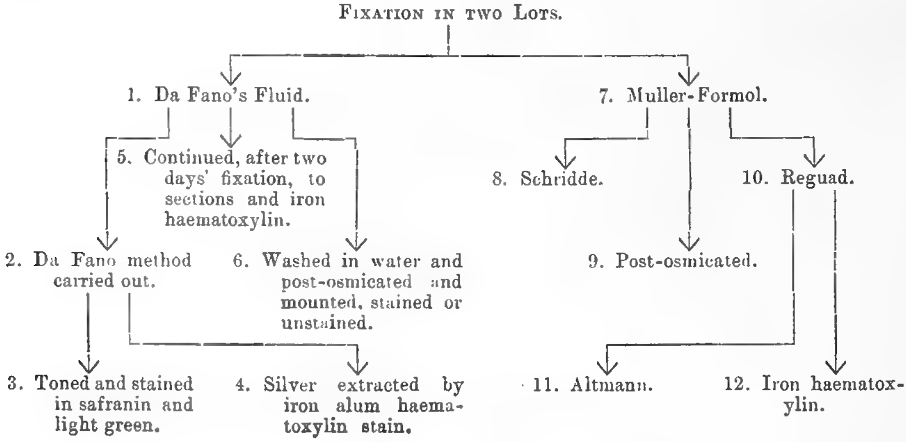
5. The authors conclude that this new extract is produced under the influence of the maturing ova by the follicle cells: and since the extract was obtained from hogs, and works on rats and mice, it is not specific for any species.

IV.—Technique.

Obviously the surgeon's assistant could not be bothered with the large number of fixing fluids used when studying the lower animals, and it was necessary to restrict the number of bottles of fluid to two. The two modern fixing mixtures which I have found most suitable for after-treatment by a variety of methods are those of Da Fano (cobalt nitrate formalin) and of Regaud (chromeformalin). The appended table gives the various after-treatments. Under the Da Fano method 1, 2, and 3, one gets the Golgi apparatus; under 4, Golgi apparatus dissolved away, and an ordinary iron haematoxylin stain; as also under 5. By method 6 (Sjövall) one gets mitochondria or lutein granules, and sometimes Golgi apparatus as well. Under 7, one gets mitochondria (10) fat and lutein granules (8 and 9), and general stains, 11 and 12.

Mann's methyl blue eosin, and safranin and light green, after Da Fano sections toned, gave splendid results.

Fixation in two Lots.



V.—PERSONAL OBSERVATIONS.

The material herein described consisted only of one corpus luteum preserved by several methods as already mentioned. It is because these methods have succeeded so well, and the material is so clear, that I decided to bring forward my views on the human corpus luteum of menstruation.

In Pl. III, fig. 1, is a drawing of the cross section of the entire corpus luteum: this is the typical three weeks' menstrual corpus figured in the text-books on human embryology and menstruation. The centre of the corpus luteum is occupied by a fibrous plug of connective tissue which gives off processes ramifying into the substance of the organ. On the left of this plug the original granulosa wall has remained partly open to form a space occupied by a semi-coagulable fluid, into which many white blood corpuscles and fibroblasts have penetrated. All around the connective tissue tunica (theca externa), one finds ingrowing trabeculae carrying large blood-vessels. In Pl. III, fig. 1, below, is a fragment of the ovary showing how the corpus luteum protrudes above the surface as a round nodule.

The more intimate structure of the human corpus luteum is shown in Pl. III, fig. 3.. Here one of the ingrown trabeculae formed of theca externa elements is shown, and the various cellular structures are also to be noted. This drawing has been made from a section of Da Fano material, toned, and then stained in safranin and light green. In all the sections of human corpus luteum, there appear the extraordinary stellate elements which are drawn in Pl. III, figs. 2 and 3 at *AS*. These elements lie among the true luteal cells. Heavy staining methods such as those of silver reduction, iron haematoxylin, prolonged immersion in Mann's methyl blue eosin, etc., demonstrate these cells in a remarkable manner. So far as I can ascertain no other observer has noted these cells in human beings; but Corner, in the sow, has described what are probably the same elements. These cells are remarkable for their chromophility and their excentric nucleus. I will return below to a further treatment of these cells.

Apart from these stellate cells the other elements which at once attract attention are the ordinary luteal cells. These are splendid large cells, polygonal, with a fairly smooth nucleus containing one or two nucleoli, and a cytoplasm with a huge Golgi apparatus. My Da Fano preparations were particularly successful, and beautiful objects for study, In Pl. III, fig. 3, these luteal cells are marked *L*.

Another category of cells may easily be noted in the corpus luteum—these are the small cells lying in between the large luteal cells, and forming canals, vessels, spaces, and general supporting tissue (Pl. III, fig. 2, *T*, and

Pl. V, fig. 5, *GT*). These cells are probably derived from the original theca interna or from endothelial elements, as is indicated by our knowledge of lower animals, and by the figures of Novak for the human Graafian follicle, just before rupture.

If one studies such Da Fano sections more closely, one gets the impression of the presence of still another kind of cell in the human corpus luteum. These cells are not much smaller than the lutein and stellate cells, and are characterized by the fact that they are very elongate and that their nuclei often take the green stain instead of the safranin (which stains the nuclei of stellate cells). This difference may be due to some slight change in the ordinary stellate cells, and I do not wish to stress the staining behaviour of such enigmatic cells.

In the human corpus luteum of menstruation we seem to have at least five sorts of cells:—(*a*) luteal cells, (*b*) stellate cells, (*c*) endothelial cells, (*d*) elongate or spindle cells, and finally the cells of the theca externa columns and lamellae. As before mentioned, Corner has noted two sorts of cells, other than the luteal and theca externa cells. His additional cells, type 1, are probably category (*d*), above, and his additional cells, type 2, are almost certainly category (*b*), above. In Ornithorhynchus the corpus luteum seems to contain three types of cells, derived simply from the three elements of the Graafian follicle. No such stellate cells could be found in the platypus.

We may now proceed to a more minute examination of each type of human cell, and endeavour to throw some light on the origin and true nature of each.

(a) *The Luteal Cell.*

The luteal cells of the human corpus luteum are large elements sometimes as much as 30 *u*. in diameter. They vary considerably in size from the smallest, which are situated in nests (*N*) near the theca externa (*T*) in Pl. III, fig. 3, to the largest, which are found towards the interior of the corpus luteum. These nests of unchanged cells have a characteristically dense small Golgi apparatus, which grows larger and looser in the bigger luteal cells, deeper in towards the centre of the organ. In Pl. III, fig. 3, there are three nests of almost unchanged follicle epithelial cells at *N*: these nests of small cells pass imperceptibly into the larger, more glandular luteal cells, and are probably of the same nature. There is no evidence that these cells are theca interna elements, even though the nests do abut against the theca externa tunic. In Pl. III, fig. 2, the characteristic arrangement of luteal (*L*) and stellate cells (*AS*) is shown: surprisingly few interstitial or cicatricial elements were present in this corpus luteum especially in view of what J. P. Hill and I found in the platypus. Corner figures more cicatricial elements in the sow, but not nearly so many as occur in the platypus.

In Pl. III, fig. 2, the so-called lutein granules have been added, from a study of osmic preparations, but in fig. 3, this has not been done.

In Pl. IV, fig. 4, there are five or six lutein cells shown surrounding a stellate chromophile cell. Each lutein cell has an enormous Golgi apparatus (*G*) nearly always larger than the nucleus itself. The Golgi apparatus never shows a network, but it is made up of single granular or rod-like dictyosomes which form a spherical structure, throughout all parts of which granules exist. There is no evidence of a cortical arrangement of dictyosomes. In some cases nearly half the cell is occupied by this large Golgi apparatus. In Pl. IV, fig. 4, the lutein granules have been added from a study of Schridde and Sjövall preparations, but in fig. 5, the cells are drawn exactly as they appear in Da Fano preparations : it should be mentioned that in many of the better preserved Da Fano cells, the lutein granules appear as chains of empty vacuoles.

In Pl. IV, fig. 4, the characteristic arrangement of the lutein granules is shown. They are arranged exactly like the mitochondria of many tissue and genital cells, in irregular chains and groups of discrete granules, occupying the space left between Golgi apparatus, nucleus, and the cell wall.

The nucleus of the lutein cells contains one or two elongate oxyphile nucleoli, and is amphophile with basophil preponderance in Mann's methyl blue eosin.

The ground cytoplasm of the luteal cells becomes very reticular in fat solvent fixatives, and is in this way quite different from that of the stellate chromophile cells.

(b) *The Stellate Chromophile Cells.*[1]

The remarkable cells drawn in Pl. III, figs. 2 and 3, Pl. IV, figs. 4 and 5 (*AS*), I have called stellate chromophile cells : these are probably a normal constituent of the human corpus luteum. Two similar cells are given in Pl. I, fig. 3 *b*, of Corner's paper, and, as I have already remarked, these cells appear to have been noted first by this observer. Corner describes his cells as "ranging in shape from spindles to branching and spherical forms," and this agrees fully with the illustrations given in the present paper. Corner speaks of such cells as a normal constituent of the sow's corpus luteum, so

[1] Preparations of human ovary recently made (January, 1924) show that the stellate cells are theca interna elements ; in the wall of the ripe Graafian follicle the theca interna cells stain like the stellate cells of the corpus.

that I do not believe that the presence of these cells in this human corpus luteum is a sign of a pathological state.

In Pl. IV, fig. 4, is a drawing of a stellate chromophile cell (*AS*) lying in a typical manner surrounded by lutein cells (*L*). This is a stellate example, but extremely elongate forms are found, as depicted on the right of Pl. III, fig. 2, and in Pl. IV, fig. 5.

The Golgi apparatus of the stellate chromophile cell is typically a dense coarsely granular juxta-nuclear body as depicted in Pl. IV, fig. 4 (*GC*). In other cases where the cell is much compressed and spindle-shaped, as in Pl. IV, fig. 5 (*AS*), the Golgi apparatus (*GC*) tends to lie within the branching processes (*GS*) of the cell.

Now one of the most characteristic points about the stellate cells is the position of the nucleus: as will be noted, especially in the cells (*AS*) on the left of fig. 2, the nucleus is markedly excentric. It is unusual to find a case where the nucleus lies in the middle of the cell. This peculiarity is also found in certain free cell elements of areolar connective tissue.

As with the cells (*AS*) on the left of fig. 2, it is often possible to find stellate chromophile cells far removed from the thecal trabeculae of the corpus luteum (*T* in fig. 3), and one is obliged to believe that these stellate cells are able to push forward and insinuate themselves between the lutein cells.

The nature of these stellate cells shown in Pl. III, figs. 2 and 3, is difficult to ascertain. They are possibly connected in some way with the ingrowing connective tissue thecal elements of the corpus luteum. Not only is this indicated by the relationship to the connective tissue thecal cells, which they exhibit, but also by the structure of their cytoplasm. These elements have a cytoplasm which is dense and stains very much like that of the young connective tissue cell. By this I mean such properties as going yellow in osmic acid, holding reduced silver nitrate and iron haematoxylin: these properties may not necessarily mean identity of origin of thecal cell and stellate cell, but they constitute important additional evidence. The cytoplasm of the luteal cell is delicate and generally appears in the reticulate form. This never applies to the cytoplasm of the stellate cell: it is evidently more "gelatinous" and less watery than that of the luteal cells.

While there is an undoubted resemblance between the theca externa cells and the stellate cells, it also is true that the walls of the theca externa abutting against the substance of the corpus luteum are clearly marked, except near the ingrowing lamellae. There is a possibility that the stellate cells are really the theca interna elements, but in view of Corner's descriptions this cannot be accepted without further examination of earlier stages.

(c) *The Theca Interna Cells.*

In the platypus and many of the lower mammals there is no doubt that the theca interna elements are easily distinguishable. With the exception of small spindle cells (Pl. V, fig. 5, *GT*), and of groups of small cells which may be endothelial in nature, no certain theca interna elements have been identified by me. The small spindle cells are so few and atypic that it is difficult to look upon them as being theca interna elements, and one is forced to believe that the stellate cells may represent the theca interna. This view is mentioned at length below.

(d) *The Theca Externa Columns and Lamellae.*

In Pl. III, fig. 3, is drawn a typical theca externa ingrowth. These lamellae and columns protrude into the substance of the corpus luteum, carrying blood, and lymph vessels. In Pl. III, fig. 2, *T*, is drawn at a higher power one of the finer cords of thecal cells. Between these cords, and also between individual lutein cells, are found small lymph spaces (Pl. IV, fig. 4, *SP*). These are not so well organized and complex in the human as in bats and the platypus.

(e) *The Follicle Epithelium Cells or Membrana Granulosa.*

The follicle epithelium cells of the Graafian follicle metamorphose into the luteal cells of the corpus luteum. This is the view which is most widely held, and which, among all animals, is best upheld in the case of the duck-billed platypus described by J. P. Hill and the present writer.

The follicle epithelial cell contains a strongly impregnating dense juxta-nuclear Golgi apparatus, oriented towards the egg, especially in the young stages. Arranged between the cell wall and the nucleus and in the spaces left between the Golgi apparatus and the cell wall, is a cloud of granular mitochondria, much like the lipin granules of the corpus luteum, only less fugitive and staining by mitochondrial methods. No fat granules were noted in the cells of the human Graafian follicle.

In my material the Graafian follicles were too young to allow of a proper comparison between granulosa cell and lutein cell.

VI.—CELL GRANULATIONS OTHER THAN THE GOLGI APPARATUS NOTED IN CELLS OF THE CORPUS LUTEUM.

Two lots of my material show the cell granulations very well—one fixed in Müller-Formalin and post-osmicated, the other fixed in Da Fano's fluid and treated likewise. The granules go quite black in most cases, but in many of the cells they are only grey or yellow-brown. In Pl. IV, fig. 4, is a group of luteal cells surrounding a stellate cell. The granules marked *L* in such osmicated preparations reduce the $OsO4$ vigorously and appear quite black. There can be no doubt, from the variety of methods which show these granules (they also show by iron haematoxylin after Müller-Formalin fixation), that we are not dealing with artifacts or cell coagulates of a suspicious description.

In some parts of the sections of corpus luteum the stellate cells exhibit a heavy granulation, as in Pl. IV, fig. 4, even when, for some reason, the granules of the luteal cells either show faintly, or are not even visible. One concludes from this that the granules of the stellate cells are of a somewhat different nature from those of the luteal cells, or the cytoplasm of the stellate cells, being denser than that of the luteal cells, is more suitable for holding the osmic acid. In preparations made in the latter, the cytoplasm of the stellate cells is of a dense yellow colouration.

The chemical nature of the granules within the cells of the corpus luteum is not easy to ascertain. Some observers have loosely called all the blackened granules of these cells neutral fat. Cell granules, which in the fresh state go black in osmic acid, and reddish brown in Sudan III, are often considered to be neutral fat: I have not been able to try either of these tests. The osmicated tissue I examined had been previously treated in formalin: tissue which has been treated in formalin may reduce osmic acid in almost any part or in any cell organella. Nevertheless the granules which so regularly blackened in formol-osmic could be extracted completely in turpentine: in sections treated in turpentine the position of the black granules is marked by rows and groups of empty vacuoles. The evidence that these granules are true fat is as follows:—

Formol-Osmic.	Blacken.	Extract in turpentine.
Birchromate-Osmic.	Blacken.	Ditto.
Formol fixation alone.	Left as vacuoles.	

The evidence against the view that the granules are true fat is that they do not occur in the same irregular manner in which true fat appears in cells; they do not vary much in individual size; they do not always reduce the osmic vigorously; and finally they correspond in position with the expected arrangement of the mitochondria. I am therefore inclined to believe that these granules are lipin and not true fat: this would agree with the results of Cesa-Bianchi and Loisel. Phosphatides, cholesterin-fatty acid mixtures, and to a less extent certain other "fatty" substances, have the power of reducing osmic acid and also giving the Sudan III test. *In vitro* tests are much more reliable than microchemical ones, and before one could decide the nature of any cell granules, one would need to use *all* the latest methods. Corner and certain other observers, on the slenderest evidence, conclude that they have been dealing with fat. As a matter of fact, ordinary medullated nerve goes black in osmic acid, and does not contain a trace of neutral fat. This should serve as a warning against rushing into conclusions as to the microchemical nature of intra-cellular granules.

The difficulty of the subject cannot be overestimated; and until biochemists provide the zoologist with, firstly, a clear account of the chemistry of the fatty and lipoid bodies of the cell, and then with microchemical methods for their detection, there will be little advance from the cytological side.

VII.—On the two Regions of the Cavity of the Corpus Luteum.

The human corpus luteum herein described, like that of many mammals, exhibits two regions in its interior—one filled by a plug of connective tissue formed by invading fibroblasts (Pl. III, fig. 1, *ct.* Pl. V, fig. 8), the other filled by a coagulable gelatinous fluid (Pl. III, fig. 1, *cc*). The coagulable fluid in the cavity *cc* is probably different from that of the antrum folliculi, and when preserved in formalin and stained in iron haematoxylin, it shows as a mass of fine threads. The replacement of the liquor folliculi by a new fluid is regarded by Van der Stricht as evidence of a serous secretion from the follicle cells. The new fluid might be lymph reinforced by some denser material, but there is little doubt that it is not pure lymph alone. This seems to support Van der Stricht's view.

In Pl. V, fig. 10, is a microphoto of the edge of the cavity *cc*, in Pl. III, fig. 1, and coagulum (*c*) is well shown. Wandering into this cavity are numerous fibroblasts (*f*) and leucocytes (*b*). In this connexion I may mention that I have found a cavity in the corpus luteum verum of both cows and ewes: the contained fluid gave a dense precipitate with absolute alcohol, and was quite different from lymph. Such cavities are present in about 5 per cent. of the cow corpora lutea examined by me. In many of the corpora lutea of the cow, sheep, pig, and of the smaller mammals, no such cavity occurs, and, in view of this, it is difficult to believe that great importance should be attached to its presence in the human.

VIII.—Discussion.

In this paper among the new points brought forward for the first time are the description of the stellate theca interna cells, and the account of the minute structure of the luteal elements. In figure 21, in Novak's book on "Human Menstruation and its Disorders," is a microphoto of a corpus luteum of early pregnancy, and I believe that I can see in it the dark stellate elements which have been described by me in this present paper. In the corpus luteum of menstruation described in this paper I did not find the para-lutein elements of Novak, unless the nests of small cells (*N*) in Pl. III, fig. 3, are to be interpreted as such. In Novak's account of Marcotty's table of supposed differences between the corpus of menstruation and that of pregnancy, no mention is made of para-lutein cells as providing a method of discrimination between the two sorts, and it is difficult to believe that Marcotty's evidence would really cover the variations in structure and development of different corpora lutea of menstruation. As a comparative histologist I find Marcotty's criteria for man of no use for the lower mammals I have studied.

In the corpus luteum of human menstruation, the Golgi apparatus of the lutein cells retains its excentric juxta-nuclear position in almost every cell: the exceptions to this rule are few in the corpus examined by me. In the corpus luteum of pregnancy it will probably be found that the Golgi apparatus tends to alter or spread out much more in the lutean cells. The spreading out and alteration of the Golgi apparatus seem to occur in the rat, and are followed by a fluidifying or regression of the dictyosomes or Golgi elements: thus, it should be possible on cytological grounds to discriminate between the corpus luteum of menstruation and that of pregnancy. If this is so, the claim made in older works on Medical Jurisprudence that the corpus luteum can be used as an index of pregnancy will be theoretically fulfilled. The Golgi network methods are so difficult and capricious, and the material needs to be so fresh, that such a cytological line of evidence would be only of little value, and difficult to bring forward.

As above mentioned, Riquier has described a Golgi apparatus in the corpus luteum of the cow, and it has been shown that the human corpus luteum in this way falls into line with the lower mammals. In the case of the Golgi apparatus of cells other than spermatic, we have no inklings as to the function of this remarkable intra-cellular organella. The Golgi apparatus of the luteal cells becomes such a large and important structure, that we are forced to believe that it must play some special part in the activity of the luteal cells. Histologists and cytologists are only now endeavouring to push forward along the paths that will lead us to a clear view of the part being played by the Golgi apparatus in cell activity, and thence in the life of the organism.

The work of Edgar Allen and Edward Doisy gives a completely new aspect to discussions on the function of the corpus luteum. Allen and Doisy have apparently shown that liquor folliculi extract itself contains the property of inducing those changes which were once supposed to be caused, partly at least, by the corpus luteum. If, then, the follicle cells, during the growth of the Graafian follicle, are able to produce such a hormone, it is difficult to account for the subsequent extraordinary modification of the follicle cells into peculiar luteal cells. It is also difficult to understand why Allen and Doisy get negative results with corpus luteum extracted in the same way as liquor folliculi.

It is evident that my views, or rather the opinions I have formed on the basis of the work of certain continental embryologists, as to the physiology of this period of the oestrus cycle will need re-examination and probably modification. Until further work has been carried out it would be injudicious to comment at length on the physiological aspect of this problem.

The main purpose of this paper has been to describe the minute cytology of the lutein cells; but there are one or two facts which arise in connexion with the subject of menstruation and the raised nutrition of the uterus.

Fraenkel believes that heat and menstruation are brought about by secretions from the corpus luteum; but, as Marshall has pointed out, Fraenkel's theory is disproved by the fact that ovulation in most mammalia does not occur until oestrus, or at any rate, until the end of the prooestrum, and consequently active corpora lutea are not present in the ovaries. Marshall says: "Seeing that the corpus luteum is not responsible for inducing menstruation, it becomes necessary to conclude that either the follicular epithelial cells or the interstitial cells of the ovarian stroma (or both of these) are concerned in bringing about the process (of menstruation)."

Marshall's brilliant prophecy seems to have been proven by the American observers, Allen and Doisy, whose work has apparently dismissed Fraenkel's hypothesis of menstruation.

The lutein granules, so called, in the human corpus luteum, are arranged like the mitochondria, and the fact that all the granules are equal in size, points to the conclusion that the lutein granules are formed from the mitochondria. The mitochondria presumably swell in size and become loaded with the lipochrome which gives the corpus luteum its characteristic appearance. I know of no case where neutral fat appears within any cell in the form of chains of minute granules all the same size. Corner states shortly that he found mitochondria in the corpus luteum of the sow, and mitochondria have been described in the luteal cells of various mammals. The mitochondria and Golgi elements in many invertebrate ova contain a lipochrome which colours the egg bright yellow or brownish, and there seems good reason for believing that in the case of the human corpus we have something of the same sort. At all events, it is quite certain that the evidence is strongly against the view that the lutein granules are or contain neutral fat, and there is good reason for believing that these luteal granules are formed by a swelling of the mitochondria of the follicle epithelial cells.

Finally, with regard to the origin of the lutein cells, Cohn, who has worked at various types of mammals, including man, states: ". . . das die aus der Theca interna hervorgegangenen Luteinelements mit der Histogenese der grossen Corpus luteum-Zellen sensu strictori nichts zu thun haben . . ."

Novak's figures as above mentioned, in agreement with Corner for the sow, show that in the human the theca interna cells may swell up and closely resemble lutein cells. It would be difficult to deny the possibility that the two types of cells, follicle epithelial and thecal, which after all are both derived from mesoderm, could both travel along the same line of differentiation. If the theca cell did not enter into the substance of the growing corpus luteum with its "cast" as a connective cell too deeply branded upon it, there is good reason for supposing that it would be caught up in the train of the developing luteal cells and caused to differentiate along their lines. In the Platypus the "cast" of the theca interna cell is strong, it is never forgotten, and the theca cells always remain connective, but in the higher mammals the brand is not so strong and deep, and there seems to develop a remarkable approximation in structure between the large glandular lutein cells and the former thecal connective tissue cells.

According to Corner's latest results in the sow the pockets of cells marked *N* in fig. 3 would presumably be clumps of theca interna cells. Corner distinguished his luteal cells from the interna cells by means of the vacuoles and rings in the former; this I cannot do in the human. So far as my examination of the human corpus has gone I have been led to consider that the pockets *N* passed imperceptibly into the luteal cells *L* of fig. 3.

There are two courses for me to follow as the result of my own scanty observations: one, to conclude that the luteal cells are of mixed origin; that most of the theca interna cells so closely approximate in cytological arrangement to the membrana cells that it is impossible to distinguish the two; and finally that the stellate cells are fibroid elements derived from free cells of the theca externa.

The other, which I favour, is to look upon the stellate cells as theca interna elements, and thus to deny the theory of mixed origin of lutein cells. Until more material has been examined, and until Corner's material has been viewed in the light thrown by Da Fano's method, we cannot be certain as to the nature and origin of the stellate elements.

Addendum (*February*, 1924). The wall of the ripe human Graafian follicle, by Da Fano's method, exhibits a layer of densely blacked cells which are theca interna elements, and which undoubtedly give rise to the stellate elements of the corpus luteum. From my small quantity of sow corpora lutea, recently prepared by Da Fano's method, it appears that Corner is only partly correct in claiming for this animal that the theca interna cells often closely approximate to the luteal cells. This statement is provisional and must be confirmed by the examination of a larger series of stages.

IX.—SUMMARY.

1. A human corpus luteum of menstruation is described from two to three weeks old. It was cut in half, one moiety being treated by Da Fano's method, the other by Regaud-Schridde.

2. The histological examination revealed a peculiar type of cell called the stellate chromophil cell. These cells have probably been described in the sow by Corner under the names "additional cell, type 2" and "spindle cells," and recent work (February, 1924) has shown them to be theca interna elements.

3. These cells are extremely numerous in parts of the human corpus luteum, and are characterized by the fact that they stain heavily in Mann's methyl blue eosin, impregnate densely in reduced silver, and stain intensely in iron haematoxylin after ordinary fixation. These cells contain granules which blacken in osmic acid. Their Golgi apparatus is condensed, solid-looking, and may occasionally lie partly within one of the cell processes. The nucleus of these cells is markedly excentric and oxyphil in nearly all cases. The normal tissue elements which most closely resemble these cells are the clasmatocytes of areolar connective tissue.

4. The Golgi apparatus of the human corpus luteum is described for the first time, and it is concluded that the so-called lutein granules are not true fat, but are probably lipin in nature.

5. The coagulate in the non-fibrosed centre of the corpus luteum is mentioned in connexion with Van der Stricht's theory of serous secretion.

6. Possible criteria for distinguishing cytologically the corpus luteum of pregnancy from that of menstruation are given.

7. The various other cell elements of the human corpus luteum are described.

8. It is suggested that the lutein granules are swollen mitochondria loaded with lipoid and some form of lipochrome.

9. Attention is drawn to the work of Edgar Allen and Edward Doisy on an ovarian hormone. This work has special bearing on certain hitherto unsolved problems of the oestrus cycle.

10. The evidence brought forward is against the view of a mixed origin of luteal cells.

11. Preparations of sow corpus luteum, made since this paper was written, do not lend support to Corner's view that in this animal the theca interna stellate cells approximate very closely to the lutein cells, and the differences in appearance between Da Fano preparations of human and of sow corpora lutea are not striking. Before this opinion can be established a more extensive collection of Da Fano preparations will have to be made.

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XI.—DESCRIPTION OF PLATES.

LETTERING.—*a*, stellate chromophil cells (theca interna); *AS*, stellate chromophile cells (theca interna); *b*, blood corpuscles; *BV*, blood-vessel; *c*, ovarian cortex; *ca*, corpus albicans; *cc*, uninvaded part of unclosed antrum folliculi, containing coagulable fluid; *cl*, corpus luteum; *ct*, invaded part of antrum folliculi, containing organized connective tissue; *f*, fibroblasts; *Gg*, Golgi apparatus; *Gc*, Golgi apparatus of luteal cells; *gf*, Graafian follicle; *GG*, granules of stellate chromophile cells; *GS*, Golgi apparatus lying within stellate cell process; *GT*, Golgi apparatus of spindle cell; *L*, lutein granules (probably mitochondrial); *l*, lymph channel; *m*, ovarian medulla; *mx*, inner plug of connective tissue (*ct* above); *Nn*, nests of smaller (luteal) cells; *NL*, nucleolus; *NU*, nucleus of connective tissue (thecal) cells; *s*, stroma: *SP*, inter-cellular lymph space; *Tt*, theca externa tunic; *x*, area of invasion into cavity of old antrum folliculi.

Plate III.

Fig.

1. Low-power drawing of human corpus luteum of menstruation, showing cortex of ovary (*c*) below which the plicate-looking glandular corpus lies (from *b* to *ct* in thickness). The original antrum folliculi is now organized into two areas—one, *ct*, containing a wad of connective tissue, the other, *cc*, containing a coagulable fluid. The theca externa or tunic of the corpus is marked *t*. At *ca* is a degenerated corpus luteum or so-called corpus albicans.

   In the figure below is a low-power drawing of a part of the human ovary, showing the corpus luteum as a protuberance at *cl*.

2. Stellate chromophile (theca interna) cells (black) and luteal cells from a medullary region of the corpus luteum. Da Fano and Schridde results combined.

3. One of the theca externa or tunic ingrowths (*T*), showing the nests (*N*) of little-changed follicle cells and the stellate chromophile cells (black). Da Fano, Safranin.

Plate IV.

4. A stellate chromophile (theca interna) cell surrounded by luteal cells. The Golgi apparatus granules of the latter are shown. Da Fano and Schridde results combined.

5. Spindle-shaped "stellate" chromophile cell, luteal cells, and small spindle cell (*NU*). Da Fano, Safranin.

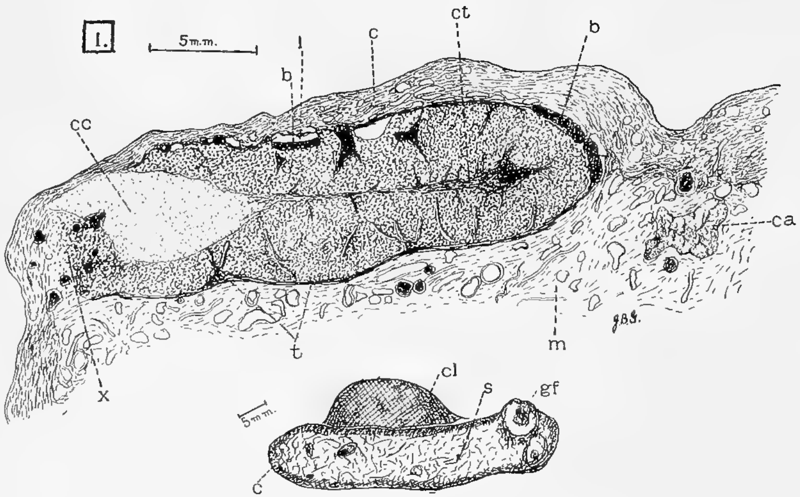
Plate V.

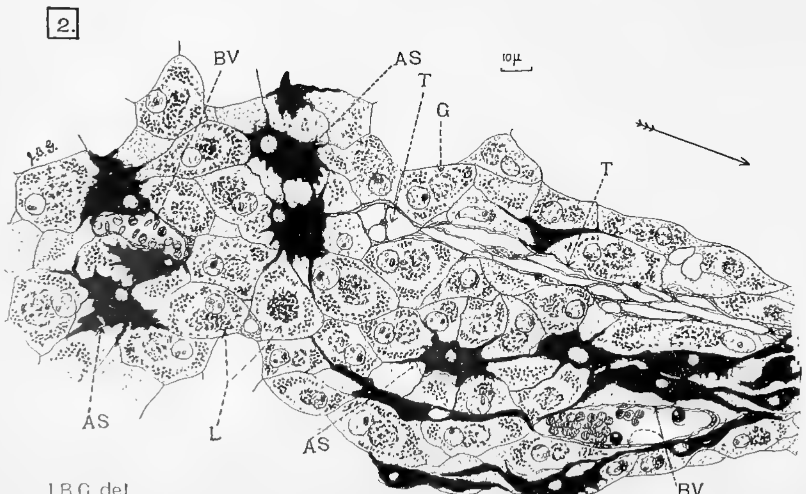
6 and 7. Tunic edge (*t*) and cortex of corpus luteum, showing nest of smaller cells (*n*) and stellate cells (*a*).

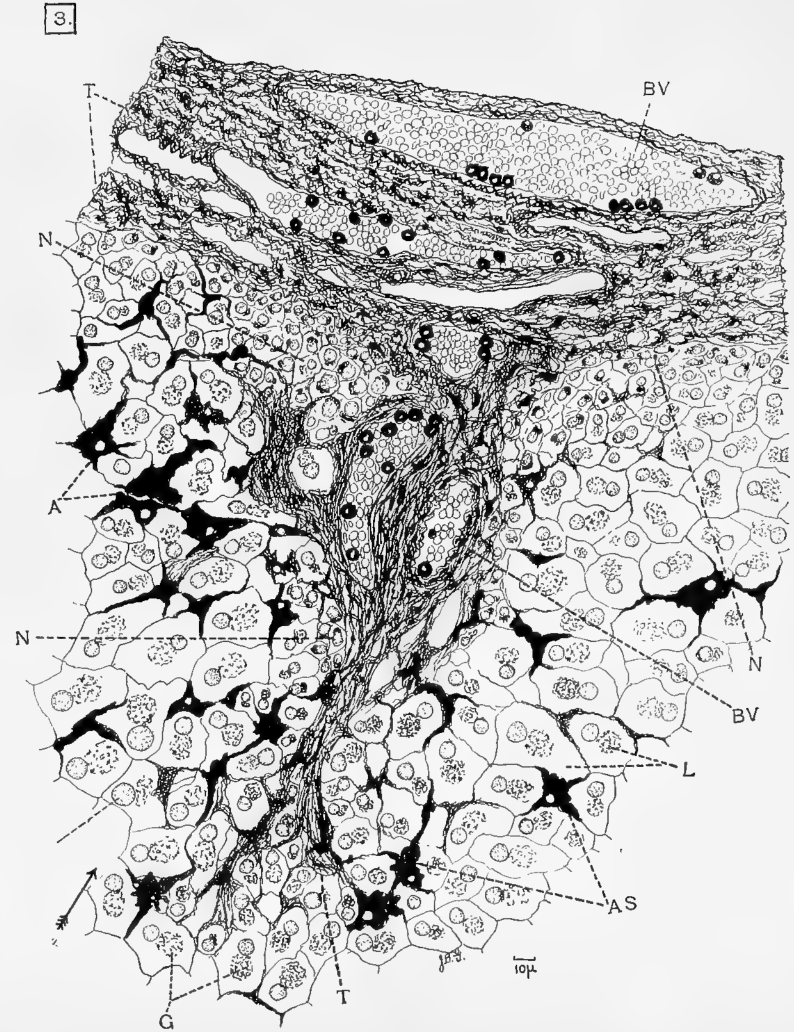
8. Connective tissue plug or core of corpus luteum (*mx*).

9. Stellate chromophile cells at higher power.

10. Invasion of old cavity of corpus luteum by leucocytes (*b*) and fibroblasts.







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GATENBY—NOTES ON THE HUMAN OVARY.

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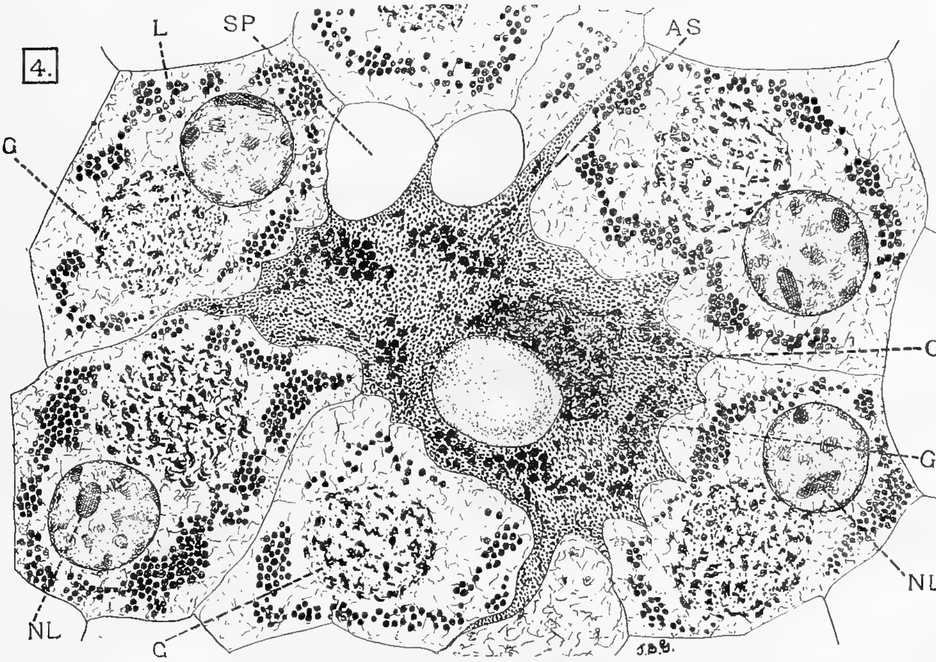

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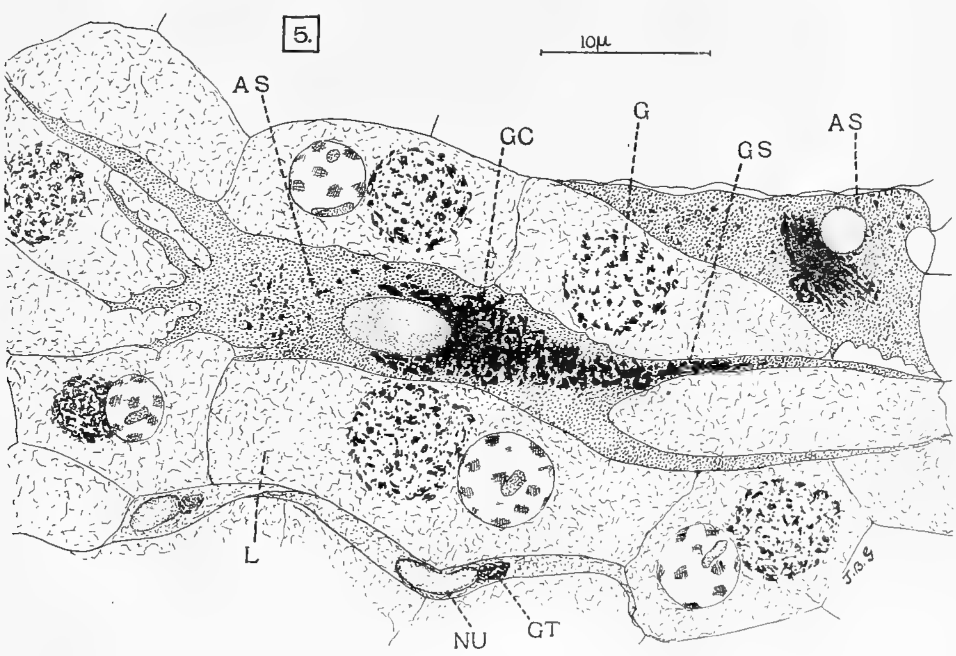
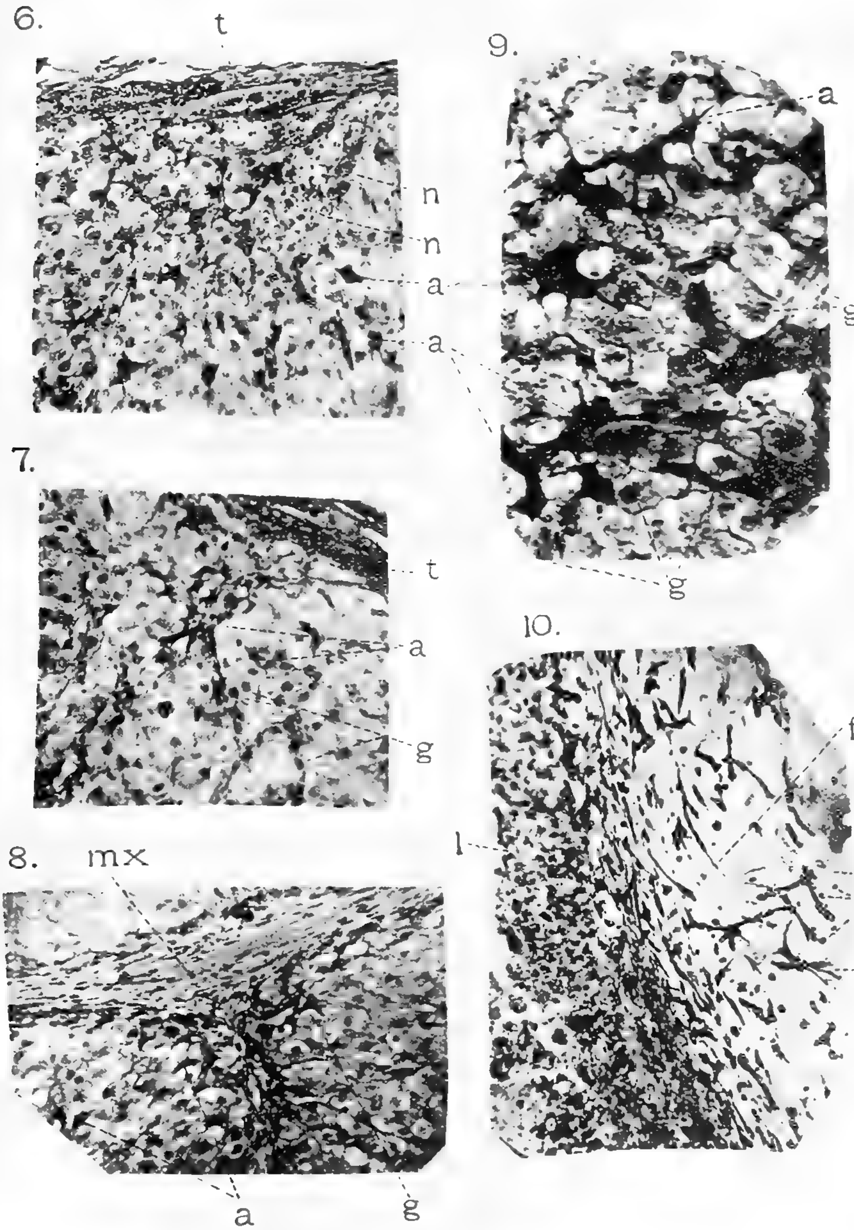


Gatenby—Notes on the Human Ovary.



Gatenby—Notes on the Human Ovary.

VIII.

SEVENTH REPORT ON THE FISHES OF THE IRISH ATLANTIC SLOPE.

THE MACRURID FISHES (CORYPHAENOIDIDAE).

By G. P. FARRAN.

(Plates VI–VII.)

[Read January 28. Published May 26, 1924.]

Contents.

I.—Introductory.

The present paper, the preparation of which was undertaken at the suggestion of the late Mr. E. W. L. Holt, continues the series which has been contributed from time to time by Mr. Holt and Mr. L. W. Byrne to the Scientific Investigations of the Fisheries Branch of the Department of Agriculture and Technical Instruction.[1] It deals with the Coryphaenoididae or Macrurids, which, in the S.S. *Helga*'s trawling operations in deep water off the west coast

[1] Previous reports were published in Fisheries, Ireland, Sci. Invest. 1905, ii [1906]; 1906, v [1908]; 1908, iv [1910]; 1908, v [1910]; 1910, vi [1911]; 1912, i [1913].

of Ireland, were found to be, in general, after the Gadoids, the best represented family, both in numbers of species and in actual abundance, and its aim is to give an account of the local distribution of the species met with, accompanied by brief descriptions sufficient for identification. The outline figures which are included in the paper have been taken with some modifications from published figures or have, in a few instances, been drawn from *Helga* specimens; they are intended merely as aids to the recognition of the species. The plate of *Lyconus brachycolus* has been specially drawn by Mr. J. Green from the specimen in the British Museum. Several of the species here included have already been dealt with very fully by Mr. Holt and Mr. W. L. Calderwood (1895) in their account of the deep-sea fishes taken in the Royal Dublin Society's Fishery Survey of 1890–91, to which reference should be made for a more detailed description than can be given here.

The Macrurids are not at present fished for commercially, and from that point of view it is not likely that they will ever be of much importance, as they seldom reach a large size, and, furnished as they are with a large head and a slender tail, the proportion of food to waste is small; though with suitable cooking, as experiments made on board the *Helga* have shown, they are just as palatable as many other fishes commonly exposed for sale. Their numbers, however, entitle them to close investigation, as playing a large part in the balance of life, either as consumers of the available food or as food for other fishes, in a region in which commercial trawlers are continually extending their operations.

The classification proposed by Gilbert and Hubbs (1916) in their revision of this family has been followed in this paper. Their re-arrangement of species has entailed the inclusion of the type species of the two genera *Macrurus* and *Coryphaenoides* in a single genus; and as *Coryphaenoides* is the earlier name, it takes the place of the better known, though rather vaguely defined, *Macrurus*.

The Coryphaenoididae, better known under the now obsolete name Macruridae, are Anacanthini, distinguished externally by the anterior position of the ventral fins, below the pectorals, a protrusible mouth which is anterior or inferior, an elongate tapered body with dorsal and anal fins continued backwards to meet posteriorly, the anterior portion of the dorsal being usually separated from the rest, and ventrals with 7–12 rays.

The scales are sometimes smooth and cycloid, but more usually armed with strong or numerous spines, which furnish well-marked specific characters.

The family has a world-wide distribution, but individual species seem to have a fairly restricted range, considering the uniform conditions under which they live. Of the species known from the east side of the North Atlantic only about one-fifth have been recorded from the west side; but it seems probable that the comparison of specimens from both sides may increase the number. About the same proportion has been recorded from the Pacific or Indian Oceans; but, until the family has been reviewed by some authority who has access to collections from all parts of the globe, the identity and range of a number of species must remain doubtful.

Amongst the species dealt with in this paper there is only one addition, viz., *Trachyrhynchus Murrayi*, to the list of Irish species already published (Holt and Byrne, 1910). One species, however, recorded in that list as *Macrurus mediterraneus*, appears here under the name of *Coryphaenoides Murrayi.*

The form of net used by the S.S. *Helga* for the capture of the fish referred to in this report was, on almost every occasion, a small beam trawl of the ordinary shallow-water type, with a beam of from 30 to 32 feet long, which was found to fish with no less success and with no greater difficulty in manipulation in 700 fathoms than in ten fathoms.

The relative abundance at various depths off the west coast of Ireland of the commoner species mentioned in the paper is shown below in graphic form. The diagram is based on the average numbers in hauls of the trawl made by the *Helga* at various depths, the data from which it is constructed being given separately in the account of each species.

This is followed by a table showing the recorded distribution, at various depths, of the species mentioned in the paper, both in the area explored by the *Helga* and in areas to north and south of it. These areas are taken so as to coincide with the limits given in Canon Norman's definition of the British Marine Area. Although it is clear that the table contains many unfilled gaps, yet it seems to show, in the case of *Trachyrhynchus Murrayi* and *Coryphaenoides rupestris*, that these species inhabit shallower water in the northern than in the southern parts of their range. It is not evident that this is so in the case of the other species tabulated.

Another table compares the species of Macrurids taken by the various vessels which have explored the deep water of the N.E. Atlantic. When the name used by the describer of the collection is definitely stated, or generally believed, to be a synonym of a more commonly used name, the latter has been given, followed by the former in brackets. When two species from different collections are closely allied and may prove to be identical, they are given under separate names, but in the same line. This table shows that we are still far from having a satisfactory knowledge of the fish fauna of the area in question, seven species having each been taken by one expedition only.

II.—Diagram of Vertical Distribution.

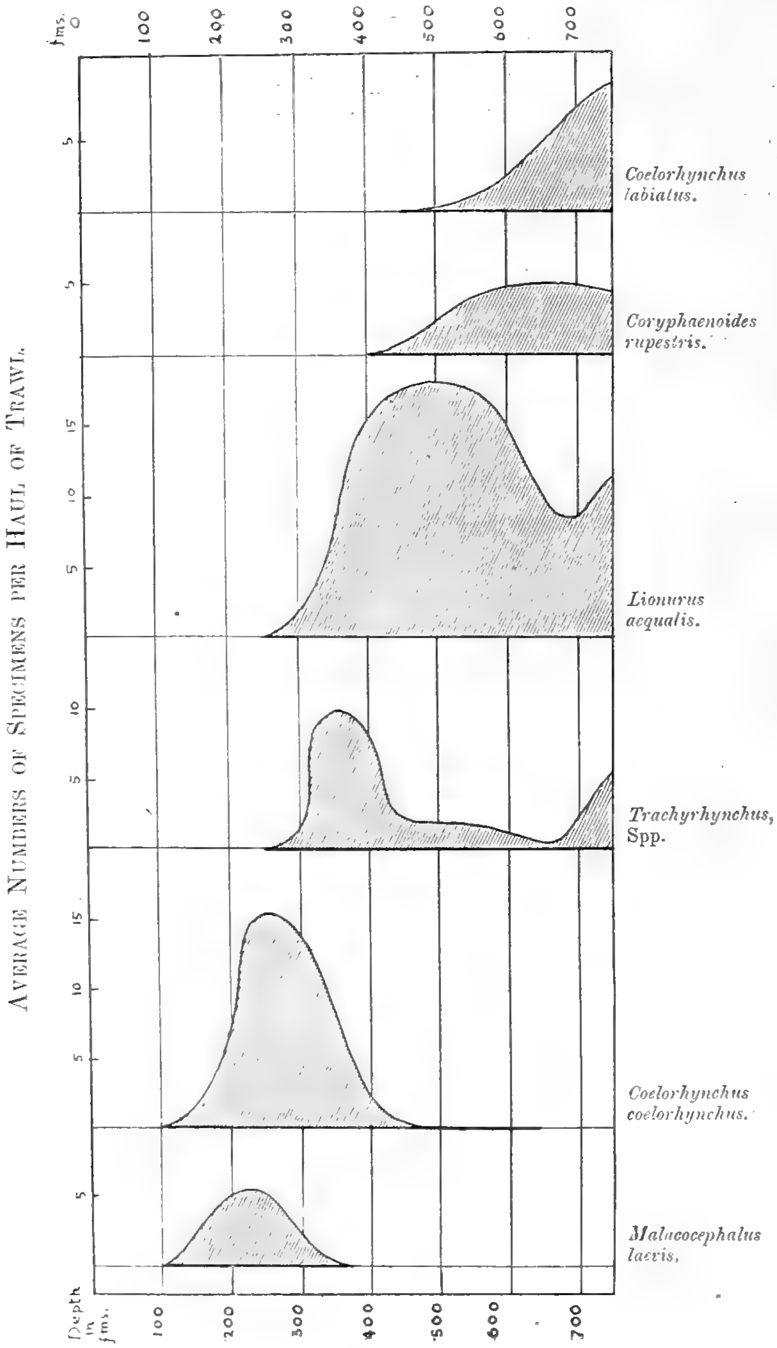


Fig. 1.

III.—TABLE OF VERTICAL AND HORIZONTAL DISTRIBUTION OF IRISH MACRURIDS ON THE EAST SIDE OF THE NORTH ATLANTIC.

	0–250 fms.	250–500 fms.	500–750 fms.	750–1,000 fms.	Below 1,000 fms.
North of line 60° N. as far as 5° W., thence N.E. to 1° W., thence eastwards.		L. aequalis, M. C. labiatus, M. Trach. Murrayi, M.	Trach. Murrayi, K.		
South of above-mentioned line to 56° N. Scottish Atlantic Area.	C. rupestris, M. M. laevis, S.	. . . .	C. rupestris, M. C. labiatus, M. Trach. Murrayi, M.		
56° N. to 49° 30′ N. Irish Atlantic Area.	C. coelorhynchus, H. M. laevis, H.	C. rupestris, H. C. coelorhynchus, H. L. aequalis, H. M. laevis, H. T. trachyrhynchus, H.	C. rupestris, H. C. Murrayi, H. C. coelorhynchus, H. C. labiatus, H. M. L. aequalis, H. M. B. melanobranchus, H. T. trachyrhynchus, H. T. Murrayi, H.	C. rupestris, H. C. Murrayi, H. M. C. labiatus, H. L. Guntheri, H. ?T. Murrayi, H.	
49° 30′ N. to 36° N. Off the Bay of Biscay and Spain.	C. coelorhynchus, C. P. M. laevis, C. P.	C. rupestris, C. C. coelorhynchus, C. S. C. labiatus, C. L. aequalis, S. P. M. laevis, C. S.	L. aequalis, T. B. melanobranchus, P.	C. labiatus, C. P. L. aequalis, C. L. Guntheri, P. B. melanobranchus, P. T. trachyrhynchus, C.	L. aequalis, P. L. Guntheri, P.
South of 36° N. Off Africa.	C. coelorhynchus, T. M. laevis, T. T. trachyrhynchus, T.	C. coelorhynchus, T. M. C. labiatus, T. M. laevis, T. M. B. melanobranchus, T. T. trachyrhynchus, T.	C. labiatus, T. L. aequalis, T. M. B. melanobranchus, T.M. T. trachyrhynchus, T.	C. labiatus, T. M. L. aequalis, T. B. melanobranchus, T. P. T. trachyrhynchus, T.	C. Murrayi, M. L. aequalis, M.

EXPLANATION OF ABBREVIATIONS.—H., Helga. M., Michael Sars. S., Silver Belle. K., Knight Errant. C., Caudan. P., Prince of Monaco's Expeditions. T., Travailleur and Talisman.

IV.—Table of Species taken by the principal

—	Travailleur and Talisman. (Vaillant, 1888.)	Caudan. (Koehler, 1896.)	Hirondelle. (Collett, 1896.)
Coryphaenoides, ...	—	rupestris.	rupestris.
Coryphaenoides, ...	—	—	—
Coryphaenoides, ...	—	—	—
Coryphaenoides, ...	—	—	—
Coryphaenoides, ...	—	—	—
Coelorhynchus, ...	coelorhynchus.	coelorhynchus.	—
Coelorhynchus, ...	Talismani (japonicus).	labiatus.	—
Lionurus, ...	aequalis (smiliophorus).	aequalis.	aequalis.
Lionurus, ...	Guntheri (holotrachys).	—	Guntheri.
Lionurus, ...	sclerorhynchus.	—	sclerorhynchus.
Lionurus, ...	hirundo.	—	hirundo.
?Lionurus, ...	zaniophorus.	—	—
?Lionurus, ...	—	Caudani.	—
?Lionurus, ...	—	—	—
Trachonurus, ...	asperrimus.	—	—
Hymenocephalus, ...	—	—	italicus.
Cetonurus, ...	globiceps (crassiceps).	—	—
Echinomacrurus, ...	—	—	—
Malacocephalus, ...	laevis ? sublaevis (aequalis.)	laevis.	—
Nematonurus, ...	gigas.	—	—
Bathygadus, ...	melanobranchus.	—	melanobranchus.
Bathygadus, ...	longifilis.	—	longifilis.
Trachyrhynchus, ...	trachyrhynchus.	trachyrhynchus.	—
Trachyrhynchus, ...	—	longirostris.	—
Trachyrhynchus, ...	—	—	—
Lyconus, ...	—	—	—

Expeditions in the North-East Atlantic.

Hirondelle. (Zugmayer, 1911.)	Michael Sars. (Murray and Hjort, 1912.)	Hirondelle. (Roule, 1914.)	Helga.
—	rupestris.	—	rupestris.
—	brevibarbis.	—	—
—	simula.	simula.	—
—	—	mediterranea.	—
—	Murrayi.	—	Murrayi.
elorhynchus (atlanticus)	coelorhynchus.	coelorhynchus.	coelorhynchus.
ralellus.	Talismani.	Vaillanti.	labiatus.
qualis.	aequalis.	aequalis (serratus).	aequalis.
—	Guntheri.	Guntheri.	Guntheri.
—	sclerorhynchus.	sclerorhynchus.	—
—	—	hirundo.	—
—	zaniophorus.	—	—
—	—	—	—
olaceus.	—	—	—
—	asperrimus.	asperrimus.	—
alicus.	—	italicus.	—
—	globiceps.	—	—
—	—	mollis.	—
evis.	laevis.	laevis.	laevis.
—	armatus.	gigas,	—
—	melanobranchus.	melanobranchus.	melanobranchus.
—	longifilis.	longifilis.	—
—	trachyrhynchus.	—	trachyrhynchus.
—	—	—	—
—	Murrayi.	—	Murrayi.
—	—	—	brachycolus.

V.—Feeding.

As is usual amongst fishes provided with an air bladder, when brought to the surface from great depths, the stomachs of the Macrurids taken by the *Helga*, when not actually driven into the throat of the fish, were found not to contain any food, and our records consequently give us no information as to what they feed on; but, on the other hand, there is evidence that they furnish food for other fishes, a specimen of *C. coelorhynchus* having been found in the stomach of a ling (*Molva abyssorum*) on station S.R. 440, 350–390 fathoms.

We know from other sources that the Macrurids are general feeders, Collett (1896, 1903, 1905) having found that stomachs of *C. rupestris* taken on lines at a depth of about 100 fathoms in Norwegian fiords contained as a rule large crustacea, chiefly *Pandalus borealis, P. annulicornis, P. propinquus*, and *Pasiphae tarda. Hemimysis abyssicola* also occurred. In *C. berglax*, a northern species not represented in the present collection, he found *Pandalus borealis, Hymenodora glacialis*, remains of *Buccinum* and *Fusus*, one specimen of the fish *Mallotus villosus*, and the brittle star *Ophiacantha abyssicola*.

That the Macrurids may be of great importance as food for other fishes we learn from Gilchrist's statement that the South African Hake (*Merluccius capensis*) seems to feed almost exclusively on *Coelorhynchus fasciatus*, which is very abundant in deep water of 100–300 fathoms off the Cape of Good Hope. It is very probable that the N. Atlantic Hake also feeds on Macrurids, two species of which, *C. coelorhynchus* and *M. laevis*, are very abundant on the Hake grounds to the S.W. of Ireland.

VI.—Reproduction.

Not much is definitely known about the spawning of the Macrurids. Collett (1905) has examined ripe ovarian eggs of *Coryphaenoides rupestris* from 83 to 89 cm. in length, taken in Norway in the month of October, and found that they measured 1·8 mm. in diameter, and similar eggs from *Coryphaenoides berglax* of 71·5 cm., taken in July, measured 1·5 mm.

A specimen of *Lionurus aequalis*, length 32 cm., taken by the *Helga* in August, 1906 (S.R. 359), had clear ova, nearly ready for extrusion. They measured, after preservation in formaline, 1·75–1·85 mm. in diameter, the oil globule measuring ·43 mm.

It appears that the spiny egg of 1·5 mm. in diameter, which occurs frequently over deep water in the Atlantic and Mediterranean in summer, and which has been doubtfully ascribed by Lohmann and others to a species of *Macrurus*, is in reality the egg of a species of *Scopelus* (see Rapp. at Procès Verbaux, Conseil International pour l'Exploration de la Mer, vol. xiii, 1911, App. to Repts. I and III).

Coryphaenoid larvae have the general form of the adult, with the addition usually of much-elongated ventral fin rays, and a pectoral fin of a transverse oval shape attached by a constricted peduncle. Specimens have been taken from time to time by the *Helga*, but their identification has not as yet been satisfactorily worked out.

I am much indebted to Mr L. W. Byrne for his kindness in reading through the MS. of this paper and in making some useful suggestions which I have been glad to avail myself of. He is, of course, not responsible for any of the opinions herein expressed.

VII.—DESCRIPTIONS AND NOTES ON SPECIES.

Coryphaenoides rupestris, Gunner.

Coryphaenoides rupestris, Gunner (1765), Day (1880), Gilbert and Hubbs (1916).

Macrurus rupestris, Gunther (1887), Holt and Calderwood (1895), Koehler (1896), Collett (1896), Lütken (1898), Brauer (1906), Holt and Byrne (1910), Murray and Hjort (1912).

(Plate VII, fig. 1.)

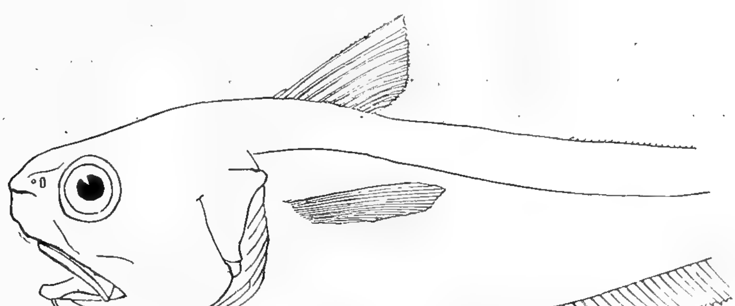


Fig. 2.—*Coryphaenoides rupestris* (after Holt and Calderwood).

Description.—Head short, moderately compressed, covered with small scales. Snout short, blunt, obliquely truncated in front. Eye large, circular, or slightly higher than wide. Sub-orbital ridge low and flattened, curving upwards in front of the eye in the direction of the snout. Cleft of mouth wide, lateral, reaching to behind the centre of the eye. Teeth in villiform bands in both jaws. Barbel very short. Inter-orbital space flattened or slightly convex, its width greater than the diameter of the eye, which is contained from $3\frac{1}{3}$ to 4 times in the length of the head, being proportionately larger in young specimens than in full-grown ones.

Body compressed, greatest thickness being contained about $1\frac{3}{4}$ times in its height, which is about $\frac{4}{5}$ of the length of the head. Dorsal outline of body rises very slightly from the head to the beginning of the first dorsal, and is continued as a straight line from behind the first dorsal to the extremity of the tail. The ventral outline of the body is parallel to the dorsal for a distance about equal to the length of the head, and then trends upwards to form the long and compressed tail.

Scales (Pl. VII, fig. 1) with the exposed portion densely covered with fine slender backward-directed spinules, giving a velvety appearance to the body. Seven to nine scales in a transverse series between the lateral line and first dorsal fin, and about twenty between the lateral line and the vent.

First dorsal rays II + 8–10. The first spinous ray is minute and covered by skin; the second is elongate and has its front edge armed with numerous small close-set serrations. Pectoral rays 19, ventral 7–8, the first ventral ray being produced into an elongate filament.

Colour brownish on the back, dull silvery grey on the sides and belly. Gill membrane and mouth black. Fins dark grey or black.

The dimensions of two large Irish specimens have already been published (Holt and Calderwood, 1895). These may be supplemented by the following measurements taken from a medium and a small specimen. It will be noticed that the size of the eye is proportionately greater in the smaller specimens. The increase of the proportional height of the body with age, which is characteristic of some species of Macrurids, does not occur in this species.

	cm.	cm.		cm.	cm.
Total length, ...	$49{\cdot}5 + x$	$28{\cdot}0 + x$	Greatest height of head, ...	6·7	4·0
Length of head,	8·5	5·2	Greatest width of head, ...	4·3	2·7
Length of snout,	1·6	1·4	Inter-orbital, ...	3·1	2·1
Length of prae-maxilla, ...	3·3	1·9	Isthmus to vent,	6·2	2·9
Length of barbel,	·5	·1	Tip of snout to first dorsal, ...	9·2	5·6
Eye, vertical diam.,	2·8	1·4	Tip of snout to vent, ...	12·1	6·7
Eye, horizontal diam., ...	2·6	1·7	Eye to hind edge of operculum, ...	4·0	2·5
Greatest height of body, ...	7·0	4·2			

General Distribution.—Round the north of the North Atlantic on the upper continental slope, extending southwards to 37° N. on the American side, and to the Bay of Biscay (44° 39′ N.) on the European. It has been taken at depths of from 85 fathoms off Newfoundland (*Hirondelle*) and 164 fathoms in the Skagerack (*M. Sars*), to 1245 fathoms off Iceland (*Ingolf*) and 900 fathoms on the east coast of the United States (*Albatross*).

Recorded range of temperature from + 8·07° C. (*M. Sars*) to + 2·0° C. (*Ingolf*).

Irish Distribution:—*Coryphaenoides rupestris* was first trawled off the Irish coast, 54 miles off Achill Head, Co. Mayo, during the Royal Dublin Society's Fishery Survey in 1890 (Holt, 1892), and a detailed account of these specimens has been given by Holt and Calderwood (1895). It was taken by the *Helga* in 29 hauls off the W. and S.-W. coasts of Ireland, its certain range being 509 to 775 fathoms, i.e. from the greatest depth recorded on the shallowest haul to the least depth recorded on the deepest haul.

By taking the number of hauls between each successive depth of 100 fathoms, whether the species was present or not, and the total number of specimens obtained in these hauls, and dividing the latter by the former, an approximate average of the number of specimens per haul can be arrived at. This method gives the following result in the case of *C. rupestris*.

Depth.			Specimens per Haul.	No. of Hauls.
400–500	...	...	·6	11
500–600	...	...	4	21
600–700	...	...	4·8	14
700–800	...	...	4·5	5½

When a haul lies partly in one zone of depth and partly in another, the specimens taken are apportioned between the two zones according to the probable extent of the haul included in each zone.

Though this method is a rough one, it probably gives a fairly reliable picture of the vertical distribution of the species. It seems evident that the lower limit of its range has not been reached by the *Helga*.

The normal range of bottom temperature corresponding to a range of 500 to 700 fathoms on the S.W. coast of Ireland is approximately 9°C. to 7·2°C. The actual bottom temperatures on some of the stations where *C. rupestris* was taken are given in the list of captures at the end of this paper. They range from 6·84°C. (700 fms.) to 9·19° C. (500 fms.) most of them being above the highest previous record for the species, viz., 8·07°C.

There appears to be no relation between the sizes of the specimens taken by the *Helga* and the depths at which they lived. Thus the largest eleven specimens, all over 80 cm. in length, were taken at an average depth of 548 fathoms and the smallest twelve, all under 20 cm., at an average depth of 585 fathoms.

Coryphaenoides Murrayi, Günther

Macrurus Murrayi, Günther (1887), Murray and Hjort (1912).

Coryphaenoides Murrayi, Günther (1878), Gilbert and Hubbs (1916).

Macrurus mediterraneus, Holt and Byrne (1910), Hoeck (1914), *nec* Giglioli.

(Plate VII, fig. 3.)

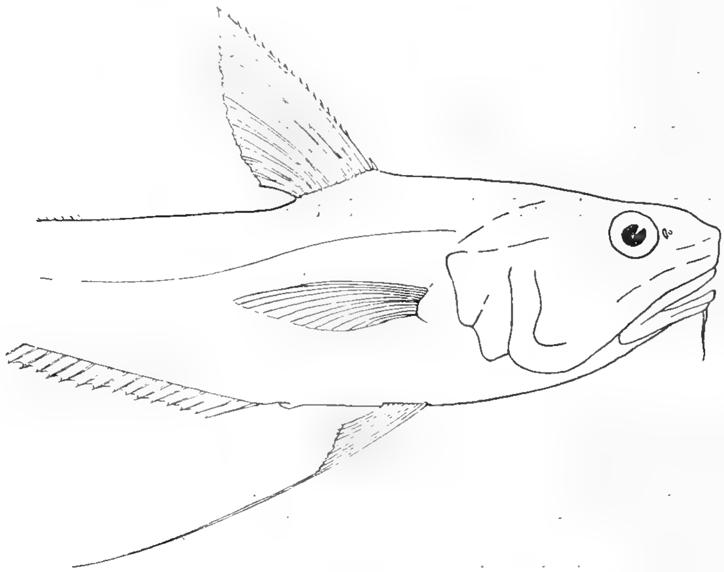


Fig. 3.—*Coryphaenoides Murrayi* (after Günther).

This species was included in the list of Irish deep-sea fishes published in 1910 (Holt and Byrne, 1910), under the name of *Macrurus mediterraneus*, and under that name also figures in the list compiled by the late Dr. Hoeck and Dr. Redeke in "Publications de Circonstance, No. 12," 2nd edition. A re-examination of the specimens, and comparison with those in the British Museum collections, has led me to the conclusion, in which Mr. Holt concurred, that they ought to be referred to the closely allied species *C. Murrayi*, which was described by Günther from five specimens taken by the *Challenger* off New Zealand, and was found by the *Michael Sars* in the N.E. Atlantic in 1910.

C. Murrayi appears to be separated from all the other species of the obsolete sub-genus *Chalinura*, including *C. mediterraneus*, by the wide interspace between the first and second dorsal fins. In one respect it closely resembles *C. mediterraneus*, namely, in the great development of the dorsal region of the body in large specimens. The first specimen taken by the *Helga* shows this in a marked degree, the dorsal profile rising in a strongly convex curve from above the eye to the first dorsal fin, producing the hump-backed appearance shown in Giglioli's figure of *C. mediterraneus* (Goode and Bean, 1895). In the Irish specimen, the length of head was 8·7 cm., and the height of the body was ·94 of that length. That this is a developmental and not a specific character is shown by the capture of a second example, length of head 7·4 cm., in which the dorsal profile is much lower, the height of the body being only ·88 of the length of the head, though not so low as in the specimen figured by Günther, length of head 65 cm., in which the height of body is ·83 of the length of head. In *C. mediterraneus* the hump-backed stage is reached at a much smaller size, 21·5 to 23·5 cm., with length of head 4·5 to 5 cm.

Description.—Snout broad and blunt, not much produced. A slightly convex, blunt median rostral ridge from between the eyes meets the lateral rostral ridges at the tip of the snout. These ridges are covered with a thickened fleshy skin, with numerous pores, which is also continued round the nostrils and along the suborbital region. The remainder of the head is covered with scales similar to those on the body, but with less well-marked ridges. A row of very small, isolated scales, each with a comb-like ridge, or crest, runs horizontally across the snout, and a very irregular, narrow band of similar scales is to be found beneath the orbit. These minute scales are deeply imbedded in the fleshy skin, and persist after the other scales have been rubbed off. Eye small, almost circular, or slightly higher than wide, diameter one-fifth to one-sixth of length of head. Mouth lateral, subterminal, with broad, fleshy lips. Cleft of mouth extending to beyond the centre of the eye. Dentition in upper jaw heterodont, with an inner band of fine villiform teeth and an outer row of sharp, widely spaced teeth, about twelve on each side, diminishing slightly from front to rear. Teeth in lower jaw in a single row, similar to the outer row of the upper jaw, but slightly smaller. Barbel well developed, considerably longer than the diameter of the eye. Interorbital space wide, equal to the distance between the eye and tip of snout. Body only slightly compressed, increasing in height with age, covered with moderately large scales (Pl. VII, fig. 3) with numerous minute low spinules arranged in from five to ten slightly radiating ridges. There may be as many as nine spinules in each ridge. In Günther's description the ridges are said to be crenulated, but an examination of the type specimen in the British Museum shows that they are in reality raised into minute backward-directed spines. Scales, in transverse series, seven or eight above the lateral line, and about eighteen or nineteen below. In the smaller *Helga* specimen all the body scales are missing, except for a few in the axilla of the pectoral, which are cycloid, with no radiating ridges. Tail tapering to a fine point. In the smaller *Helga* specimen, which appears to be complete, the total length is 5·9 times the length of the head. This agrees closely with Günther's type, in which the total length is figured as being six times that of the head.

Fin rays: 1st Dorsal, II + 9; Pectoral, 20; Ventral, 12–13.

First dorsal with the first spinous ray short and stout, just penetrating the skin; second ray long and strong, about three-fifths of length of head, with numerous (*ca.* 22–25) fine, depressed barbs; space between first and second dorsal about four-fifths of length of head. Second dorsal fin low and inconspicuous, the minute filamentous anterior rays not being joined by membrane. Ventral fin with twelve rays in the larger, and thirteen in the smaller Irish specimen, the first ray being stout and produced into a filament which reaches to about the seventeenth anal ray.

Colour in formaline light brown, the fleshy portions of the head being an opaque white, and the deep black of the opercular membranes showing through the slightly transparent gill cover.

In addition to the two large specimens above mentioned, a young specimen from station S.R. 593, 670–770 fathoms, also belongs almost certainly to this species. Its length is 77 + x mm., at least 5 mm. being missing from the end of the tail. The length of head is 13 mm. The snout is more prominent than in large specimens, having in lateral view the form of a sharp tubercle from which a median dorsal and a paired lateral ridge run backwards. The lateral ridge runs from the tip of the snout through the nasal tubercle towards the centre of the eye, and dips abruptly at the orbit below the eye. This ridge is deeply hollowed between the rostral and nasal tubercles, making the former acute in dorsal view. The first dorsal has II + 9 rays, the elongate spinous ray tapering to a minute filament, and having six slender diverging spines on its distal two-thirds. The scales are all missing. The space between the first and second dorsal fins is proportionately less than in the larger specimens, but not so small as in *C. mediterraneus.* The barbel is very small.

The following measurements have been taken from the *Helga* specimens:—

	S.R. 336.	S.R. 497.	S.R. 593.
	cm.	cm.	cm.
Total length, ...	47·0 + *x*	43·3	7·7 + *x*
Length of head, ...	8·7	7·4	1·3
Length of snout, ...	2·0	1·75	·4
Snout to eye, ...	2·3	2·15	·48
Snout to 1st dorsal fin, ...	10·5	9·0	1·5
Snout to vent, ...	12·7	12·0	2·0
Snout to front of mouth, ...	1·2	1·05	·45
Eye, horizontal diameter, ...	1·45	1·25	·35
Eye, vertical diameter, ...	1·6	1·4	·35
Inter-orbital space, ...	2·1	2·2	·55
Eye to hind edge of operculum, ...	5·0	4·4	·6
Height of body at 1st dorsal, ...	8·2	6·5	1·2
Width of head, ...	5·1	3·6	·75
Base of 1st dorsal, ...	2·3	2·2	·52
Interval between 1st and 2nd dorsal, ...	7·0	6·0	·7
Length of spine of 1st dorsal, ...	6·3	4·9 + *x*	·95
Length of elongate ray of ventral, ...	9·8	8·1	·85
Isthmus to vent, ...	8·4	7·7	1·0
Length of barbel, ...	2·1	2·2	—

General Distribution.—The *Challenger* specimens were taken off New Zealand in 1,100 fathoms. The *Michael Sars* specimens were taken off Gibraltar in 1,258 fathoms, and off the S.-W. coast of Ireland in 983 fathoms. The three *Helga* specimens also came from the S.-W. coast of Ireland between 670 and 795 fathoms. From these few records we may infer that *M. Murrayi* is widely distributed at the foot of the continental slope, where uniform conditions prevail over wide areas.

Irish Distribution.—Only three specimens, all captured by the *Helga*, are known from off the Irish coast from the following stations:—

S.R. 336.—12 v '06—51° 19′ N., 12° 21′ W., 673–720 fathoms. Trawl—one, 48 cm.

S.R. 497.—10 ix '07—51° 02′ N., 11° 36′ W., 775–795 fathoms, ooz Trawl—one, 44 cm.

S.R. 593.—6 viii '08—50° 31′ N., 11° 31′ W., 670–770 fathoms, ooze Temp. at 650 fathoms 7·75°C. Trawl—one, 7·7 cm.

Coelorhynchus coelorhynchus (Risso).

Lepidoleprus coelorhynchus, Risso (1810).

Macrurus coelorhynchus, Bonaparte (1832).

Macrurus coelorhynchus, Günther (1887), Vaillant (1888), Günther (1889), Bourne (1890), Scharff (1890), Holt (1892), Holt and Calderwood (1895), Koehler (1896), Brauer (1906), Holt and Byrne (1910), Murray and Hjort (1912).

Macrurus atlanticus, Lowe (1839), Günther (1862), Zugmayer (1911).

Coelorhynchus atlanticus, Goode and Bean (1895).

Coelorhynchus coelorhynchus, Gilbert and Hubbs (1916), Roule (1919).

(Plate VII, fig. 2.)

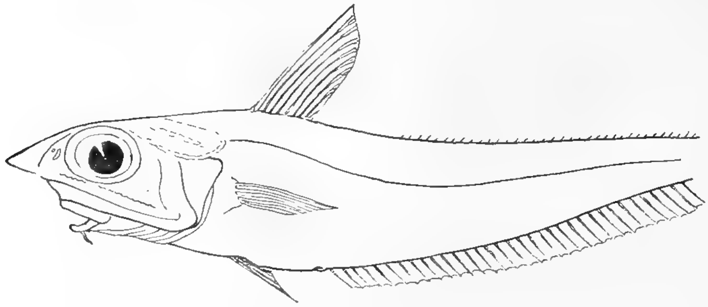


Fig. 4.—*Coelorhynchus coelorhynchus* (after Holt and Calderwood)

Description.—Head pointed, flattened below, the infra-orbital ridge forming a well-marked division between the lower surface and the rest of the head. Snout moderately elongated, a little shorter than or equal to the eye. Profile of the head slightly convex, meeting the infra-orbital ridge at the extremity of the snout at an angle of about 50°. Head completely covered with small scales which are easily detachable and are set with numerous irregular rows of small blunt spinules. Excepting the sub-orbital ridge, the ridges on the head are not well marked, but they are distinguishable by the larger size and regularity of the scales which they bear. They consist of a median ridge running from between the eyes to the tip of the snout and, on each side of the head, a supra-orbital running from above the gill-cover to above the eye, where it divides, one branch following the orbit for a short distance and then terminating, the other descending in front of the nostril to the infra-orbital ridge. On each side of the occipital region a ridge runs from above the eye, close to the supra-orbital ridge, to the back of the head. The space between the supra-orbital and occipital ridges has a median row of moderately large slightly keeled scales, which have the appearance of a faint ridge continuous with the anterior end of the lateral line. The tip of the snout projects to form a small spinulose process, usually trifid, but sometimes bifid.

Outline of the body rising slightly from the head to the front of the first dorsal fin. The rise is gradual and continuous with the profile of the head in small specimens, but is somewhat abrupt in large individuals. The body is only slightly compressed, its width at the first dorsal being about two-thirds of the height.

The variations in the proportions of the body with age seem to be inconsiderable. There is a slight proportional increase in the height of the body, which, in specimens of 15 cm. in length, is about $\frac{3}{5}$ of the length of the head, and in a specimen of about 40 cm. is almost $\frac{4}{5}$.

C. coelorhynchus does not seem as liable to the loss of the tip of its tail as some other species of Macrurids, and it may be possible to fix a definite relation between the length of the head and the total length. The measurement of five apparently perfect specimens of from 27·7 cm. to 35 9 cm. gave an average of 470 : 100 as the proportion of total length to length of head; and of three smaller specimens of 12 to 16 cm., whose measurements are given by Holt and Byrne (1908), the average is 490 : 100. This may indicate either that the rate of growth of the body is slightly checked, or that loss of the caudal extremity in very small specimens is not perceptible at a later stage.

Between the ventral fins is a scaleless oval depression, black in colour.

Scales (Pl. VII, fig. 2) of moderate size, covered with small, strong spines, sloping backwards in more or less regular slightly radiating lines, the number of the spines increasing with age. There are five scales in a transverse series between the first dorsal and the lateral line, and fourteen to fifteen between the lateral line and vent.

Fin rays: 1st Dorsal, II + (8–9). Pectoral, 18–20. Ventral, 7.

Dorsal spine smooth.

Colour dull, silvery grey on the sides and back, blackish on the throat and abdomen in the neighbourhood of the pelvic fins, which are dark.

The following measurements were taken from specimens captured by the *Helga*:—

	cm.	cm.	cm.	cm.
Total length, ...	28·0	30 + x	36·0	37·5 + x
Length of head, ...	5·8	6·4	8·2	8·6
Length of snout, ...	1·9	2·1	2·6	2·4
Width of head, ...	3·0	3·1	4·7	4·8
Inter-orbital width,	1·4	1·5	1·85	2·2
Length of eye, ...	2·0	2·2	2·9	3·2
Greatest height of body,	3·6	4·3	5·6	6·5
Tip of snout to 1st dorsal,	6·6	7·6	9·4	10·3
Tip of snout to anal,	8·1	9·7	12·7	13·0
Vent to isthmus,	3·7	4·6	5·6	6·6

General Distribution rather limited. This species is found in the Mediterranean and, in the Atlantic, for about 20° to N. and S. of the Straits of Gibraltar, occurring along the edge of the continental shelf and descending for a short distance down its upper slopes. It is also found at the Azores and Cape Verde Islands.

The Norwegian record of a young specimen from the stomach of a cod-fish (Collett, 1879) seems to be outside the area of normal distribution, the northern limits of which may, with our present knowledge, be placed on the west coast of Ireland in about 54° N.

Irish Distribution. C. coelorhynchus was first taken off the coast of Ireland by the Rev. W. S. Green during the cruise of the *Flying Falcon* in 1888 (Scharff, 1890), and subsequently by the *Flying Fox, Research*, and *Fingal* expeditions.

It was trawled by tho *Helga* in 31 hauls off the W. and S.-W. coasts of Ireland, its certain range being 214 to 627 fathoms, and its probable range 160 to 627 fathoms.

The average number of specimens per haul, estimated in the manner described above in the case of *M. rupestris*, is as follows:—

Depth.	Specimens per haul.	Number of hauls.
100–200 fms.	0·77	17
200–300 „	15·7	10
300–400 „	9·0	15
400–500 „	0·46	11
500–600 „	0·33	21
600–700 „	0·2	14

These figures show that its normal habitat is between 200 and 400 fathoms. The average bottom temperatures corresponding to depths of 200 and 400 fathoms on the S.-W. coast of Ireland are 10·2°C. and 9·5°C. respectively.

Coelorhynchus labiatus (Koehler).

Macrurus labiatus, Koehler (1896), Holt and Byrne (1910).
Macrurus japonicus, Vaillant (1888).
Macrurus Talismani, Collett (1905), Murray and Hjort (1912).
Coelorhynchus Vaillanti, Roule (1919).

(Plate VII, fig. 6.)

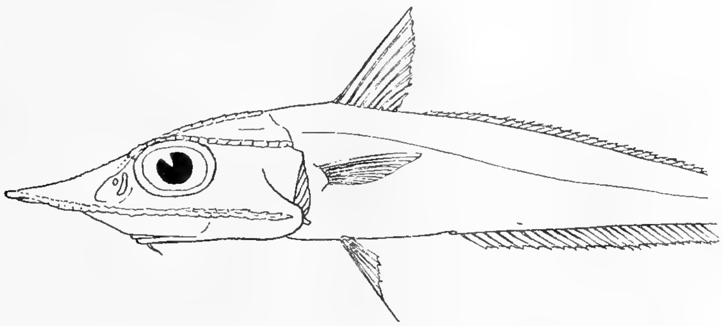


FIG. 5.—*Coelorhynchus labiatus* (after Vaillant).

Description.—Head pointed, with long sub-trihedral depressed snout, which measures from $1\frac{2}{3}$ times to nearly twice the length of the eye. Head ridges well marked, the most prominent being the infra-orbital, which runs backwards from the tip of the snout almost to the hind edge of the preopercular, dividing the lower surface from the rest of the head. The posterior portion of this ridge is composed, as is the case in many Macrurids, of a double series of spinose scutes, the anterior portion, from the centre of the eye to the tip of the snout, consisting of a single series. The other ridges present are: a supra-orbital, running from the back of the head above the eye and nostril, in front of which it terminates; an occipital, running forward from the back of the head, and terminating above the eye close to the orbital ridge, and a median (unpaired) from the anterior inter-orbital region to the tip of the snout. All these ridges are marked with backward-sloping spinules, in groups of three to five. The scales clothing the areas between the ridges are, in small specimens, small and separated by membranous skin, but in larger sizes they are larger, and form a continuous covering. They bear a few small spinules each. The underside of the head is smooth and scaleless, or with a few small spinules near the tip of the snout or along its margin. It often bears several small soft papillae. The mouth is small and of an elongated horseshoe shape. It is situated in the centre of the underside of the head, and is separated from the suborbital ridge by a distance nearly equal to half the diameter of the eye. Body very slightly compressed. In small specimens the width is very slightly less than the height; but in the largest specimen found, the width was only three-fourths of the height. The proportion of the total length to length of head in most specimens measured was 385 : 100. It is not certain, however, that these specimens were uninjured. In one specimen of 37·7 cm. it reached 410 : 100, which may, perhaps, be taken as the normal proportion for large uninjured specimens. A small specimen of 14·2 cm. gave the proportion 418 : 100. The proportion of the height of the body to the length of the head (taken as an index of total length) increases slightly with age. In specimens up to 38 cm. in length it is about 4 : 10, but above that size it begins to increase, the maximum found being 5½ : 10 in a specimen of 46 cm.

Scales (Pl. VII, fig. 6) large, each scale with eight to ten longitudinal rows of stout, sharp, backward-directed spinules, each row with two to four spinules. One of the central rows is enlarged, and forms a sort of keel to the scale. The rows on each side of the median row are alternately long and short. In small specimens of about 15 cm. long there are only six or seven rows of spinules.

Fin rays: 1st Dorsal, II + (7–8). Pectoral, 17. Ventral, 7.

First dorsal spine very minute, second normal, but slender, and without serrations. First ventral ray elongate, reaching at least to the commencement of the anal fin. Distance between first and second dorsal fins about two-thirds of the interorbital space, the anterior rays of the second dorsal being very minute.

Colour, body uniform grey, first dorsal and ventral fins dark, mouth and gill-openings and opercular membrane deep blackish-blue, posterior nasal opening bordered with black anteriorly.

The following measurements have been taken from specimens captured by the s.s. *Helga*:—

	cm.	cm.	cm.	cm.	cm.
Total length, ...	14·2	18·5	19·0 + x	37·7	46·0
Length of head, ...	3·4	4·8	5·9	9·2	12·0
Length of snout, ...	1·55	2·25	3·0	4·1	5·4
Length of eye, ...	·9	1·3	1·6	2·5	3·1
Inter-orbital space, ...	·7	·9	1·2	2·0	2·5
Snout to 1st dorsal, ...	3·8	5·1	6·5	11·0	13·6
Snout to vent, ...	4·6	6·7	8·1	14·0	18·0
Height of body, ...	1·8	1·9	2·4	4·5	6·6
Space between 1st and 2nd dorsal,	·5	—	·8	1·7	—

The distribution of this species cannot be given with any exactness, as its synonymy is still uncertain. Several closely allied species of long-snouted

Macrurids have been described; but until an opportunity arises for comparing species of various sizes from different localities their identity or otherwise must remain doubtful.

Leaving aside *C. Japonicus*, which appears to be distinguished by the radial arrangement of the rows of spines on the scales, the first to be described was *C. parallelus*, taken by the *Challenger* in the widely separated localities of Japan and Kermadec and New Zealand. Judging from Günther's description, confirmed by a brief inspection of the specimens in the British Museum, *C. parallelus* is characterized by a great development of spinose scales on the head, including the underside, and by the presence of a small number of large spines, with broad bases, on the body scales. The New Zealand specimens, to which Günther refers as being slightly divergent from the type, seem to vary in the direction of *M. labiatus.*

In 1888 Vaillant, working out the collections of the *Travailleur* and *Talisman* expedition, found large numbers of a long-snouted Macrurid from the N.E. Atlantic off the Senegal coast, the Cape Verde Is., and the Azores. He identified these with *Macrurus Japonicus*, Schl., suggesting *M. parallelus* and *M. occa* as synonyms, but withdrawing *M. parallelus* in the appendix. Shortly afterwards, in 1896, Koehler described *Macrurus labiatus* from the Bay of Biscay, distinguishing it from the *M. Japonicus* of Vaillant by the form of the mouth and the more numerous rows of spinules on the scales. Collett in 1905 examined specimens taken by the *Michael Sars* in the Faeroe-Shetland Channel, and identified them with Vaillant's species, but, recognizing that they were distinct from *M. Japonicus* of Schlegl, proposed the new name of *M. Talismani.*

Roule (1916) has also proposed a new name (*Coelorhynchus Vaillanti*) for Vaillant's species, which he found in the collections made by the Prince of Monaco off the Azores, and (1919) has published excellent coloured figures of large and small individuals.

The *Helga*'s specimens represent a wide range of size, from 11 cm. to 46 cm The smaller specimens agree most nearly with Collett's description of *Macrurus Talismani*, but the larger show no adequate grounds for separation from *M. labiatus.* The peculiar conformation of the mouth, which Koehler has emphasized, appears to have been described from a specimen in which the mouth was abnormally protruded; and an examination of a *Helga* specimen which was in the same condition showed similar features, but not in such a marked degree as Koehler's specimen. It appears to me safe to conclude that *C. labiatus*, *C. Talismani*, and *C. Vaillanti* are identical, and that consequently the name *C. labiatus* should be used.

A nearly allied species from the west side of the Atlantic, *C. occa*, may perhaps also prove to be conspecific, in which case its name, having been given in 1885, will take priority. The description of *C. occa* given by Goode and Bean suggests a fish which, except as regards the eye, which is said to be nearly circular, and the position of the ventral fins, under the centre of the 1st dorsal, is hardly to be distinguished from *C. labiatus*. The figure accompanying the description does not bear out the statement made about the eye. Gilbert and Hubbs (1920), who have examined specimens of *C. occa*, separate it from *C. Talismani* in their diagnostic table of the genus, on the grounds of its smaller orbit.

General Distribution.—Including *M. Talismani* in the synonymy, the distribution of *C. labiatus* is from the Faeroe-Shetland Channel to the Cape Verde Is., or from about 17° N. to 60° N., in depths of from 250 to 1,200 fathoms (460–2,220 metres).

Irish Distribution.—The *Helga*'s captures were all made off the W. and S.-W. coasts of Ireland between 468 and 893 fathoms, with a certain range of 520–775 fathoms.

The average numbers per haul were :—

Depth.	Specimens per haul.	No. of hauls.
500–600 fms.,	·9	21
600–700 „	4·4	14
760–800 „	9·1	5½

From these records it would seem that the *Helga*'s explorations did not reach the lower limits of its normal range on the S.-W. coast of Ireland. The total number of specimens taken was 132. They varied in size from 11 to 46 cm. There is no indication that either large or small specimens are most abundant at any particular depth, the ten largest specimens (35–46 cm.) having been taken at an average depth of 615 fathoms, and the seventeen smallest (11–13 cm.), at an average depth of 656 fathoms.

Lionurus aequalis (Günther).

Macrurus aequalis, Günther (1878, 1887), Holt and Calderwood (1895), Collett (1896, 1905), Koehler (1896), Holt and Byrne (1910), Zugmayer (1911), Murray and Hjort (1912).

Macrurus smiliophorus, Vaillant (1888).

Macrurus serratus, Roule (1919).

Lionurus aequalis, Gilbert and Hubbs (1916).

(Plate VII, fig. 5.)

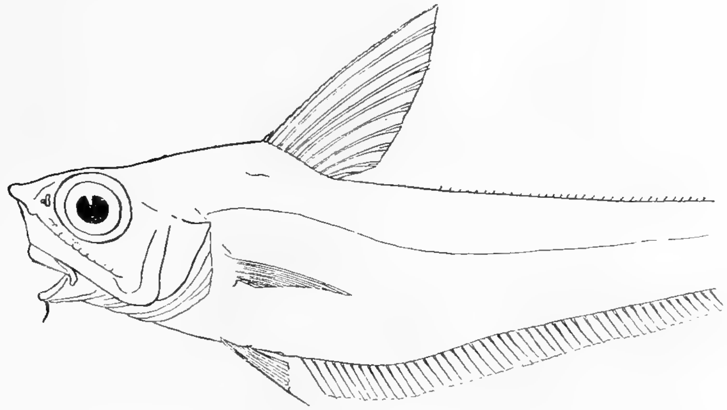


Fig. 6.—*Lionurus aequalis* (after Holt and Calderwood).

Description.—Head moderately compressed. Snout projecting conically beyond the mouth, the cleft of which extends almost to below the centre of the eye. Head, including the underside, completely covered with small spinulose scales. A well-marked sub-orbital ridge terminates posteriorly at the anterior margin of the preopercular, and is continued forwards in a straight line, as a lateral rostral ridge, to the tip of the snout. The scutes forming this ridge are in a double series below the eye. The median rostral and pre-nasal ridges are indicated by low keels, but are not marked by any differentiation of the scales. There is a small bifid rostral tubercle, and a low nasal tubercle, marked with slightly enlarged spinules, is situated on the anterior end of the sub-orbital ridge. Inter-orbital space flat, or slightly convex, variable in width within the limits of one-fourth to one-fifth of the length of the head. Eye large, slightly longer than high, its greatest diameter being parallel to the sub-orbital ridge, and measuring ·35 to ·4 of the length of the head.

Posterior margin of pre-opercular forming a right angle with the long axis of the head (from the tip of the snout to the upper posterior angle of the operculum). In the allied species, *L. Bairdii*, it is figured as sloping backwards from the long axis at a slightly acute angle.

Dorsal profile of body rising rapidly from the back of the head to the first dorsal, the proportion of height of body to thickness being about 7 : 4.

Extremity of tail very slender and thread-like, rarely found complete. The largest apparently complete specimen measured 24·0 cm., and gave a proportion of head to total length of 100 : 730.

Body scales (Pl. VII, fig. 5) of medium size, the exposed portion being completely covered with small, broad, flattened, lancet-shaped, imbricating spinules, which project beyond the posterior margin of the scale. There are eight scales in a transverse series between the first dorsal and the lateral line, and about fourteen, often irregularly arranged, between the lateral line and the anus.

Fin rays: 1st Dorsal, II + (8–10). Pectoral, 17. Ventral, 8.

First dorsal fin large, the first spinous ray consisting of a stout but short spine, which projects visibly from the skin. Second ray very strongly serrulate, slightly longer than the head.

The distance between first and second dorsal fins shows wide variation, but is usually more than half the length of the head, being, apparently, greatest in large specimens, possibly on account of injury to the anterior rays of the second dorsal.

First ray of ventral fin elongated and filamentous, usually broken, but reaching, when complete, to at least the fifth ray of the anal fin.

Colour on the anterior and lateral part of the head and the caudal region dull silvery-grey. Trunk deep indigo, darkening ventrally into blue-black, which extends to the under-surface of the head. Antero-superior part of the first dorsal black.

The following measurements are taken from specimens trawled by the *Helga*:—

	cm.	cm.	cm.
Total length, ...	19·3 + x	24·0	25·5 + x
Length of head, ...	2·9	3·3	4·1
Length of snout, ...	·75	·75	1·0
Eye, vertical diameter, ...	·95	1·0	1·2
Eye, horizontal diameter, ...	1·05	1·2	1·4
Greatest height of body, ...	—	3·0	4·3
Greatest width of body, ...	—	1·7	2·4
Inter-orbital width, ...	·6	·75	·85
Tip of snout to 1st dorsal, ...	3·6	4·2	5·2

General Distribution.—Apparently limited to the east side of the N. Atlantic, from 15° N. to 61° N., at depths of from 250 fathoms (*Travailleur* and *Talisman*) to 1,424 fathoms (*M. Sars*).

Irish Distribution.—First taken off the Irish coast during the Royal Dublin Society's Fishery Survey in 1890 (Holt, 1892), seven specimens having been trawled in 500 fathoms, 54 miles off Achill Head. These specimens have been described very fully by Holt and Calderwood (1895).

In the *Helga*'s trawlings it was the commonest Macrurid, and occurred regularly between 350 and 700 fathoms, its certain range being 346 to 707 fathoms.

The average number per haul at various depths, estimated as in the case of *Coryphaenoides rupestris*, were :—

Depth.	Specimens per haul.	No. of hauls.
300–400 fms.	9·4	15
400–500 „	17·4	11
500–600 „	17·8	21
600–700 „	7·4	14
700–800 „	11·4	5½

The apparent increase below 700 fathoms is probably due to the small number of hauls, a large haul of 30 specimens at 720 fathoms, and another of 26 specimens at 707–710 fathoms, being responsible for bringing up the average. The figures indicate that the lower limit of the range of the species on the S.-W. coast of Ireland has not yet been reached by the *Helga*. The total number of specimens taken was 872. Specimens of all sizes seem to be uniformly distributed at the various depths, the average depth at which the smallest fourteen specimens (11–17 cms.) were taken being 496 fathoms, and the largest ten (34–36 cms.) 452 fathoms.

Lionurus sclerorhynchus, a species closely allied to *L. aequalis*, was taken by the *Michael Sars* Expedition in 1910 (Murray and Hjort, 1912) in 50° 22′ N. 11° 44′ W, at a depth of 1,797 metres, 983 fathoms, the position being very close to the area in which the *Helga* worked, but at a greater depth than was explored by her trawl.

Lionurus Guntheri (Vaill.).

Macrurus Guntheri, Vaillant (1888), Collett (1896, 1905), Holt and Byrne (1910), Roule (1919).

Macrurus sclerorhynchus, Günther (1887) *nec* Valenciennes.

Macrurus holotrachys, Vaillant (1888) *nec* Günther.

Coryphaenoides Guntheri, Gilbert and Hubbs (1916).

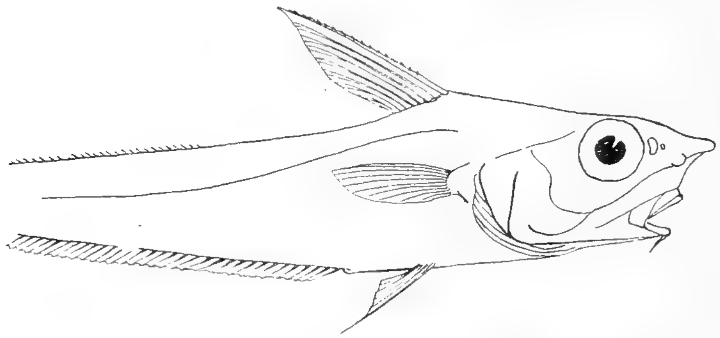


Fig. 7.—*Lionurus Guntheri* (after Günther).

Resembles *Lionurus aequalis* in general appearance, but may be distinguished by its broader and longer head, the inter-orbital space being equal to the vertical diameter of the eye, and the snout equal to its horizontal diameter.

The scales are of a less specialised type than those of *L. aequalis*. They bear eight or nine rows of small spinules, the central row being slightly enlarged. The most posterior spine of the central row alone projects beyond the margin of the scale. The scales of the head are armed with long divergent spinules.

Roule (1916) considers this species to be a variety of *Lionurus sclerorhynchus*. Gilbert and Hubbs, on the contrary, put them in separate genera. I have had no opportunity of examining a specimen, but the published descriptions seem to suggest that its proper place is in the genus *Lionurus*.

General Distribution.—East side of the N. Atlantic from off Morocco (1,200 fathoms) to the Faeroe Channel (656 fathoms).

Irish Distribution.—One small specimen of 13·6 cm., identified by Mr. Holt, was taken by the *Helga* in 673–893 fathoms on station S.R. 335, the normal habitat of the species being apparently beyond the range in depth of our investigations.

Malacocephalus laevis (Lowe).

Macrurus laevis, Lowe (1843), Günther (1887, 1889), Bourne (1890), Holt (1892), Holt and Calderwood (1895), Brauer (1906), Holt and Byrne (1910), Zugmayer (1911), Murray and Hjort (1912).

Malacocephalus laevis, Günther (1862), Lütken (1898), Goode and Bean (1895), Koehler (1896), Gilbert and Hubbs (1916), Roule (1919).

? *Coryphaenoides aequalis*, pars, Vaillant (1888).

(Plate VII, fig. 7.)

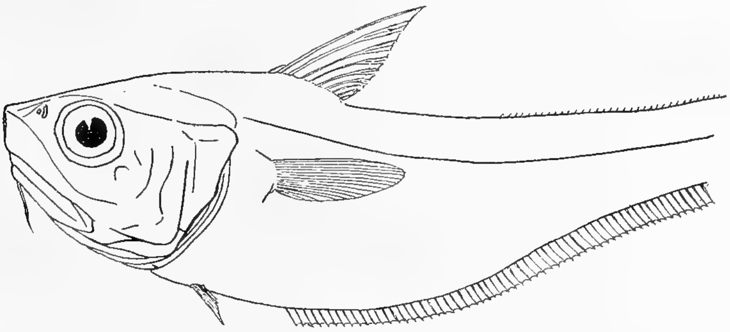


Fig. 8.—*Malacocephalus laevis* (after Holt and Calderwood).

Description.—Snout short and rounded, lower profile descending steeply to the mouth, which is sub-terminal and inferior. Gape of the mouth reaching back to beyond the centre of the eye. Head moderately compressed, with vertical sides and without any marked ridges or differentiated scales, completely covered with minute roughened scales. Eye large, longer than high, showing a slight proportional decrease in size with the increase of length of the head. In a specimen with a head-length of 4·2 cms. its length is 36 per cent. that of head, but in a specimen of which the head measures 6·3 cms. its length is 33·5 per cent. Inter-orbital space wide, a little less than the longest diameter of the eye, flat or slightly hollowed by the sinking in of the tissues. Dorsal profile of the head almost straight, with a very slight curve from the tip of the snout to the commencement of the first dorsal fin. Teeth in the upper jaw in two series, an outer, widely spaced, single row of moderately large teeth pointing downwards, and an inner, more irregular row, doubled anteriorly, of smaller teeth pointing inwards. In the lower jaw the teeth are in a single row similar to the outer row of the upper jaw. Barbel slender, a little shorter than the vertical diameter of the eye.

Body oval, tapering rapidly to the compressed tail. Total length about $6\frac{1}{2}$ times or more the length of head. Body scales (Pl. VII, fig. 7) very small, about 16 in a series between the first dorsal fin and lateral line, deeper than long, and bearing from ten to fourteen long, slender spinules sloping slightly backwards. A triangular, scaleless, black-coloured depression lies between the bases of the ventral fins, and immediately behind this is a similar depression of an oval shape.

Fin rays: 1st Dorsal, II + (9–10). Pectoral, 16–18. Ventral, 8–9.

First spinous ray of first dorsal very minute, not appearing through the skin; second ray smooth, elongate, almost three-fourths of the length of head; ventrals small, outer ray slender and slightly prolonged, reaching to about the sixth anal ray. Distance between first and second dorsal fins slightly more than half the length of head.

Colour, greyish-brown, with a darker, bluish tinge on the abdomen; sides of head silvery; lining of gill cavity dark greyish purple, of mouth light-coloured.

The largest size reached by specimens taken by the *Helga* was 52 cms., three of that size having been taken. The largest recorded size for the species is 54·5 cms., this measurement having been taken from a specimen captured off the W. coast of Ireland (Holt and Calderwood, 1895).

Malacocephalus laevis is figured, after Günther, in Goode and Bean, "Oceanic Ichthyology," but the figure is, by an obvious error, referred to a quite different species, *Nematonurus gigas*.

Measurements of a specimen (*a*) taken by the *Silver Belle* off the coast of Portugal[1] and two specimens (*b*) (*c*) taken by S.S. *Helga*:—

	(*a*)	(*b*)	(*c*)
Total length, ...	430 mm.	385 + *x* mm.	277 + *x* mm.
Length of head, ...	63	61	42
Length of snout, ...	14	13	10
Length of eye, ...	15	17	11
Height of eye, ...	18	17	13
Eye to hind edge of operculum, ...	29	27	18
Inter-orbital space, ...	20	21	13
Snout to 1st dorsal fin, ...	70	69	47
Snout to anal fin, ...	94	85	54
Height of body, ...	62	57	37
Width of body, ...	37	27	15
Width of head, ...	—	31	19
Length of barbel, ...	13	14	9

General Distribution.—East side of the Atlantic from Madeira to the Skagerack and Norway. On the west side it was taken by the *Challenger* off

[1] Kindly put at the disposal of Mr. Holt by Dr. Wolfenden.

Pernambuco, and it is represented on the coast of the United States by a closely allied species, *M. occidentalis*, which Jordan and Evermann (1896–98) suggest may be identical. Günther (1887) states that it occurs in the Mediterranean. It is widely distributed in the Indian Ocean, and has been taken at the Sandwich Islands.

It is always found at moderate depths for a Macrurid. The recorded depths of capture, 187–534 fathoms, correspond closely with the *Helga*'s results, which give a certain range of 177–354 fathoms. The bottom temperatures on the S.-W. coast of Ireland corresponding to depths of 177–354 fathoms fall within the limits of 9·5° C.–10·5° C., and agree fairly well with those recorded for the species on the *Valdivia* expedition, viz. 8·0° C.–10·5° C.

Possibly it is even more widespread than the records suggest, in view of the fact that deep-sea expeditions usually pursue their investigations in greater depths than those in which it is most plentiful, while it is beyond the reach of ordinary fishing carried on from the shore.

Irish Distribution.—Before the *Helga*'s investigations this species had been taken off the west coast of Ireland by the *Flying Fox* and *Fingal* expeditions.

The average number of specimens per haul taken by the *Helga* at various depths were:—

Depth.		Specimens per haul.	No. of hauls.
100–200 fathoms,	... ...	2·6	17
200–300 „	... ...	5·4	10
300–400 „	... ...	·53	15

Total number of specimens, 115.

The approximate average depth at which the largest eighteen specimens (46–52 cms.) were taken was 268 fathoms, and the smallest eighteen 191 fathoms.

This suggests a possible migration of larger specimens into deeper water; but as only one sounding was taken on some stations, and as other considerations, which there are not sufficient data to elucidate, may affect the result, this cannot be regarded as proved.

GENUS **Bathygadus.**

The genus *Bathygadus* is distinguished externally by the forward position of the mouth, the mandible usually extending in front of the snout; the small space between the first and second dorsal fins, the bases of which are almost continuous; the proportionately great development of the second dorsal, the rays of which are longer than those of the anal; the slight development of the anal, which in most Macrurids is a powerful fin; the teeth, which are in the form of small, equal asperities, arranged in a band on the inner surface of both jaws, except for a gap at the symphysis of the upper jaw, where a shallow depression receives the tip of the mandible; and the cycloid scales.

The genus has been sub-divided by some authors (Regan, Weber, Gilbert and Hubbs, and others), but as they are not in agreement as to the limits of the divisions, it is more convenient to continue to use the name in its widest sense.

Bathygadus melanobranchus (Vaillant).

Bathygadus melanobranchus, Vaillant (1888), Goode and Bean (1895), Collett (1896), Holt and Byrne (1908, 1910).

Melanobranchus melanobranchus, Regan (1903).

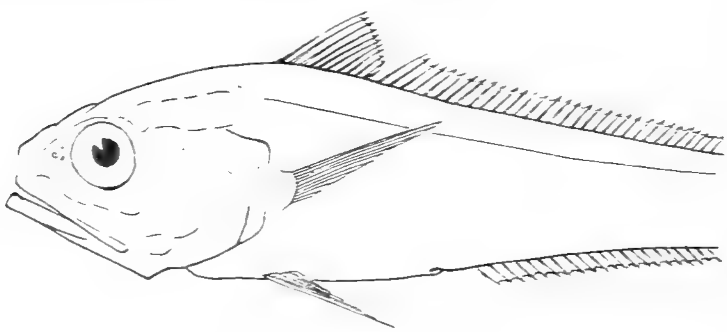


Fig. 9.—*Bathygadus melanobranchus.*

Description.—Head large, about 5 to 5½ times in total length, moderately compressed. Snout blunt, ⅕ of length of head. Mouth large, terminal, and inferior, reaching back to beyond the centre of the eye. Lower jaw extending slightly in advance of the upper, the tip curved slightly upwards, and fitting into a depression in the upper jaw at the symphysis of the intermaxillaries; it has a prominent mental process, marked by a small hard brown tubercle, and no barbel. Both upper and lower jaws with a band of fine equal villiform teeth. Eye almost circular, large, diameter equal to or slightly greater than the length of the snout. Inter-orbital space may be slightly less than diameter of eye (Vaillant) or distinctly greater (*Helga* specimen). Bones of head thin and papyraceous, easily injured, with large mucous cavities.

Body moderately compressed, covered with cycloid scales without spines. These scales are easily rubbed off, and were absent from the *Helga* specimen.

Fin rays: 1st Dorsal, II + 9. Pectoral, 18. Ventral, 8.

First dorsal with first spinous ray very minute, not emerging from the skin; second ray of moderate length, unarmed, broken in the *Helga* specimen. The fin is low, but slightly higher than the second dorsal, from which it is separated by a space equal to the interval between two fin rays. The anal fin begins under the tenth ray of the second dorsal, and its rays are considerably shorter than those of that fin. The pectoral arises very slightly behind, and the ventral very slightly in front of the level of the commencement of the first dorsal. The pectoral and ventral fins in the *Helga* specimen were damaged, but did not show any signs of having had elongated rays.

Colour of specimen preserved in formaline silvery, the lining of the mouth and gill cavity being deep brownish-black.

The following measurements are taken from the specimen captured by the *Helga*:—

	cm.		cm.
Total length, ...	28·8 + x	Snout to vent, ...	8·6
Length of head from snout,	5·2	Snout to front of mouth, ...	·7
Length of head from tip of jaw, ...	5·4	Diameter of eye, vertical,	1·25
Length of snout, ...	1·1	Diameter of eye, horizontal,	1·45
Snout to eye, ...	1·4	Inter-orbital space, ...	1·7
Snout to 1st dorsal, ...	5·5	Eye to hind edge of operculum,	2·7
Snout to 2nd dorsal, ...	7·7	Height of body, ...	4·4
Snout to ventral, ...	5·9	Width of body, ...	2·4
		Width of head, ...	2·6

General Distribution.—*Bathygadus melanobranchus* was described by Vaillant from specimens taken off Senegal, Morocco, and the Canaries, where the *Travailleur* and *Talisman* found it abundantly in 834–1,495 fathoms. The *Hirondelle* extended its range to the Azores, and the *Michael Sars* also found it in the same locality.

B. melanobranchus is not known from outside the Atlantic, as *B. furvescens*, which Brauer (1906) and Weber (1913) believed to be the same species, has been shown by Gilbert and Hubbs (1920) to be distinct, having a much longer snout, longer than the eye and 3·5 to 3·7 times in the length of the head.

Irish Distribution.—The capture by the *Helga* of a single specimen in 51° 46′ N., 12° 05′ W., 549–646 fathoms (S.R. 397, 2 II '07) extended the known northern limit of 39° 36′ 30″ N. (*Hirondelle*) by more than ten degrees. This capture has already been briefly recorded (Holt and Byrne, 1908).

Trachyrhynchus trachyrhynchus (Risso).

Macrurus trachyrhynchus, Günther (1862), Vaillant (1883).

Trachyrhynchus scabrus, Goode and Bean (1895).

Trachyrhynchus trachyrhynchus, Günther (1887), Koehler (1896), Murray and Hjort (1912).

(Plate VII, figs. 4, 8.)

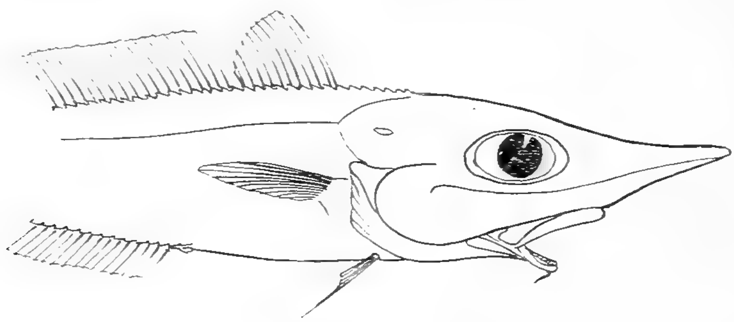


Fig. 10.—*Trachyrhynchus trachyrhynchus.*

Description.—Body elongate, increasing very slightly from the head to the first dorsal fin, and thence tapering gradually to a pointed tail. Body about as wide as high at the first dorsal, and becoming slightly compressed in the caudal region.

Head contained about $3\frac{3}{4}$ times in the total length and produced into a flattened pointed snout. A strong ridge, separating the upper and lower surfaces of the head, runs from the snout to the operculum, passing close beneath the eye. Eye about $1\frac{1}{2}$ times as long as high, and contained $3\frac{1}{2}$ times in length of head. Head completely covered with small elongate scutes, each with a denticulated ridge or keel. The scutes are arranged so that their keels unite to form elongated ridges converging towards the snout. The underside of the head is covered with similar but smaller scutes with crests of from 3 to 6 cusps, the linear arrangement of scutes not being so evident as on the upper surface of the head. Occipital fossa not very noticeable, hardly more than a shallow depression between two ridges. Supra-orbital ridge almost obsolete. Mouth inferior, horseshoe-shaped. Barbel small.

Body covered with stout scales. In a specimen of 24·0 cms. each scale has a single strong backward-directed spine (Pl. VII, fig. 8), except those of the lateral line, which have two spines, one on each side of the channel. In a larger specimen of 49·5 cms. the scales bear one large and, usually, two smaller spines, short and robust, the whole scale being thickened and massive, and the surface striae obliterated (Pl. VII, fig. 4). The form of the scales differs on different parts of the body; on the sides they are much deeper than wide, but towards the tail the difference in proportion diminishes, and in young specimens the caudal scales are almost circular. On either side of both the dorsal and anal fins a ridge is formed of modified, saddle-shaped scales, each with a large central backwards-directed compressed spine, which is usually crenulated or cut into smaller teeth. This ridge is continued backwards for a variable distance until it merges in the general scale-covering of the body. The precise point at which it ceases to be differentiated is not easy to determine, but, for the dorsal ridge, it lies between $1\frac{1}{10}$ and $1\frac{1}{4}$ times the length of the head behind the commencement of the first dorsal fin. The dorsal ridges are continued forwards, slightly diverging, to the head. In small specimens of about 24 cms. the crenulation of the spines of the ridges is very slight and is only found on a few scales, but it increases with age, and, in addition, subsidiary spines are developed on each side of the median one. The ventral ridges are similar to those beside the dorsal fin except that their teeth are more depressed and that they are continued backwards for a greater distance, at least $1\frac{1}{2}$ times the length of the head, behind the anus, and possibly further, as in all the *Helga* specimens the caudal region was bare of scales. The ventral ridges are not continued forwards in front of the anus, the whole underside of the body in front of the anus being covered with uniform spinose scales.

Fin rays: 1st dorsal, I + (10–11); Pectoral, 20–22; Ventral, 7.

First dorsal spine rather less than half as long as the succeeding ray.

The first dorsal fin is about equal in height to the longitudinal diameter of the eye. The second dorsal is slightly lower than the first and is separated from it by a space equal to the distance between two fin rays. The anal fin is considerably lower than the second dorsal, not more than the vertical diameter of the eye in height. The pectoral arises under the beginning of the first dorsal and reaches back to the level of the commencement of the second dorsal. The ventral arises slightly in advance of the pectoral. Its outermost ray is elongate and reaches about half way to the anus.

Colour, uniform grey, with interior of mouth and branchial cavity black.

Measurements of five *Helga* specimens :—

	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)
	cm.	cm.	cm.	cm.	cm.
Total length, ...	24·0	25·2	34.5	38·7	49·5
Length of head, ...	6·4	6·5	9·2	10·6	13·5
Length of snout, ...	2·6	2·8	4·1	4·1	5·4
Diameter of eye, vertical, ...	1·1	1·2	1·5	1·5	2·2
Diameter of eye, horizontal, ...	1·8	1·8	2·5	2·8	3·5
Inter-orbital space (least), ...	1·4	1·4	2·2	2·5	3·2
Width of head, ...	2·9	2·7	4·5	4·8	6·6
Snout to 1st dorsal fin, ...	6·3	6·9	10·0	11·6	14·4
Snout to vent, ...	9·1	9·7	13·5	15·8	20·5
Snout to front of mouth, ...	2·5	2·6	3·6	4·1	5·0

General Distribution.—Well known from the Mediterranean. Taken by the *Travailleur* and *Talisman* off the N.-W. coast of Africa (342–820 fathoms) and off Cape Verde Islands, by the *Caudan* in the Bay of Biscay (780 fathoms), and by the *Michael Sars* off the S.-W. coast of Ireland (504 fathoms) and off Gibraltar (664 fathoms).

Irish Distribution.—Taken by the *Helga*, in twenty-two hauls between 300 and 600 fathoms off the W. and S.-W. coasts of Ireland. Certain range, 346–550 fathoms.

In addition to the above, specimens of *Trachyrhynchus* were taken in seven hauls made below 650 fathoms. Two specimens, put away for future reference, from S. R. 363, 673–720 fathoms, proved on examination to be referable to *Trachyrhynchus Murrayi.* These specimens, along with four others, were erroneously recorded, at the time of capture, as *T. trachyrhynchus*, and it is probable that most, if not all, of the specimens taken below 660 fathoms should be referred to *T. Murrayi.* This view is supported by the fact that there is a distinct gap in the vertical distribution of the genus between 600 fathoms and 700 fathoms, nine hauls of the trawl having been made wholly within those limits, in none of which was *Trachyrhynchus* present. This is well seen in the diagram of vertical distribution given above (p. 94). Particulars of the six hauls below 660 fathoms are given under *T. Murrayi.*

The average number of specimens of the genus *Trachyrhynchus* taken per haul at various depths, estimated as explained above under *M. rupestris*, were :—

Depth.	Specimens per haul.	Number of hauls.
200–300 fms.	0	10
300–400 „	10·5	15
400–500 „	2·0	11
500–600 „	1·5	21
600–700 „	·8	13
700–800 „	5·6	5

Trachyrhynchus Murrayi, Günther.

Trachyrhynchus Murrayi, Günther (1887), Goode and Bean (1895), Collett (1905).

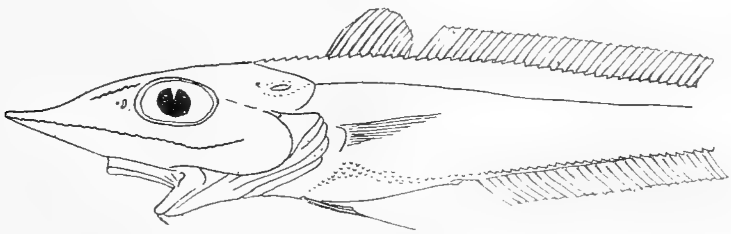


Fig. 11.—*Trachyrhynchus Murrayi.*

Description.—Form of the head and body as in *T. trachyrhynchus.* The head appears to be slightly larger in relation to the body, though the proportions, or measurement, are approximately the same.

Body covered with thin scales, with three or fewer spines near the hinder margin. In the two specimens examined the scales were wanting over almost the whole body; the few which remained had one spine or none, the scales of the lateral line being without spines. A dorsal ridge of thickened scales, saddle-shaped, and with a strong entire median tooth directed backwards, commences at the head, and is continued backwards on either side of the dorsal fin for an uncertain distance. A similar ridge, with more depressed spines, runs along either side of the anal fin, and is represented in front of the anal fin and below the pectorals, by a scattered band of smaller spines, more persistent than the general scaling, and remaining when all the other scales have been rubbed off. The bands on each side meet in front of the ventrals, and enclose a scaleless area in front of the anus.

The head, as to its sides and top, is covered with small, elongate scutes, arranged to form longitudinal ridges, each scute bearing a row of spinules. A well-marked ridge, from the snout to the operculum, separates the upper and lower surfaces of the head, and a much smaller ridge runs above the eye and nostril. The under-surface of the head is covered with very small scutes, not forming ridges, each scute, in specimens of 23–25 cms., with from two to four spinules. Profile of the head somewhat higher above the nostrils than in *T. trachyrhynchus.* The occipital fossa is comparatively well marked, the scales which surround it being joined to form a definite enclosing ridge. Mouth inferior, horseshoe-shaped, reaching back a short distance behind the level of the eye. Barbel very small.

Fin rays: 1st Dorsal, I + 10. Pectoral, 22–23. Ventral, 7.

Only one spinous ray could be seen in the first dorsal, a slender spine, less than half as long as the following ray.

Colour not noted when alive, probably as in *T. trachyrhynchus.*

Measurements of *Helga* specimens :—

	(*a*)	(*b*)
	cm.	cm.
Total length, ...	23·3	25·0
Length of head, ...	6·3	6·8
Length of snout, ...	2·6	2·7
Diameter of eye, vertical, ...	1·2	1·3
Diameter of eye, horizontal, ...	1·8	2·0
Inter-orbital space (least), ...	1·5	1·65
Width of head, ...	3·2	3·4
Snout to 1st dorsal, ...	6·7	7·2
Snout to vent, ...	9·4	9·7
Snout to front of mouth, ...	2·2	2·4

The somewhat brief description of this species given in the *Challenger* reports has been supplemented by Collett in his account of the fishes taken by the *Michael Sars.* The measurements from the *Helga* specimens, taken in conjunction with those which he records, indicate a gradual increase in the size of the eye relative to the length of the head, and a constant length of snout, forty to forty-one per cent. of the total length of head. The other dimensions given, which involve distances between fixed points on the head and body, show a variation of about one-tenth of their length, irrespective of the size of the individuals.

General Distribution.—Previous records of *T. Murrayi* have been from the neighbourhood of the Faeroe Bank (*Michael Sars* and *Knight Errant*) and Iceland (*Ingolf*), with a bottom temperature recorded as 5·5 to 8·07.

Irish Distribution.—Helga.—S.R. 363.—10 viii '06—51° 22′ N., 12° 00′ W., 698–720 fathoms, ooze. Trawl—seven, 16–35 cms.

The present record indicates a considerable extension southwards of its range at an increased depth but similar temperature. Though no bottom temperature was recorded at the time of capture, physical investigations in the neighbourhood indicate that the bottom temperature at 700 fathoms would have been below 7·5°. A reading taken shortly afterwards at 600 fathoms, over a depth of 620 fathoms, gave 7·92°; and a reading taken three months earlier close to the same position at 700 fathoms, over a depth of 720 fathoms, gave 6·84°.

As noted above under *T. trachyrhynchus*, specimens of *Trachyrhynchus*, which should probably be referred to *T. Murrayi*, though recorded at the time as *T. trachyrhynchus*, were taken on the following stations:—

S.R. 335.—12 v '06—51° 15′ N., 12° 17′ W., 673–893 fathoms, ooze. Trawl—seven, 36–42 cms.

S.R. 336.—12 v '06—51° 19′ N., 12° 20′ W., 673–720 fathoms. Temp. at 700 fathoms, 6·84° C. Trawl—eight, 24–35 cms.

S.R. 477.—28 viii '07—51° 15′ N., 11° 47′ W., 707–710 fathoms, ooze. Temp. at 700 fathoms, 7·19. Trawl—three, 22–32 cms.

S.R. 497.—10 ix '07—51° 02′ N., 11° 36′ W., 775–795 fathoms, ooze. Trawl—one, 31 cms.

S R. 499.—11 ix '07—50° 55′ N., 11° 29′ W., 666–778 fathoms. Trawl—eleven, 26–52 cms.

S.R. 593.—6 viii '08—50° 31′ N., 11° 31′ W., 670–770 fathoms, ooze. Temp. at 650 fathoms, 7·75° C. Trawl—two, 27–36 cms.

Lyconus brachycolus, Holt and Byrne.

Lyconus brachycolus, Holt and Byrne (1906, 1908).

(Plate VI.)

Only one specimen, the type, which is now in the British Museum collection, has been taken by the *Helga*, under circumstances which leave it in doubt whether the capture was made in midwater or at the bottom. It was caught in August, 1906, in a Petersen pelagic fish trawl about 90 miles off the S.-W. coast of Ireland, soundings 800 fathoms. The net was used with 800 fathoms of warp, and was estimated to have fished at 700–750 fathoms, but it must, during some part of the haul, have touched the bottom, as it brought up some fragments of mollusca and bottom-living crustacea.

The only other known species of the genus, *L. pinnatus*, was first taken at the surface in the S. Atlantic, and very small specimens (2–4 cms.) have since been captured by the *Valdivia* in vertical nets lowered to 2,000 metres over a depth of about 5,000 metres. These facts seem to indicate that the genus is a pelagic one, which may account for its apparent rarity. The following description and the tables of measurements and comparison with *L. pinnatus*, including the foot-note, are taken without alteration from the paper by Mr. E. W. L. Holt and Mr. L. W. Byrne (1906) in which the original specimen is described, except for the correction of a clerical or printer's error by which the number of rays in the dorsal fin is given as 210 instead of, apparently, 110.[1]

Description.—Head contained about $5\frac{1}{2}$ times in total length without caudal fin, rather compressed, about twice as long as broad, and as deep as its length without the snout. Eye 4 times in head, slightly shorter than the snout, the length of which is subequal to the width of the nearly flat interorbital space. The extremity of the snout is blunt and abrupt, with a median prominence in front of the eyes. From the snout the dorsal profile rises gently to the origin of the dorsal fin, which is opposite the origin of the pectorals and a little in front of the origin of the ventrals; the height of the body at the base of the pectorals is slightly less than double its width at the same point and about $\frac{3}{4}$ the length of the head.

Mouth terminal, jaws subequal, gape slightly oblique, hinder extremity of maxilla behind vertical from eye.

Praemaxilla with 1 (or 2 closely apposed) fang anteriorly, but at some distance from the symphysis, followed by about 15 smaller sharp teeth in a single diminishing series. Mandible with 1 or 2 small teeth near the symphysis, followed by 2 fangs, separated by about 3 smaller sharp teeth, of which the last may be nearly as large as the second fang. The praemaxillary fang smaller than the anterior mandibular fang. Vomer with about 4 teeth on either side.

Pectoral fin with a narrow base and 13 rays, the longest rays extending about halfway to origin of anal, about $\frac{2}{3}$ as long as head; ventral set a little behind pectoral, with 9 rays, the longest about $\frac{2}{3}$ the length of the longest pectoral rays. None of the rays of either fin truly filamentous. Dorsal fin commencing opposite pectoral with about 110 rather long and slender rays, continuous throughout as to fin membrane and spacing of rays, but showing indication of subdivision by inflection of outline (reduction in length of rays) at the tenth ray; the first four rays (broken in type) possibly somewhat produced. Anal fin with rays shorter than the corresponding rays of dorsal. Skin delicate and rather loose; scales rather small, thin, cycloid, present everywhere except on jaws, underside of head, and fins; transverse formula behind pectorals apparently ca. 6/ca. 15. Lateral line indefinite posteriorly.

Coloration in life silvery, after preservation greyish-brown, with the head, vent, and marginal fins darker.

Length of the type 237 mms. (232 without the caudal rays).

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[1] A re-examination of the specimen in the British Museum gave, in three successive counts, 104, 108, and 108 as the number of rays in the dorsal fin. I am indebted to Mr. J. Green, who drew the specimen for reproduction, for calling attention to this error.

The following table gives the measurements of the types of the two species of the genus in millimetres, with the proportions they bear to the lengths of the body and head respectively :—

	L. PINNATUS.*		L. BRACHYCOLUS.	
Length without caudal, ..	120	800 p.c. of head.	232	560 p.c. of head.
„ to origin of dorsal fin,	15	12·5 p.c. of length.	45	19 p.c. of length.
„ „ „ anal fin,	39	32·5 „ „ „	94	40 „ „ „
Height at pectorals, ...	13 (11)*	11 (9) „ „ „	33	14 „ „ „
„ „ anus, ...	8 (7)*	6·6 (6) „ „ „	21·5	9 „ „ „
Breadth at pectorals, ...	4	27 p.c. of head.	18	43 p.c. of head.
„ „ anus, ...	3	20 „ „ „	11	27 „ „ „
Length of head, ...	15	12·5 p.c. of length.	41·5	18 p.c. of length.
„ „ snout, ...	3·5	23 p.c. of head.	12	29 p.c. of head.
„ „ eye, ...	5	33 „ „ „	10·5	25 „ „ „
Inter-orbital width, ...	3	20 „ „ „	13	31 „ „ „
Breadth of head, ...	5	33 „ „ „	13	31 „ „ „
Length of pectorals, ...	27 (16)*	180 (107) p.c. of head.	26	62 „ „ „
„ „ ventrals, ...	8 (3·5)*	53 (23) „ „ „	17	41 „ „ „

These measurements show that *L. brachycolus* may be, at comparable sizes, a stouter fish than *L. pinnatus*, and has certainly a comparatively longer head and abdomen and shorter caudal region. In the former species the head is contained about $5\frac{1}{2}$ and the distance to the origin of the anal fin about $2\frac{1}{2}$ times in the total length, while in the latter the proportions borne by these measurements are 8 and 3 respectively. These differences cannot be wholly accounted for by the difference in size and stage of growth, and are, in fact, in some particulars in a direction contrary to the usual change of developmental proportion.

A further distinction lies in the much longer pectoral fins of *L. pinnatus*; while both specimens are too large to be affected by the great development of

* The type of *L. pinnatus* is not in a particularly good state of preservation, and measurements taken from it must not be regarded as necessarily accurately representing its dimensions when in the flesh; a careful comparison with Günther's figure seems, however, to show that, excepting that the original form was somewhat deeper in the body, and that the pectorals and ventrals (as their present state indicates) have been broken, the distortion is not very great. Where the measurements shown by Günther's figure and by the type differ in any material degree, our table shows both measurements, those taken from the actual specimen being given in brackets.—[E. W. L. H. and L. W. B.]

the pectorals, which is not uncommon in larval Teleosteans, the present imperfect state of the type of *L. pinnatus* makes it impossible for us to make an exact comparison of the two species in this respect, though we have no reason to doubt the accuracy of Günther's figure.

The relatively much larger eye of *L. pinnatus* may be a youthful character only, and the present state of the type of that species makes any comparison of its scale and fin ray formulae with those of *L. brachycolus* impossible.

L. pinnatus has only one canine-like tooth on each side of the vomer; this may be a distinction of importance, because, so far as we know, vomerine teeth tend rather to decrease than to increase in number with age. It has certainly some of the anterior dorsal rays considerably prolonged. In *L. brachycolus* the first four rays are broken, and, though the first ray is slightly stouter than the rest, none of them seem to be stout enough to afford foundation for any considerable prolongation. Moreover, prolongation of the anterior dorsal rays may be a feature of merely sexual importance (cf. *Onus cimbrius*).

The following key should suffice to distinguish the two known species of this genus :—

LYCONUS, Gthr.

1. Head 8, and length to origin of anal fin 3 times in total length (without caudal); pectoral fins longer than (and probably more than half as long again as) head,[1] . *L. pinnatus*, Gthr.

2. Head $5\frac{1}{2}$, and length to origin of anal fin $2\frac{1}{2}$ times in total length (without caudal); pectoral fins about $\frac{2}{3}$ as long as head, . . *L. brachycolus*, H. & By.

Lyconus brachycolus is only known from the type-specimen which was taken by the *Helga* on station S. R. 352, 50° 22′ N., 11° 40′ W.

VIII.—GROWTH MARKS ON SCALES.

An attempt was made to discover whether the scales of the Macrurids showed any markings which would indicate periodic growth. The existence of such markings has been pointed out by Murray and Hjort (1912); but they do not attempt to explain them.

The form of the Macrurid scale is in most cases roughly hexagonal with the posterior and two postero-lateral angles rounded off, the posterior

[1] See foot-note on p. 129.

portion, which is not overlapped by the scale in front, being armed more or less strongly with superficial spines, characteristic of the species. The remaining portion of the scale consists superficially of a thin covering layer bearing numerous parallel, close-set ridges or *striae*, which are sometimes continued on to the exposed portion, and then usually merge into the bases of the spines. These striae are parallel to the dorsal and ventral margins of the scale and converge anteriorly, meeting in the middle line of the scale at a sharper angle than the anterior angle of the scale. The outermost striae thus run out to the anterior margin of the scale. It follows that, as the scale grows, new striae are laid down successively along the dorsal and ventral margins of the scale, while the striae which meet the anterior margin of the scale increase by additions to their length. The deeper portion of the scale is, as is usual, formed of successive layers, showing a fibrous appearance under the microscope, each layer, when the superficial striated layer is scraped off, appearing to have the fibres running in a direction transverse to the preceding one, exactly as in the case of herring scales, as described by Mr. Savage (1919). When examined by polarised light, the method used by Mr. Savage in the case of herring scales, the margin of these layers appear as alternate dark and light *bands* parallel to the margin of the scale.

Under a low magnification, by ordinary light, there can often be seen faint concentric markings, or lines, which will be referred to as *rings*, at various distances parallel to the edge of the scale. These seem to be superficial, and to be due to the closing in, bending, or interruption of the striae, which cross them at a low angle, accompanied sometimes by a faint groove or scar-like marking. They would appear to be homologous, as far as their outward appearance is considered, to the annual rings on herring scales, which are believed to mark the end of a year's growth. The position of these rings, and their relation to the dark and light bands, were investigated in the available species of Macrurids, with the results given below. In tabulating these results, the convention adopted by Dr. Lea and others, when dealing with herring scales, has been followed, the position of the successive rings being indicated by the proportion which their distance from the centre of the scale bears to the radius of the scale, the latter measurement being expressed by a figure corresponding to the total length of the fish in millimetres, which is shown as the concluding figure of the series. Well-marked rings are indicated by a vertical line; doubtful rings by a colon.

The total length of the fish, in cases where the tail has been injured, has been deduced from the length of the head, the proportion of head to length adopted for the purpose being, for *Coryphaenoides rupestris*, 17·2 : 100

Coelorhynchus coelorhynchus, 21 : 100; *Coelorhynchus labiatus*, 24·5 : 100; *Lionurus aequalis*, 13·4 : 100; the proportions being taken from apparently uninjured specimens.

The total numbers of light bands, and the numbers corresponding to the spaces between the rings, are also given. The central bands cannot always be accurately counted, but their numbers have been estimated, the estimated figures being given separately from those definitely counted, e.g. ca. 3 + 14 represents three doubtful and fourteen counted bands. The exact relation between the bands and rings is often difficult to see, and the number of bands to the spaces between the rings may easily be over- or under-estimated by one band.

Coryphaenoides rupestris (Pl. VII, fig. 1).

Three specimens showed rings on their scales arranged as follows (averages taken from 3 or 4 scales):—

Length in cm.		No. of bands.	Bands to spaces.
(*a*) 50·5 ...	198 | 333 | 385 | 439 | 472 | 492 | 505	ca. 6 + 18	8 | 6 | 3 | 2 | 2 | 2 | 1
(*b*) 31·3 ...	75 | 128 | 195 | 239 | 310	12	
(*c*) 29·0 ...	77 | 125 | 150 | 290	8	

b and *c* have for their size more rings than *a*. Possibly the inner rings have been lost or obscured in the largest specimen.

Coryphaenoides Murrayi (Pl. VII, fig. 3).

Only one specimen, length 51·0 cms., had retained a few scales. These showed two faint rings on the outer part of the scale, with the average arrangement of 318 | 436 | 510. Nineteen or twenty bands were present, of which six corresponded to the space between the inner ring and the margin, the inner ring coinciding with a slight broadening of the bands.

Coelorhynchus coelorhynchus (Pl. VII, fig. 2).

This species does not show the rings as clearly as *C. labiatus*, though occasionally well-marked specimens were met with:—

Length in cm.		No. of bands.	Bands to spaces.
(*a*) 39·8 ...	122 | 255 | 306 | 337 | 357 : 368 | 383 | 398	ca. 6 + 19	.... 2 | 2 | 1
(*b*) 40·8 ..	227 | 309 | 317 : 343 | 368 | 384 | 396 : 408	ca. 5 + 19	11 | 4 | 2 | 2 | ...... | 1
(*c*) 37·5 ...	203 : 282 | 322 | 357 | 375	ca. 2 + 20	17 | 2 | 2 | 1
(*d*) 30·0 ...	203 | 256 | 300	ca. 5 + 12	10 | 4 | 3
(*e*) 30·2 ...	239 | 302	ca. 4 + 15	16 | 3
(*f*) 30·0 ...	225 | 300	ca. 3 + 12	
(*g*) 27·6 ...	125 | 201 | 276	ca. 4 + 11	7 | 4 | 4
(*h*) 28·4 ...	246 | 284	ca. 2 + 8	10 | 2

The averages for *c* are taken from scales which gave the following individual results :—

3 scales above l.l.	...	212 |	284 |	326 |	354 |	375
			275 |	321 |	355 |	375
			288 |	324 |	360 |	375
2 scales from l.l.	...		284 |	320 |	356 |	375
		207 :	275 |	315 |	355 |	375
5 scales below l.l.	...	188 :	272 |	319 |	356 |	375
			294 |	322 |	362 |	375
		206 :	288 |	330 |	365 |	375
			268 |	315 |	355 |	375
			290 |	329 |	355 |	375

There are indications here of an innermost ring which is only represented on a few scales.

The scales of *d* are difficult to read. Thirteen scales from the body gave the following results :—

6 scales above l.l.	...				256 |	300
				204 :	252 |	300
			147 |	200 :	260 |	300
			138 |	228 |	300	
			171 |	212 :	266 |	300
			182 |	237 |	300	
2 scales on l.l	...				255 |	300
				210 |	250 |	300
5 scales below l.l.	...	198 | ?	outer markings illegible.			
		196 | ?				
		200 | ?				
		225 | ?				
		223 | ?				

The lines here are confusing, but there seems to be evidence for a ring at 203 and another at 256, with possibly a third ring inside them.

Coelorhynchus labiatus (Pl. VII, fig. 6).

In the largest specimen examined, length $46 + x$ cms. = 49 cms., thirteen out of fourteen scales taken at random from the body were regenerated and gave no results, both bands and striae being absent from the central part of the scale; the outer part where the striae were regular showed also regular banding and a few ill-defined rings. A perfect scale showed rings distant from the centre in the proportion 136 | 236 | 295 | 342 | 384 | 413 | 442 | 460 | 490, and another scale on which the outer rings were not clearly marked had inner rings at distances of 135 | 280 | 316 | . . . . 490. The light bands were seventeen, clearly marked, with obscure central bands estimated as five. On the outer part of the scale the spaces between the rings corresponded to one or two bands; in the inner part their relations could not be made out.

Smaller specimens of *C. labiatus* gave clearer results, which can be best given in tabular form, the positions of the rings being taken from two or more well-marked scales:—

Length in cms.		Rings	No. of bands.	
(*a*) 39	...	192 | 290 | 328 | 354 | 373 | 390	ca. 3 + 14	8 | 4 | 2 | 1 | 1 | 1
(*b*) 37·7	...	159 | 239 | 308 | 351 | 377	ca. 3 + 14	7 | 4 | 3 | 2 | 1
(*c*) 28·1	...	172 | 241 | 281	ca. 4 + 9	8 | 3 | 2
(*d*) 26·6	...	185 | 266	obscure	
(*e*) 26·6	...	170 | 218 | 266		
(*f*) 25·8	...	160 | 258	ca. 5 + 8	9 | 4
(*g*) 25·5	...	188 | 229 | 255	ca. 2 + 11	6 | 4 | 3
(*h*) 25·0	...	152 | 229 | 250	ca. 5 + 8	8 | 4 | 1
(*i*) 23·8	...	180 | 203 | 238	ca. 4 + 10	9 | 3 | 2
(*k*) 23·8	...	172 | 205 | 238	obscure	
(*l*) 22·1	...	192 | 221	ca. 3 + 7	9 | 1
(*m*) 21·8	...	191 | 218	ca. 3 + 8	9 | 2
(*n*) 19·7	...	165 | 197	8	7 | 1

Lionurus aequalis (Pl. VII, fig. 5).

The rings in this species are very faintly marked. In some specimens there was no sign of rings on any of the scales examined, and in others the rings could only be traced in a very small proportion of scales.

The following examples may be quoted:—

Length in cms.		Rings	No. of bands.	
(*a*) 32·2	...	169 | 240 | 287 | 322	ca. 2 + 13	6 | 4 | 3 | 2
(*b*) 31·5	...	194 | 231 | 282 | 315	ca. 4 + 12	obscure
(*c*) 31·5	...	210 | 267 | 315 (one scale only)	ca. 3 + 12	11 | 2 | 2
(*d*) 24·0	...	197 | 240	ca. 4 + 8	10 | 2

These figures give an appearance of uniformity, but it is only by rejection of a good many scales which gave doubtful readings that they have been arrived at. One specimen in addition to the above gave the following results from a number of scales taken from between the first dorsal and the vent.

3 scales above l.l.	...	187 | 206 | 238
		187 | 210 | 238
2 scales from l.l.	...	146 | 200 | 238
		138 | 198 | 238
5 scales below l.l.	...	197 | 238
		201 | 238
		197 | 238
		207 | 238
		142 | 176 | 194 | 238

This arrangement could be accounted for by supposing that growth periods were indicated at 142 and 201 mms. with an occasional intercalated ring at 183 mms.

Trachyrhynchus trachyrhynchus (Pl. VII, figs. 4, 8).

On the thickened, oval, massive scales from the body of large specimens the rings cannot be made out; but on the more circular and thinner scales from the tail region they are usually visible. Small specimens up to about 30 cms. show rings on the body scales. By polarised light the thickened scales show the bands very indistinctly, as the latter coalesce into broad light and dark patches, which obscure the normal banding.

A specimen of 49·5 cms. showed irregular rings, at distances of 297 | *x* | *x* | *x* | *x* | 495, on scales from the tail region, corresponding to ca. 3 + 18 bands, the spaces between the rings corresponding approximately to 8 | 2 | 2 | 2 | 2 | 2 bands. Only six bands, and no rings, can be made out on the thickened body-scales.

A specimen of 39 cms. showed rings at relative distances of 167 | 267 | 313 | 357 | 390 on scales from the tail region, with bands ca. 2 + 11, the correspondence to spaces between rings being 6 | 3 | 2 | 1 | 1.

A specimen of 34·5 cms. had rings at 192 | 243 | 325 | 345 and bands ca. 2 + 10 corresponding to spaces 7 | 2 | 2 | 1.

In a specimen of 25·2 cms. no rings were visible. There were seven light bands, of which the three outermost were broad and widely separated.

A specimen of 24·0 cms. had one ring dividing the radius in the proportion 150 | 240, the outer division corresponding to two light bands. Total of bands, four, with a light centre, which may represent one or two bands.

Other specimens, of which no scale measurements were made, showed, for a fish of 24 cms. one ring, 25 cms. no rings, 36 cms. two rings, and 38·5 cms. three rings.

For comparison with the Macrurids, the scales of some other deep-water fish from the west coast of Ireland were examined.

Argentina silus, with a range from 105 to 337 fathoms off the west of Ireland, has large scales, in which the striae are approximately parallel to the margin throughout their course. In a specimen of 32·5 cms. there were well-marked growth-rings, chiefly recognisable by the striae being crowded together, but also by definite scar-like markings in the same region. The proportionate distances of these rings from the centre were *x* | 164 | 213 | 262 | 284 | 299 | 314 | 325. By polarised light the whole scale is light, with darker shading corresponding to the superficial rings, and apparently, caused by them; but there is no definite division into dark and light zones as in the Macrurids. The appearance of the scale by ordinary light is not unlike that of a salmon or trout, in which the year-rings are indicated by the approximation of the striae. By polarised light the resemblance also holds good, as in salmon and trout the banded dark and light zones were not visible in any which I examined. This fish cannot be called a true deep-water species, and the occurrence of year-rings, as these apparently are, is not surprising.

Haloporphyrus eques, 330–707 fathoms, has comparatively large, oblong scales, closely covered with fine striae which converge slightly towards the anterior end of the scale. With oblique transmitted light faint rings are visible, due in part to a slight bending of the striae where they cross the ring. From two to four rings could be made out on different scales of a specimen of 29 cms. In the outer part of the scale the spaces between the rings correspond to two light bands, with sometimes an additional incomplete band showing at the anterior end of the scale.

In *Phycis blennioides*, 160–627 fathoms, the light bands are conspicuous by polarised light, but no ringed markings could be made out. Examination of a small number of scales from *Rhombus Boscii*, *Solea profundicola*, and *Scorpaena dactyloptera* revealed no signs of periodic or interrupted growth.

Through the kindness of Dr. Scharff I had an opportunity of examining, in this connexion, the scales of three species of fish from Jamaican waters in the collections of the Dublin Museum, labelled *Chaetodon striatus*, *Platyglossus internasalis*, and *Mesoprion chrysurus*, the last two names being synonyms, according to Jordan and Evermann, of *Irido cyanocephalus* and *Oxyurus chrysurus*.

In *Mesoprion*, on four out of seven scales there was an indication of a single growth-ring running round part of the scale, parallel to the margin. It was accompanied by a slight unconformity in the arrangement of the striae, which are parallel to the scale margin, where they run out on to the exposed portion of the scale, and also seemed to be a starting-place for some of the radial grooves with which the anterior part of the scale is well provided. The striae in this species are parallel to the covered margin of the scale and are finely denticulated on their inner side.

In *Chaetodon striatus*, which has scales of an almost exactly similar type, no sign of growth-rings was observed.

Platyglossus internasalis, with very large scales, has two systems of radial grooves, one, as in *Chaetodon* and *Mesoprion*, running forwards to the anterior margin, the other backwards to the exposed portion. The striae on the unexposed portion are of the concentric type and finely denticulated. There was no sign of growth rings on the scales.

From these few examples nothing more can be inferred than that the occurrence of growth-rings is not universal amongst tropical fishes. It cannot be said definitely that the markings on *Mesoprion* scales are true growth rings.

A detailed examination of the scales of some species of *Bathygadus* (*Gadomus*) has been made by Gilbert and Hubbs (1920), and they reach the conclusion that, in the shallow-water forms (ca. 200–300 fathoms), rings which probably represent annual periods of growth are clearly present, but that these markings are very obscure or entirely absent in species inhabiting great depths. These rings in the species examined were due to (*a*) a crowding together of the striae (circuli), a form of ring not found in any of the Macrurids which I have examined, or (*b*) a sudden bending of the striae along a line parallel to the margin of the scale—a type of marking which corresponds very nearly to that described above.

The observations on the Macrurid scales show us:—

1. That very few scales show rings clearly marked all round.

2. On the same scale the same ring gives slightly different proportional measurements along different radii of the scale, sometimes being nearer proportionately to the lateral margin, but more often to the anterior.

3. In the same fish different scales give different numbers of rings at different proportional distances from the centre; but usually a majority of the scales will be found to agree in the relative positions of one or more rings.

In the case of the herring, in which the theory of annual rings has been most fully studied, it is found that:—

1. Almost all the scales show rings clearly marked all round.

2. On the same scale the rings are proportionately the same distance from the centre on every radius.

3. On the same fish almost all the scales have the same number of rings at the same or slightly different distances from the centre, with the following exceptions (Paget, 1920):—

(*a*) Individual fish may sometimes be found with a secondary or false ring intercalated between two annual rings.

(*b*) On the same fish individual scales may sometimes show a ring which is not represented on the other scales of the fish.

These two exceptions are not so frequent as to put any serious difficulty in the way of determining a fish's age and rate of growth from its scales, at any rate in its earlier years.

In the case of the Macrurids here considered, the most reasonable explanation of the condition observed seems to be that rings are formed at periodic intervals on the scales, but that the two exceptions *a* and *b* have become so frequent that, assuming that the growth periods represent years, it is not possible to assign a definite age to any particular fish. Theoretically, if this were the full explanation, the scales showing the minimum number of rings ought to give the maximum age which can be assigned to the fish; but there appears to be a further complication in that all the normal growth periods are not represented on every scale. This is evident from the fact that unregenerated scales may be found showing no signs of growth-rings. Although the conditions of temperature and light and, probably, food supply are, even at about 500 fathoms, not subject to any significant annual variations, it is not incredible that annual periods of growth should exist without an external stimulus, owing to some inherited habit either of migration from greater to lesser depths, or of feeding, or even to some inherited physiological rhythm.

IX.—LIST OF CAPTURES.

Station.	Date.	Position.	Depth in fms.	Bottom.	Temp. at	Gear	Species captured.
Helga, cxxi	24/viii/'01	53° 54′ N., 11° 50′ W.	199	Fine sand	—	Trawl	*C. coelorhynchus*, one, 33 cm. *M. laevis*, four, 27–49 cm.
S. R. 44	17/viii/'03	53° 34′ N., 11° 29′ W.	116	Fine sand	116 fms. 10·15° C.	„	*M. laevis*, three.
S. R. 97 *b*	3/v/'04	50° 31′ N., 10° 55′ W.	181	Fine sand	—	„	*C. coelorhynchus*, three, 23–25 cm. *M. laevis*, two, 28–36 cm.
S. R. 107	9/v/'04	53° 37′ N., 11° 33′ W.	121	Fine sand	116 fms. 9·3° C.	„	*M. laevis*, eight, 26–39 cm.
S. R. 171	5/xi/'04	52° 07′ N., 11° 58′ W.	337	—	—	„	*C. coelorhynchus*, 'wenty-six, 26–38 cm. *T. trachyrhynchus*, thirty-three, 25–53 cm.
S. R. 188	3/ii/'05	51° 53′ N., 11° 59′ W.	320–372	Mud	300 fms. 10·12° C.	„	*C. coelorhynchus*, twenty-one, 26–39 cm. *L. aequalis*, thirty-five, 11–35 cm. *T. trachyrhynchus*, thirty-six, 11–55 cm.
S. R. 212	6/v/'05	51° 54′ N., 11° 57′ W.	411	Fine muddy sand	350 fms. 9·82° C.	„	*C. coelorhynchus*, seven, 25–38 cm. *L. aequalis*, seventeen, 23–35 cm. *T. trachyrhynchus*, eleven, 35–52 cm.
S. R. 217	9/v/'05	52° 44′ N., 12° 30′ W.	208	Fine sand	200 fms. 10·0° C.	„	*C. coelorhynchus*, four, 11–25 cm. *M. laevis*, four, 35–44 cm.
S. R. 220	11/v/'05	53° 39′ N., 12° 24′ W.	185	Fine sand and shells	—	„	*C. coelorhynchus*, one, 25 cm. *M. laevis*, four, 43–48 cm.
S. R. 222	12/v/'05	53° 01′ N., 14° 34′ W.	293	Fine sand	—	„	*C. coelorhynchus*, eighty-six, 22–38 cm. *M. laevis*, two, 42–51 cm.

IX.—List of Captures—*continued.*

Station.	Date.	Position.	Depth in fms.	Bottom.	Temp. at	Gear.	Species captured.
S. R. 227	14/v/'05	53° 20′ N., 13° 00′ W.	164	Fine sand	—	Trawl	*C. coelorhynchus*, three, 21–25 cm. *M. laevis.* three, 38–40 cm.
S. R. 321	1/v/'06	50° 59′ N., 11° 17′ W.	208–480	Fine sand	—	”	*C. coelorhynchus*, seven, 22–35 cm. *T. trachyrhynchus*, one, 51 cm.
S. R. 327	8/v/'06	51° 41′ N., 12° 16′ 30″ W.	550–800	Ooze	—	”	*C. rupestris*, nineteen, 27–85 cm. *L. aequalis*, thirteen, 20–29 cm. *T. trachyrhynchus*, seven, 21–36 cm.
S. R. 329	9/v/'06	51° 21′ 30″ N., 11° 35′ W.	215–415	—	400 fms: 9·55° C.	”	*C. coelorhynchus*, forty-six, 20–40 cm. *L. aequalis*, seven, 21–34 cm. *M. laevis*, three, 47–52 cm.
S. R. 331	9/v/'06	51° 12′ N., 11° 55′ W.	610–680	Ooze	—	”	*C. rupestris*, ten, 29–85 cm. *C. coelorhynchus*, one, 34 cm. *C. labiatus*, one, 30 cm. *L. aequalis*, ten, 18–30 cm.
S. R. 333	10/v/'06	51° 37′ N., 12° 09′ W.	557–579	Ooze	500 fms. 9·2° C.	”	*C. rupestris*, one, 57 cm. *C. labiatus*, one, 17 cm. *L. aequalis*, four, 16–26 cm.
S. R. 334	10/v/'06	51° 35′ 30″ N., 12° 26′ W.	500–520	Ooze	—	”	*C. rupestris*, three, 48–52 cm. *C. labiatus*, one, 26 cm.
S. R. 335	12/v/'06	51° 15′ N., 12° 17′ W.	673–892	Ooze	—	”	*C. rupestris*, twelve, 41–76 cm. *C. Guntheri*, one, 13 cm. *C. labiatus*, eleven, 19–32 cm. *Trachyrhynchus* sp., seven, 36–42 cm.
S. R. 336	12/v/'06	51° 19′ N., 12° 21′ W.	673–720	Ooze	—	”	*C. rupestris*, four, 44–60 cm. *C. Murrayi*, one, 48 cm. *Trachyrhynchus* sp., eight, 24–35 cm.
S. R. 338	13/v/'06	51° 28′ 30″ N., 11° 29′ W.	291–330	Mud	—	”	*C. coelorhynchus*, six, 32–36 cm. *M. laevis*, one, 47 cm.
S. R. 339	13/v/'06	51° 34′ N., 11° 41′ W.	344	—	—	”	*C. coelorhynchus*, three, 36–39 cm.
S. R. 351	5/viii/'06	50° 19′ 30″ N., 11° 06′ W.	230–	Fine sand	245 fms.	”	*C. coelorhynchus*, sixteen, 13–31 cm.

S. R. 353	... ...	6/viii/'06	50° 38′ N., 11° 32′ W.	250–542	Muddy sand	500 fms. 8·58° C.	„	*C. rupestris*, three, 35–66 cm. *C. coelorhynchus*, four, 23–37 cm. *L. aequalis*, twenty-one, 17–32 cm. *M. laevis*, one, 47 cm. *T. trachyrhynchus*, two, 44–50 cm.
S. R. 359	... ...	8/viii/'06	52° 00′ N., 12° 06′ W.	465–492	Ooze	—	„	*L. aequalis*, seventeen, 20–32 cm. *T. trachyrhynchus*, two, 42, 43 cm.
S. R. 361	... ...	8/viii/'06	51° 49′ 30″ N., 11° 42′ W.	177–213	Fine sand	—	„	*M. laevis*, seven, 38–52 cm.
S. R. 363	... ...	10/viii/'06	51° 22′ N., 12° 00′ W.	695–720	Ooze	—	„	*C. rupestris*, four, 36–64 cm. *C. labiatus*, fourteen, 13–29 cm. *Trachyrhynchus Murrayi*, seven, 16–35 cm.
S. R. 365	... ...	10/viii/'06	51° 25′ N., 11° 32′ W.	385–440	Sand and stones	380 fms. 9·44° C.	„	*L. aequalis*, four, 23–28 cm.
S. R. 367	... ...	11/viii/'06	51° 38′ N., 11° 37′ W.	287–332	Fine muddy sand	—	„	*C. coelorhynchus*, one, 36 cm.
S. R. 368	... ...	11/viii/'06	51° 39′ N., 12° 00′ W.	450–608	Fine sand	—	„	*L. aequalis*, twenty-six, 21–30 cm.
S. R. 380	... ...	1/xi/'06	50° 30′ 30″, 11° 00′ W.	142–214	Fine sand	—	„	*C. coelorhynchus*, one, 20 cm. *M. laevis*, ten, 30–37 cm.
S. R. 384	... ...	6/xi/'06	51° 54′ 30″, 11° 37′ W.	162–218	Fine sand	—	„	*C. coelorhynchus*, five, 15–25 cm. *M. laevis*, fifteen, 24–45 cm.
S. R. 387	... ...	7/xi/'06	51° 47′ N., 12° 12′ W.	530–535	Ooze	500 fms. 9·13° C.	„	*C. rupestris*, two, 59, 64 cm. *C. labiatus*, one, 34 cm. *L. aequalis*, six, 24–33 cm. *T. trachyrhynchus*, three, 26–37 cm.
S. R. 397	... ...	2/ii/'07	51° 46′ N., 12° 05′ W.	549–646	—	500 fms. 8·71° C.	„	*C. rupestris*, forty-three, 14–74 cm. *C. labiatus*, three, 16–34 cm. *L. aequalis*, sixty-nine, 14–32 cm. *B. melanobranchus*, one, 29 cm.
S. R. 398	... ...	2/ii/'07	51° 45′ N., 12° 2′ 30″ W.	547–549	—	—	„	*C. rupestris*, two, 18–33 cm.
S. R. 400	... ...	5/ii/'07	51° 18′ N., 11° 50′ W.	525–600	Mud and ooze	580 fms. 8·35° C.	„	*C. rupestris*, nine, 22–88 cm. *L. aequalis*, fifty-two, 17–33 cm. *T. trachyrhynchus*, three, 23–30 cm.
S. R. 401	... ...	5/ii/'07	51° 14′ N., 11° 51′ W.	600–660	—	—	„	*C. labiatus*, one, 25 cm. *L. aequalis*, two, 26, 31 cm.

IX.—List of Captures—*continued.*

Station.	Date.	Position.	Depth in fms.	Bottom.	Temp. at	Gear.	Species captured.
S. R. 440	16/v/'07	51° 45′ N., 11° 49′ W.	350–389	—	300 fms. 9·93° C.	Trawl	*C. coelorhynchus*, twenty-one, 29–41 cm. *L. aequalis*, twenty-two, 24–32 cm. *M. laevis*, one, 51 cm. *T. trachyrhynchus*, twenty-three, 39–51 cm.
S. R. 442	16/v/'07	51° 34′ N., 11° 47′ 30″ W.	465–508	—	—	" (not fishing)	*L. aequalis*, one, 14 cm.
S. R. 447	18/v/'07	50° 20′ N., 10° 57′ W.	221–343	Fine sand	300 fms. 9·87° C.	Trawl	*C. coelorhynchus*, fourteen, 11–37 cm. *M. laevis*, two, 28, 41 cm. *T. trachyrhynchus*, seven, 40–52 cm.
S. R. 448	18/v/'07	50° 21′ N., 11° 00′ W.	343–346	—	—	"	*C. coelorhynchus*, fourteen, 26–38 cm. *L. aequalis*, twenty-one, 18–36 cm. *T. trachyrhynchus*, nine, 27–54 cm.
S. R. 477	28/viii/'07	51° 15′ N., 11° 47′ W.	707–710	Ooze	700 fms. 7·19° C.	"	*C. rupestris*, two, 74, 88 cm. *C. labiatus*, nineteen, 12–30 cm. *L. aequalis*, twenty-six, 19–31 cm. *Trachyrhynchus* sp., three, 22–32 cm.
S. R. 479	28/viii/'07	51° 20′ N., 11° 41′ W.	468–560	—	—	"	*C. labiatus*, one, 12 cm. *L. aequalis*, three, 25–30 cm.
S. R. 483	30/viii/'07	51° 37′ N., 11° 56′ W.	610–664	Muddy sand and stones	550 fms. 8·34° C.	"	*C. rupestris*, eight, 27–78 cm. *C. labiatus*, thirty-seven, 12–38 cm. *L. aequalis*, nine, 19–27 cm.
S. R. 484	30/viii/'07	51° 35′ N., 11° 57′ W.	602–610	—	—	"	*M. labiatus*, one, 19 cm. *L. aequalis*, seven, 24–29 cm.
S. R. 487	3/ix/'07	51° 36′ N., 11° 57′ W.	540–660	—	500 fms. 8·65° C.	"	*C. labiatus*, three, 14–35 cm. *L. aequalis*, forty-five, 18–30 cm.
S. R. 489	7/ix/'07	51° 35′ N., 11° 55′ W.	720	—	—	"	*C. labiatus*, five, 15–31 cm. *L. aequalis*, thirty, 19–30 cm.
S. R. 490	7/ix/'07	51° 57′ 30″ N., 12° 07′ W.	470–491	Ooze	480 fms. 8·68° C.	"	*L. aequalis*, sixteen, 23–32 cm. *T. trachyrhynchus*, two, 36, 45 cm.

S. R. 491	...	...	7/ix/'07	51° 57′ 30″ N., 12° 13′ W.	491–520	Ooze	500 fms. 8·53° C.	„	*C. rupestris*, three, [illegible] cm. *L. aequalis*, fifty-four, 18–32 cm. *T. trachyrhynchus*, four, 30–39 cm.
S. R. 493	...	...	8/ix/'07	51° 58′ N., 12° 25′ W.	533–570	Ooze	—	„	*C. rupestris*, ten, 27–74 cm. *L. aequalis*, sixty-two, 17–30 cm. *T. trachyrhynchus*, three, 34–37 cm.
S. R. 494	...	...	8/ix/'07	51° 59′ N., 12° 32′ W.	550–570	—	—	„	*C. rupestris*, sixteen, 22–91 cm. *C. labiatus*, one, 47 cm. *L. aequalis*, fifty, 17–30 cm. *T. trachyrhynchus*, nine, 28–34 cm.
S. R. 495	...	...	18/ix/'07	52° 00′ N., 13° 10′ W.	364–400	Ooze	—	„	*C. coelorhynchus*, one, 38 cm. *L. aequalis*, thirty-one, 20–30 cm. *T. trachyrhynchus*, thirty-six, 35–53 cm.
S. R. 496	...	...	8/ix/'07	51° 54′ N., 12° 54′ W.	473–500			„	*L. aequalis*, eight, 22–27 cm.
S. R. 497	...	...	10/ix/'07	51° 02′ N., 11° 36′ W.	775–795	Ooze	—	„	*C. rupestris*, three, 37–56 cm. *C. Murrayi*, one, 44 cm. *C. labiatus*, one, 25 cm. *Trachyrhynchus* sp., one, 31 cm.
S. R. 499	...	...	11/ix/'07	50° 55′ N., 11° 29′ W.	666–778	Ooze	600 fms. 8·22° C.	„	*C. rupestris*, four, 24–56 cm. *C. labiatus*, nine, 12–27 cm. *L. aequalis*, three, 25–28 cm. *Trachyrhynchus* sp., eleven, 26–52.
S. R. 500	...	...	11/ix/'07	50° 22′ N., 11° 26′ W.	625–666	—	—	„	*L. aequalis*, two, 27, 28 cm.
S. R. 501	...	...	11/ix/'07	50° 49′ N., 11° 22′ W.	447–625	—	—	Prawn trawl	*L. aequalis*, two, 25, 27 cm.
S. R. 502	...	...	11/ix/'07	50° 46′ N., 11° 21′ W.	447–515	Ooze	500 fms. 8·8° C.	Trawl „	*C. rupestris*, one, 58 cm. *L. aequalis*, twelve, 25–32 cm. *T. trachyrhynchus*, one, 27 cm.
S. R. 504	...	...	12/ix/'07	50° 42′ N., 11° 18′ W.	627–728	Coral	—	„	*C. rupestris*, two, 79–80 cm. *C. coelorhynchus*, one, 28 cm. *L. aequalis*, thirteen, 23–34 cm.

IX.—List of Captures—*continued.*

Station.	Date.	Position.	Depth in fms.	Bottom.	Temp. at	Gear.	Species captured.
S. R. 505	12/ix/'07	50° 39′ N., 11° 14′ W.	464–627	—	—	Trawl	*C. rupestris*, two, 58–66 cm. *C. coelorhynchus*, seven, 33–41 cm. *L. aequalis*, forty-two, 20–35 cm. *T. trachyrhynchus*, two, 39, 43 cm.
S. R. 506	12/ix/'07	50° 34′ N., 11° 19′ W.	661–672		600 fms. 8·22° C.	"	*C. rupestris*, five, 21–71 cm. *C. labiatus*, two, 16–26 cm. *L. aequalis*, seven, 24–28 cm.
S. R. 590	3/viii/'08	51° 50′ N., 12° 08′ W.	480–493	Ooze	—	Eel trawl	*L. aequalis*, seven, 26–33 cm. *T. trachyrhynchus*, two, 36 cm.
				—	—	Trawl	*C. rupestris*, one, 77 cm. *L. aequalis*, fifty-six, 20–32 cm. *T. trachyrhynchus*, eight, 33–47 cm.
S. R. 592	6/viii/'08	50° 39′ N., 11° 25′ W.	400–510	Ooze	—	"	*C. rupestris*, five, 33–82 cm. *L. aequalis*, twenty, 12–33 cm. *T. trachyrhynchus*, three, 29–39 cm.
S. R. 593	6/viii/'08	50° 31′ N., 11° 31′ W.	670–770	Ooze	650 fms. 7·75° C.	"	*C. rupestris*, five, 50–71 cm. *C. Murrayi*, one, 7·7 cm. *C. labiatus*, nineteen, 12–36 mm. *Trachyrhynchus* sp., two, 27–36 cm.
S. R. 746	14/v/'09	51° 32′ N., 12° 13′ W.	620–658	Ooze	—	"	*C. rupestris*, one, 24 cm. *C. labiatus*, six, 18–36 cm. *L. aequalis*, seven, 22–29 cm.
S. R. 752	16/v/'09	51° 51′ N., 12° 13′ W.	523	Ooze	500 fms. 8·9° C.	Young-fish trawl	*C. labiatus*, one, 14 cm.
S. R. 753	17/v/'09	51° 24′ N., 11° 59′ 30″ W.	561–572	Ooze	550 fms. 8·79° C.	Trawl	*C. labiatus*, eight, 11–34 cm. *L. aequalis*, five, 26–29 cm.
S. R. 754	17/v/'09	51° 26′ N., 11° 57′ 30″ W.	544–572	Ooze	—	"	*L. aequalis*, three, 23–27 cm.
S. R. 805	14/viii/'09	51° 50′ 30″ N., 12° 14′ W.	539–544	Ooze	—	"	*T. trachyrhynchus*, one, 34 cm.

			641	stones & coral	7·12° C.	(net torn)	
S. R. 1174	19/v/'11	51° 41′ N., 11° 59′ W.	532	—	—	Trawl	*C. coelorhynchus*, four, 25–34 cm.
S. R. 1178	22/v/'11	51° 20′ N., 11° 30′ W.	212–229	Sand	—	„	*M. laevis*, eleven, 20–41 cm.
S. R. 1242	14/viii/'11	51° 27′ N., 11° 55′ W.	550–590	—	—	„	*C. labiatus*, five, 11–34 cm. *L. aequalis*, twenty-three, 16–32 cm.
S. R. 1243	14/viii/'11	51° 37′ N., 12° 01′ W.	670–692	—	—	„	*L. aequalis*, one, 30 cm.
S. R. 1244	15/viii/'11	51° 40′ N., 12° 02′ W.	556–670	—	—	„ (not fishing)	*L. aequalis*, two, 23, 28 cm.
S. R. 1454	24/viii/'12	51° 32′ N., 11° 56′ W.	493–509	Fine sand and gravel	—	Trawl	*C. rupestris*, one, 65 cm. *L. aequalis*, twenty-one, 21–33 cm.
S. R. 1690	19/viii/'13	51° 33′ N., 11° 51′ W.	584	Ooze	—	„	*L. aequalis*, four, 28–31 cm.
S. R. 1691	19/viii/'13	51° 34′ N., 11° 50′ W.	524–539	Ooze	—	„	*C. rupestris*, one, 99 cm. *L. aequalis*, four, 30–32 cm.
S. R. 1839	19/v/'14	51° 15′ N., 11° 26′ 30″ W.	211–354	Fine muddy sand	—	„	*C. coelorhynchus*, twelve, 26–37 cm. *M. laevis*, nineteen, 32–50 cm.
S. R. 1840	19/v/'14	51° 12′ N., 11° 29′ 30″ W.	354–436	—	—	„	*M. laevis*, one, 38 cm.
S. R. 1841	19/v/'14	51° 10′ N., 11° 32′ 30″ W.	325–439	Coarse sand and sandy ooze	—	„	*C. coelorhynchus*, one, 35 cm.
S. R. 1842	19/v/'14	51° 07′ N., 11° 35′ 30″ W.	325–410	Muddy sand	—	„	*C. coelorhynchus*, eight, 26–40 cm. *L. aequalis*, three, 30–32 cm. *M. laevis*, three, 45–52 cm.
S. R. 1843	21/v/'14	51° 06′ N., 11° 28′ W.	240–249	Fine sand	—	„	*C. coelorhynchus*, one, 22 cm.
S. R. 1844	21/v/'14	51° 01′ N., 11° 33′ 30″ W.	417–565	Muddy sand and ooze	—	„	*C. rupestris*, two, 13, 48 cm.

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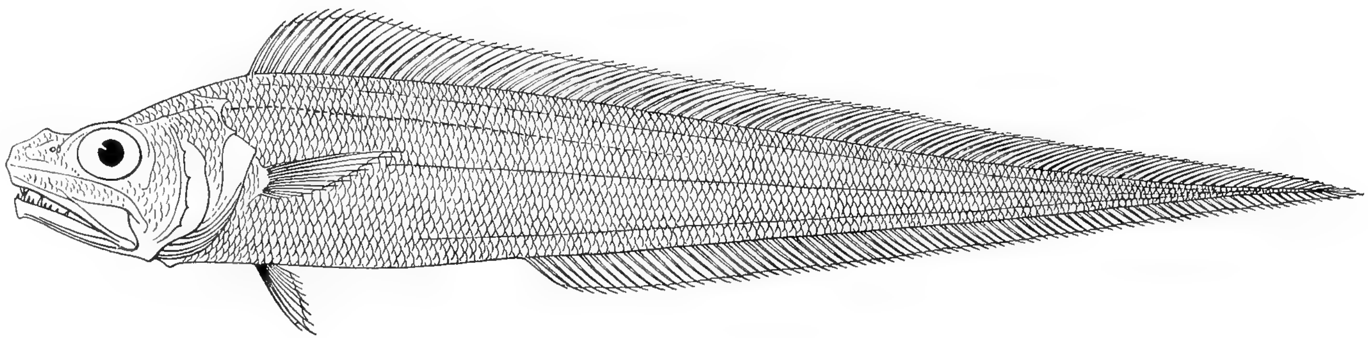
EXPLANATION OF PLATES.

PLATE VI.

Lyconus brachycolus, Holt and Byrne, $\frac{7}{9}$ natural size.

PLATE VII.

Fig. 1. Scale of *Coryphaenoides rupestris*, length 50·5 cms. × 12.
" 2. " " *Coelorhynchus coelorhynchus*, length 38 cms. × 11·5.
" 3. " " *Coryphaenoides Murrayi*, length 51 cms. × 10·5.
" 4. " " *Trachyrhynchus trachyrhynchus*, length 49·5 cms. × 10·3.
" 5. " " *Lionurus aequalis*, length 32 cms. × 15·7.
" 6. " " *Coelorhynchus labiatus*, length 36 cms. × 11·5.
" 7. " " *Malacocephalus laevis*, length 39 cms. × 29.
" 8. " " *Trachyrhynchus trachyrhynchus*, length 24 cms. × 18.



J. Green, del.

Lyconus brachycolus.

Farran—Seventh Report on the Fishes of the Irish Atlantic Slope.

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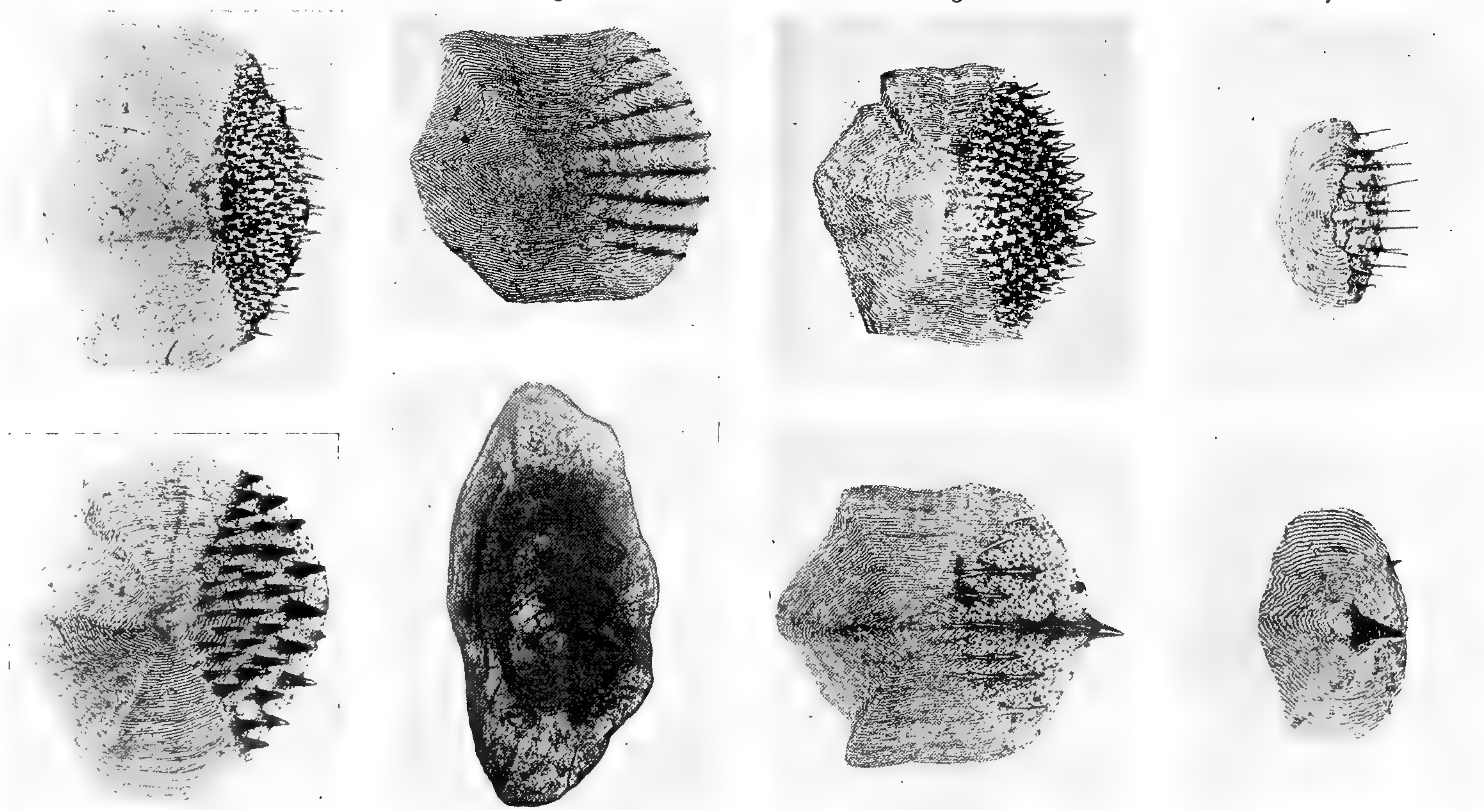

2 4 6 8

FIG. 1, *Coryphaenoides rupestris.* FIG. 2, *Coelorhynchus coelorhynchus.* FIG. 3, *Coryphaenoides Murrayi.* FIG. 4, 8, *Trachyrhynchus trachyrhynchus.* FIG. 5, *Lionurus aequalis.* FIG. 6, *Coelorhynchus labiatus.* FIG. 7, *Malacocephalus laevis.*

FARRAN—SEVENTH REPORT ON THE FISHES OF THE IRISH ATLANTIC SLOPE.

IX.

THE CONSTITUTION OF CATECHIN.—PART II.

ON DEOXYCATECHIN-TETRAMETHYLETHER AND DIHYDRO-VERATRYLIDENE-3·5-DIMETHOXYCOUMARANONE.

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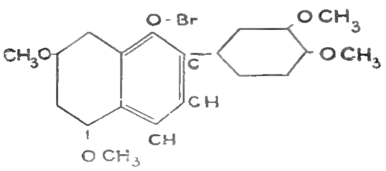
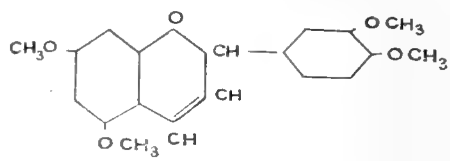
In 1902 it was suggested by A. G. Perkin and E. Yoshitake (Jour. Chem. Soc., 1902, lxxxi, p. 1169) that catechin is a derivative of 1-phenylchromane. Shortly afterwards, St. von Kostanecki and V. Lampe (Ber. Dtsch. Chem. Ges., 1906, xxxix, p. 4007) were led to the conclusion that catechin is derived from *p*-benzylcoumarane. The latter conception of the constitution of catechin appeared to be supported by the conversion of catechin-tetramethylether, by energetic reduction and methylation, into deoxyhydrocatechin-pentamethylether, which von Kostanecki and Lampe (ibid., 1907, xl, p. 720) formulated as the pentamethoxy derivative of *m*-ethylphenyl-phenyl-methane. Some doubt as to the correctness of this formula for the reduction product arose when it was shown (H. Ryan and M. J. Walsh, Proc. Royal Dublin Soc., 1916, N.S., xv, p. 113) that an oily product, obtained by the reduction of veratroyl-ethyl-phloroglucinol-trimethylether, did not crystallise when inoculated with crystals of deoxycatechin-pentamethylether.

Later, M. Nierenstein (Jour. Chem. Soc., 1920, cxvii, p. 972), who obtained the reduction product of veratroyl-ethyl-phloroglucinol-trimethylether in a crystalline condition, showed that it was not identical with deoxyhydrocatechin-pentamethylether. It has since been claimed by M. Nierenstein (Jour. Chem. Soc., 1920, cvii, pp. 971, 1151) that deoxyhydrocatechin-pentamethylether is identical with 3·4·2′·4′·6′-pentamethoxy-$\alpha\cdot\alpha$-diphenyl-propane. K. Freudenberg (Ber. Dtsch. Chem. Ges., 1920, liii, p. 1427), on the other hand, claims to have shown that this pentamethylether is identical with 2·4·6·3′·4′-pentamethoxy-$\alpha\cdot\gamma$-diphenyl-propane.

Recently one of us (J. J. Drumm, Proc. Royal Irish Acad., 1923, xxxvi, B, p. 41) showed that catechin-tetramethylether could be converted into a chloride which readily loses hydrochloric acid when heated with pyridine. The dehydrocatechin-tetramethylether, obtained in this way, interacted with bromine to form a red monobromide which had the properties of an oxonium salt, and closely resembled the benzopyranol anhydrohydriodide prepared by E. R. Watson and Senn (Jour. Chem. Soc., 1915, cvii, p. 1485), by the action of magnesium-ethyl iodide on luteolin-tetraethylether. It was assumed therefore that the red monobromide had the formula I, and dehydrocatechin-tetramethylether the formula II.

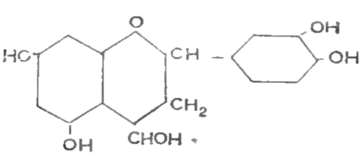


I.

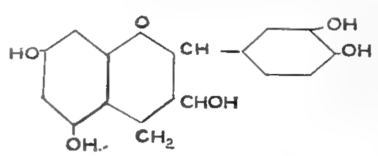


II.

If these formulae were correct, catechin would be either III or IV, and it would be easy to trace genetic relations between the catechins, the flavones, and the anthocyan pigments of plants (Cf. Ryan and Walsh, *loc. cit.*).

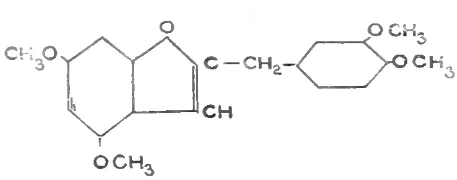


III.



IV.

R. Robinson (private communication) has, however, prepared synthetically a substance to which the formula I has been given, and which is not identical with the bromide of dehydrocatechin-tetramethylether. It is possible, therefore, that dehydrocatechin-tetramethylether may be a benzylcoumarone derivative and possess the constitution represented by formula V:—

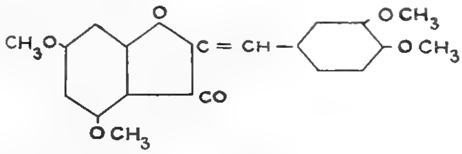


V.

In order to test this point experimentally it was decided to prepare some reduction derivatives of veratrylidene-3·5-dimethoxy-coumaranone (VI) as well as of dehydrocatechin-tetramethylether.

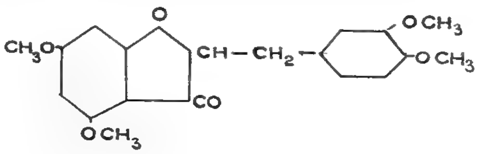
The preparation of veratrylidene-3·5-dimethoxycoumaranone has not been described hitherto in the literature. It was obtained by us from veratric aldehyde and 3·5-dimethoxycoumaranone. The latter substance was first prepared by Friedlaender and Schnell (Ber. Dtsch. Chem. Ges., 1897, xxx, p. 2153) from ω-chlorophloracetophenone-dimethylether. It was prepared by us by the more convenient method of Sonn (ibid., 1917, l, p. 1262–70) from phloroglucinol and chloracetonitrile.

Veratric aldehyde in the presence of alcoholic hydrochloric acid condensed with dimethoxycoumaranone forming veratrylidene-3·5-dimethoxycoumaranone (VI).



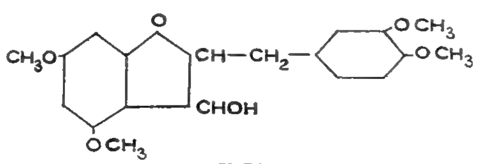
VI.

When this substance was reduced by hydrogen in the presence of platinum black dihydro-veratrylidene-dimethoxycoumaranone was obtained, and since the addition of the hydrogen apparently takes place at the double bond, the formula of the substance is represented by VII

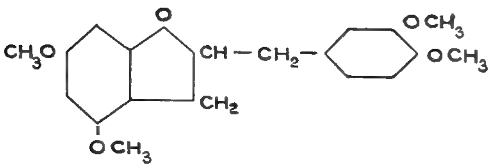


VII.

On further reduction, this substance (VII) should yield successively VIII and IX—possibly deoxycatechin-tetramethylether (below) may be represented by the formula IX.



VIII.



IX.

Deoxycatechin-tetramethylether, which melts at 136–137° C., was itself obtained by the reduction of dehydrocatechin-tetramethylether by means of hydrogen and platinum black.

Further experiments will be made with the object of preparing the substances VIII and IX.

Experimental.

A.—*Reduction of Dehydrocatechin-tetramethylether Deoxycatechin-tetramethylether.*

Dehydrocatechin-tetramethylether, prepared by the method already described by one of us (J. J. Drumm, Proc. Royal Irish Acad., 1923, xxxvi, B, p. 47) from the chloride of catechin-tetramethylether, was reduced by hydrogen in the presence of platinum black.

The platinum black required for the experiment was prepared by reduction of chloroplatinic acid with potash and formaldehyde at a temperature below 5° C. (R. Willstaetter, Ber. Dtsch. Chem. Ges., 1921, liv, p. 113). To render the platinum insoluble before filtering it, a few drops of acetic acid were added to the mixture (Feulgen, ibid., p. 360). The platinum black was dried for forty-eight hours over sulphuric acid in a desiccator.

A solution of 2 g. of dehydrocatechin-tetramethylether in 50 c.c. of glacial acetic acid was placed in a 200 c.c. flask, fitted with an inlet and an outlet tube, and 2 g. of platinum black were added. After expelling the air from the flask by a current of pure hydrogen, the outlet tube was connected with a manometer, and the flask was kept shaking until about 150 c.c. of hydrogen had been absorbed. The theoretical volume of hydrogen required for the saturation of the double bond in the amount of dehydrocatechin-tetramethylether taken is 127 c.c.

The contents of the flask were filtered and the filtrate was diluted with twice its volume of water. Needle-shaped crystals separated and these were recrystallised three times from boiling alcohol. The purified product melted at 136–137° C. (corr.). It cannot be identical with dehydrocatechin-tetramethylether, since a mixture of it with the latter substance melted about 120° C. On analysis it gave the following results:—

0·1421 substance gave 0·3586 CO_2 and 0·0852 H_2O, corresponding to C 68·82, H 6·65.

$C_{19}H_{22}O_5$ requires C 69·05, H 6·71.

Deoxycatechin-tetramethylether is insoluble in aqueous potash, and gives no coloration with alcoholic ferric chloride. Its solution in concentrated sulphuric acid has a yellow colour.

B.—*Preparation of Veratrylidene-3 5-dimethoxycoumaranone.*

1. 3·5-*Dihydroxycoumaranone.*

About 40 g. of anhydrous phloroglucinol were dissolved in 200 c.c. of dry ether and 24 g. of chloracetonitrile, prepared from chloracetamide and phosphorus pentoxide by the method of Scholl (Ber. Dtsch. Chem. Ges., 1896, xxix, p. 2417), were added. A current of dry hydrogen chloride was passed through the ethereal solution until (after about an hour) crystals of the ketimide hydrochloride no longer separated. The contents of the flask were filtered and the solid was washed with 30 c.c. of ether. It was then dissolved in 400 c.c. of water, previously heated to 30–40° C., and 60 c.c. of 30 per cent. sulphuric acid were added. The sulphate, which separated as a felted mass of colourless needles, was filtered and boiled for half an hour with 500 c.c. of water to which a few grams of potassium acetate had been added. On allowing the solution to cool slowly 38 g. of 3·5-dihydroxycoumaranone separated. The properties of the substance agreed with those described by Sonn (Ber. Dtsch. Chem. Ges., 1917, l, p. 1262), who has already prepared the substance by this method.

2. 3·5-*Dimethoxycoumaranone.*

A concentrated aqueous solution of potash was allowed to drop slowly into a mixture of 38 g. of 3·5-dihydroxycoumaranone and 100 c.c. of water until the coumaranone had just dissolved; 85 c.c. of dimethyl sulphate were then added. The mixture was kept faintly alkaline and well shaken while the dimethyl sulphate was being added. The methylated product was filtered and dissolved in 60–70 c.c. of boiling glacial acetic acid which was then cooled and filtered. By diluting the filtrate with three times its volume of water a greyish-white precipitate was obtained. The precipitate was recrystallised first from alcohol, and afterwards from boiling water with addition of a little decolorising charcoal. About 15 g. of dimethoxycoumaranone were obtained as colourless acicular crystals which melted at 136–138° C., and gave on analysis the following results:—

0·2060 substance gave 0·4676 CO_2 and 0·0946 H_2O, corresponding to C 61·9, H 5·10.

$C_{10}H_{10}O_4$ requires C 61·83, H 5·19.

3. *Veratrylidene-3·5-dimethoxycoumaranone.*

A mixture of 5 g. of 3·5-dimethoxycoumaranone, 4·5 g. of veratric aldehyde, 50 c.c. of alcohol and 20 c.c. of hydrochloric acid (sp. g. 1·14) was heated under a reflux condenser for ten minutes, and was then allowed to remain forty-eight hours at the room temperature. A crystalline solid separated. This was filtered and recrystallised successively from glacial acetic acid, alcohol, and ligroin. The pure substance weighed 6 g., and gave on analysis the following results:—

0·1790 substance gave 0·4366 CO_2 and 0·0882 H_2O.

0·1425 „ „ 0·3470 CO_2 and 0·0672 H_2O, corresponding to C 66·53, 66·38, H 5·47, 5·23.

$C_{19}H_{18}O_6$ requires C 66·63, H 5·30.

Veratrylidene-3·5-dimethoxycoumaranone consists of fine yellow needles, melting at 172–173° C. Its solution in concentrated sulphuric acid has a red colour. Ferric chloride gives no coloration with an alcoholic solution of the substance.

C.—*Reduction of Veratrylidene-3·5-dimethoxycoumaranone.*

The reduction of veratrylidene-3·5-dimethoxycoumaranone was effected in a manner similar to that described above for the reduction of dehydrocatechin-tetramethylether.

A mixture of 1 g. of platinum black with a solution of 1·5 g. of veratrylidene-3·5-dimethoxycoumaranone in 20 c.c. of glacial acetic acid absorbed 150–160 c.c. of hydrogen in less than ten minutes. After this no further absorption of hydrogen was noticed. The solution, which had become colourless, was filtered from the platinum, and was diluted with water to three times its volume. Fine needles separated; these were collected on the filter pump, and after two recrystallisations from 20 c.c. of boiling alcohol they melted at 125–126° C. The pure substance weighed 0·75 g. It was insoluble in aqueous potash, and dissolved in concentrated sulphuric acid, forming an orange solution. It gave on analysis the following results:—

0·1346 substance gave 0·3252 CO_2 and 0·0743 H_2O.

0·1626 substance gave 0·3938 CO_2 and 0·0838 H_2O, corresponding to C 65·90, 66·05, H 6·09, 5·71.

$C_{19}H_{20}O_5$ requires C 66·24, H 5·85

D.—*Summary.*

1. Deoxycatechin-tetramethylether, $C_{15}H_{10}O(OCH_3)_4$, was obtained by the indirect reduction of catechin-tetramethylether $C_{15}H_{10}O_2(OCH_3)_4$. It melts at 136–137° C.

2. Veratrylidene-3·5-dimethoxycoumaranone on reduction with hydrogen in the presence of platinum black formed a dihydro derivative, $C_{15}H_8O_2(OCH_3)_4$, which melts at 125–126° C., and which on further reduction should give an isomeride of catechin-tetramethylether, $C_{15}H_{10}O_2(OCH_3)_4$.

X.

SOME DERIVATIVES OF STILBENE.

By HUGH RYAN, D.Sc., and NICHOLAS CULLINANE, Ph.D.,
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[Read February 11. Published May 23, 1924.]

The object of the present investigation was the direct preparation of derivatives of phenanthrene from stilbenes containing no carboxylic acid group, as was the case in Pschorr's syntheses in the phenanthrene series (compare, *e.g.*, Ber. d. Dtsch. Chem. Ges., xxix, 1886, p. 497). However, although experiments were carried out under varying conditions, no phenanthrenes were obtained. Thus, the diazonium salt of 2-aminostilbene, when treated with copper bronze in the presence of alcohol, gave even at ordinary temperatures stilbene itself, the diazo-group being reduced to hydrogen. When the experimental conditions were changed, some benzaldehyde was formed, but no phenanthrene could be isolated. In like manner Sachs and Hilpert (Ber. d. Dtsch. Chem. Ges., xxxix, 1906, p. 904), by treating the diazo-compound with copper powder, and Ullmann and Gschwind (Ber. d. Dtsch. Chem. Ges., xli, 1908, p. 2291), by the action of heat on the diazo-derivative, were unable to obtain phenanthrene.

In a similar fashion 4-nitrostilbene-2-diazonium sulphate when treated with copper bronze in the presence of alcohol gave 4-nitrostilbene.

The nitro-derivatives of stilbene which were synthesized in the course of the present work were prepared by condensing, in the presence of a small quantity of piperidine, nitrotoluenes and aromatic aldehydes. The use of this condensing agent in such reactions is due to Thiele and Escales (Ber. d. Dtsch. Chem. Ges., xxxiv, 1901, p. 2842), who obtained 2·4-dinitrostilbene in this way from 2·4-dinitrotoluene and benzaldehyde. The dinitrostilbene on partial reduction by means of alcoholic ammonium sulphide was converted into 2-nitro-4-aminostilbene, the sulphate of which yielded the corresponding diazonium salt on treatment with amyl nitrite or nitrous acid (compare Thiele and Escales, *loc. cit.*). The diazo-compound by boiling with ethyl alcohol (Sachs and Hilpert, *loc. cit.*) or with amyl alcohol (Pfeiffer and others, Liebig's Annalen der Chemie, ccccxi, 1916, pp. 72–158) formed 2-nitrostilbene, which was also produced by the action of alkaline stannite on the diazonium chloride (Pfeiffer and Monath, Ber. d. Dtsch. Chem. Ges., xxxix, 1906, p. 1305). The action of stannous chloride upon the nitro-compound in acetic acid solution gave 2-amino-stilbene, which was then diazotized in alcohol solution with amyl nitrite, and the product shaken up with copper bronze, yielding stilbene. The following scheme represents the results achieved :—

2.4-Dinitrostilbene → 2-nitro-4-aminostilbene → 2-nitrostilbene → 2-aminostilbene → stilbene.

As the above results indicate, ammonium sulphide first attacks the para-nitro group in 2·4-dinitrostilbene. Stannous chloride, however, is found to attack the ortho-nitro-group first, leaving the para-group intact. For instance, when the dinitrostilbene is reduced in acetic acid solution with one molecular proportion of stannous chloride 4-nitro-2-aminostilbene results. Thiele and Escales (*loc. cit.*) acted upon the dinitrostilbene in the cold with a cold solution of stannous chloride in hydrochloric acid—acetic acid. Employing this method, however, the reaction is of long duration (4–6 hours), but an equally large yield may be obtained in 5–10 minutes by carrying out the reduction at a somewhat higher temperature.

When two molecular proportions of stannous chloride were used, 2·4-dinitrostilbene was reduced to 2·4-diaminostilbene (compare Thiele and Escales, *loc. cit.*).

The sulphate of 2-amino-4-nitrostilbene was readily converted into the corresponding diazonium salt by diazotization in alcohol solution with amyl nitrite. The product on being shaken with copper bronze in the presence of alcohol was reduced to 4-nitrostilbene, which was identified by comparison with the synthetic compound produced by the condensation of *p*-nitrophenyl-acetic acid and benzaldehyde (Pfeiffer and Sergiewskaja, Ber. d. Dtsch. Chem. Ges., xliv, 1911, p. 1109).

Stannous chloride reduces 4-nitrostilbene to its amino-derivative.

2·4-Dinitrotoluene was also condensed in the usual manner with anisaldehyde, giving 2·4-dinitro-4′-methoxystilbene (Pfeiffer, Ber. d. Dtsch. Chem. Ges., xlviii, 1915, p. 1804), on partial reduction of which, by means of stannous chloride, 4-nitro-2-amino-4′-methoxystilbene was produced. The latter substance was observed to exist in two chromoisomeric modifications, one yellow, the other red (compare Cullinane, Journ. Chem. Soc., cxxiii, 1923, p. 2053). It separated from acetone solution in bright-red prisms, while on pouring a cold solution in glacial acetic acid into water, small orange-yellow needles were obtained. The red form is the stable one; the yellow compound on being heated turns red at about 100°C., and melts at the same temperature as the red modification.

The above result is quite in accord with Pfeiffer's views on the chromo-isomerism of nitromethoxystilbenes (Ber. d. Dtsch. Chem. Ges., li, 1918,

p. 554), as our preparation contains a nitro-group in the para-position of one benzene nucleus of the stilbene molecule, and a methoxyal-radical in the para-position of the other benzene ring.

The condensation of 2·4·6-trinitrotoluene with benzaldehyde yielded 2·4·6-trinitrostilbene (Pfeiffer and Monath, *loc. cit.*; compare Ullmann and Gschwind, *loc. cit.*). Stannous chloride caused partial reduction of this compound, giving 4·6-dinitro-2-amino-stilbene. The sulphate of this amine was converted by amyl nitrite into 4·6-dinitro-stilbene-2-diazonium sulphate.

EXPERIMENTAL.

2·4-*Dinitrostilbene.*

The method employed for the preparation of this compound was that of Thiele and Escales (*loc. cit.*) from 2·4-dinitrotoluene and benzaldehyde in the presence of a little piperidine. The condensation-product, while still warm, was washed a few times with methylated spirit, and the residue, after recrystallization from glacial acetic acid, gave a pure product melting at 139°–140°C. It was slightly soluble in ether, alcohol, or chloroform, but dissolved readily in hot benzene, glacial acetic acid, or acetone.

2-*Nitro*-4-*aminostilbene.*

This substance was prepared by a method similar to that of Thiele and Escales (*loc. cit.*). Sulphuretted hydrogen was passed continuously into the ammoniacal alcohol which contained the 2·4-dinitrostilbene, until almost all the latter had gone into solution. The product was filtered, the residue was washed with a small volume of warm alcohol, and the amine hydrochloride was precipitated by passing hydrogen chloride into the filtrate. The action of water on the salt gave the free base as a red powder, which, after crystallization from alcohol, separated out in the form of bright-red prisms melting at 110°C.

The sulphate of 2-nitro-4-aminostilbene was produced by adding concentrated sulphuric acid drop by drop with shaking to a solution of the amine in alcohol. On recrystallization from glacial acetic acid it was obtained as bright-yellow leaflets, melting at about 205°C. The action of water on this salt restored the amine.

Diazonium Salts of 2-*Nitro*-4-*aminostilbene.*

The *diazonium sulphate* may be obtained by the method of Sachs and Hilpert (*loc. cit.*), or by the following method, which gives an equally good yield:—

Ten grams of 2-nitro-4-aminostilbene sulphate were finely powdered, and suspended in a mixture of 10 c.c. of concentrated sulphuric acid and 100 c.c. of water. A solution of 6 grams of sodium nitrite in 20 c.c. of water was added very slowly, the mixture being cooled with water and vigorously shaken during the addition, which lasted about one hour. The product was then allowed to remain at the room temperature for an hour more, and was then filtered, washed with a little alcohol, and afterwards with a little ether. The diazonium-salt consisted of bright-brown needles, which decomposed at about 165°C.

The *diazonium chloride* was prepared by the method of Sachs and Hilpert (*loc. cit.*). It consisted of orange-yellow flakes, decomposing at about 144°C.

2-Nitrostilbene.

Five grams of 2-nitrostilbene-4-diazonium-sulphate in powder form were added gradually to 40 c.c. of hot absolute alcohol containing a little sulphuric acid, and the mixture was boiled under reflux for two hours. A clear brown solution resulted, together with some tar, and when it had cooled the solution was poured off. On addition of a little water a brown precipitate was deposited. This contained scarcely any nitrostilbene. The filtrate from the above solid was precipitated with a large volume of water, an oily solid being thrown down which solidified on standing. The latter precipitate on crystallization from alcohol yielded bright-yellow needles melting at 76°C. The yield was 1–1·5 grams.

2-Aminostilbene.

2-*Aminostilbene* may be prepared by the method of Sachs and Hilpert (*loc. cit.*), or by the following modification:—

Five grams of 2-nitrostilbene were dissolved in 20 c.c. of glacial acetic acid, and treated with a solution of 16 grams of stannous chloride in 42 c.c. of glacial acetic acid saturated with hydrogen chloride. The solution of the tin salt, at a temperature of 40° C., was added slowly to the solution of the nitro-derivative, the temperature of which was 45° C., and the reaction-mixture was gradually raised to a temperature of 90°–100° C., where it was kept constant for a short time. The product was then poured into a shallow vessel, and allowed to remain at the room temperature for twelve hours. The precipitate formed on the addition of water was filtered from the mother liquor, and extracted with ether, on evaporation of which 2-aminostilbene was left. The amine was crystallized from alcohol, giving white leaflets, melting at 106° C.

Stilbene.

The diazonium sulphate of 2-aminostilbene was obtained by the action of amyl nitrite on an alcohol solution of the amine (Sachs and Hilpert, *loc. cit.*).

It consisted of yellow needles, which decomposed at 105° C., and gave a red dye with alkaline *α*-naphthol solution. After shaking the diazo-compound for twenty minutes, heat was applied for a short time by means of the water-bath, the mixture was then cooled, and water was added. The residue obtained on filtering was extracted with ether, and on evaporation of the solvent, colourless scales were obtained, melting at 124° C., which proved to be stilbene.

4-*Nitro-2-aminostilbene.*

A warm solution of 20 grams of 2·4-dinitrostilbene in 300 c.c. of glacial acetic acid was vigorously stirred by means of a mechanical stirrer, and, at the same time, was rapidly cooled with water. During the cooling process the nitrostilbene was precipitated from solution in a finely-divided condition. When a temperature of 35° C. had been reached, a little more than the calculated amount (for the reduction of one nitro-group) of a solution of stannous chloride (prepared by passing hydrochloric acid gas into a mixture of 60 grams of stannous chloride and 150 c.c. of glacial acetic acid until the tin salt had almost completely dissolved), at a temperature of 20° C., was added gradually, while the stirring was continued. The temperature rose slowly until in a few minutes the stilbene compound had gone almost completely into solution. The product was allowed to cool, and to remain overnight at the room temperature, when a dense yellow precipitate was observed. The latter was separated by filtration from the mother liquor, and decomposed with warm water. The red powder resulting was taken up with hot alcohol, from which, on cooling, brick-red needles, melting at 142°–143° C., separated. The yield was 11–12 grams.

4-*Nitro-2-aminostilbene* is slightly soluble in light petroleum, but dissolves readily in most organic solvents.

2·4-*Diaminostilbene.*

In this experiment somewhat more than the calculated amount of stannous chloride was employed for the reduction of the two nitro-radicals in 2·4-dinitrostilbene. On heating the mixture for a short time a dense white precipitate was formed, and the reaction was then discontinued. The deposit was separated from the mother-liquor, dissolved in water, and the addition of concentrated ammonium hydroxide to the solution caused a white solid to be thrown down. This was extracted with warm alcohol, from which the diamine was obtained on cooling as white needles, melting at 119° C. It was slightly soluble in ether, moderately soluble in alcohol, chloroform, or benzene, and readily soluble in glacial acetic acid or acetone.

4-*Nitrostilbene.*

The sulphate of 4-nitro-2-aminostilbene was diazotized in alcoholic solution with amyl nitrite (Sachs and Hilpert, *loc. cit.*). About four grams of copper bronze were added to the mixture, which contained two grams of the diazo-compound, and the contents of the vessel were vigorously shaken. Effervescence ensued, and when the evolution of gas had subsided the mixture was warmed for a short time on the water-bath. The product was filtered when cold, and the residue was washed with a small amount of cold alcohol, and then extracted with acetone. On evaporation of the solvent a brown crystalline mass resulted, and this, after recrystallization from alcohol or glacial acetic acid, gave a product consisting of straw-coloured leaflets, melting at 155° C. This substance was shown by comparison with the product obtained synthetically by Pfeiffer and Sergiewskaja (*loc. cit.*) from *p*-nitrophenylacetic acid and benzaldehyde to be 4-nitrostilbene. The yield was over 50 per cent.

4-*Aminostilbene.*

4-Nitrostilbene (2 grams) was dissolved in glacial acetic acid (40 c.c.) and a warm solution of stannous chloride (20 grams) in concentrated hydrochloric acid (20 c.c.) was added. The mixture was heated on the water-bath for an hour, and then allowed to cool. The resulting white deposit was filtered, excess of ammonium hydroxide was added, and the product was filtered again, washed free from alkali, and dried. Extraction with warm alcohol dissolved the amine, which was deposited on cooling as white needles, melting at 151° C.

4-*Aminostilbene* is readily soluble in alcohol and most other organic solvents.

2·4-*Dinitro-4′-methoxystilbene.*

2·4-Dinitro-4′-methoxystilbene was prepared by condensing, in presence of a few drops of piperidine, 2·4-dinitrotoluene and anisaldehyde (Pfeiffer, *loc. cit.*). The reddish-brown product was washed, while still warm, with methylated spirit, and then recrystallized from glacial acetic acid, yielding glittering orange-red prisms, which melted at 163° C. It dissolved with difficulty in alcohol or ether, more readily in hot benzene or acetic acid, and especially in acetone.

4-*Nitro-2-amino-4′-methoxystilbene.*

A solution (at 20° C.) of 16 grams of stannous chloride, in 42 c.c. of glacial acetic acid saturated with hydrogen chloride, was added gradually to 40 c.c. of glacial acetic acid containing 6 grams of dinitromethoxystilbene (at 40° C.). The mixture was well stirred during the process of addition by means of a mechanical stirrer, and the temperature rose gradually, the nitro-compound going gradually into solution. A yellow precipitate was deposited, becoming more dense as the reaction progressed. When it had become very dense the reaction was stopped, and the product was allowed to cool, the deposit was separated from the mother-liquor by filtration, and was then decomposed with hot water. The red powder thus obtained was dissolved in acetone, and on evaporation of the cold solvent bright-red prisms, melting at 184° C., resulted.

The following results were obtained on analysis :—

0·1302 gram substance gave 11·7 c.c. moist nitrogen at 13° C. and 752 mm.,

corresponding to N 10·54

$C_{15}H_{14}O_3N_2$ requires N 10·38.

4-*Nitro-2-amino-4′-methoxystilbene* is not very soluble in ether, alcohol, or cold benzene, but dissolves readily in hot acetic acid or acetone.

The *sulphate* was precipitated in the form of white needles on the addition of a few drops of concentrated sulphuric acid to a solution of the amine in acetone.

The *hydrochloride* was obtained as white needles on passing hydrogen chloride into a solution of the amine in the same solvent.

The action of water on both salts restored the original amine.

The *acetyl*-derivative of 4-nitro-2-amino-4′-methoxystilbene was prepared by boiling this substance under reflux for 3 hours with excess of acetic anhydride. The product separated from glacial acetic acid as bright-yellow plates, melting at 184°–185° C., and gave on analysis the following results:—

0·1006 gram substance gave 7·8 c.c. moist nitrogen at 20° C. and 765 mm.,

corresponding to N 8·96

$C_{17}H_{16}O_4N_2$ requires N 8·98.

2·4·6-*Trinitrostilbene.*

2·4·6-Trinitrostilbene was prepared by condensing with the aid of piperidine 2·4·6-trinitrotoluene and benzaldehyde, the method used being similar to that of Pfeiffer and Monath (*loc. cit.*). The oily product was pressed on a porous plate and recrystallized from glacial acetic acid, from which yellow needles, melting at 156° C., separated. It dissolved readily in hot benzene, acetic acid or acetone, but was soluble only to a slight extent in alcohol or ether.

4·6-*Dinitro-2-aminostilbene.*

Glacial acetic acid (42 c.c.) was added to stannous chloride (16 grams), and hydrochloric acid gas was bubbled into the mixture until the tin salt had almost completely dissolved. This solution (at 20° C.) was added slowly with stirring to 40 c.c. of glacial acetic acid containing 6 grams of powdered trinitrostilbene (at 30°–35° C.), the stirring being maintained until the end of the reaction. This occurred in about 10 minutes, and was indicated by the almost complete dissolution of the stilbene-derivative. The product was then poured into a shallow vessel, where it remained overnight. At the end of this time a large deposit consisting of a red solid was noted. The latter was filtered, washed with water, and crystallized from alcohol, giving brick-red prisms, melting at 216° C. The yield was 3 grams. On analysis the following results were obtained:—

0·1154 gram substance gave 14·4 c.c. moist nitrogen at 17° C. and 769 mm.,

corresponding to N 14·64
$C_{14}H_{11}O_4N_3$ requires N 14·74.

4·6-*Dinitro-2-aminostilbene* is soluble in ether, chloroform, alcohol, benzene, glacial acetic acid, or acetone, and in most organic solvents.

The following derivatives were prepared:—

(*a*) *Benzoyl*-derivative.—Benzoyl chloride and some aqueous caustic soda solution were added to an ethereal solution of dinitroaminostilbene, and the mixture was vigorously shaken for a half-hour. The yellow precipitate of the benzoylamine was filtered off, dried and crystallized from glacial acetic acid, from which bright-yellow prisms, melting at 193° C., separated. The following results were obtained on analysis:—

0·1429 gram substance gave 13 c.c. moist nitrogen at 11° C. and 752 mm.,

corresponding to N 10·76
$C_{21}H_{15}O_5N_3$ requires N 10·80.

4·6-*Dinitro-2-benzoylaminostilbene* is slightly soluble in cold alcohol, ether, or benzene, and readily soluble in glacial acetic acid or acetone.

(*b*) *Acetyl*-derivative.—A solution of dinitroaminostilbene in excess of acetic anhydride was boiled under reflux for 3 hours. On evaporating down portion of the solvent a crystalline solid was deposited, and this after recrystallization from benzene yielded bright-yellow plates, melting at 172°-173° C. Its analysis gave the following results:—

0·1034 gram substance gave 11.3 c.c. moist nitrogen at 13° C. and 764 mm.,

corresponding to N 13·02
$C_{16}H_{13}O_5N_3$ requires N 12·84.

4·6-*Dinitro-2-acetylaminostilbene* is not very soluble in alcohol or ether, but dissolves readily in hot benzene, glacial acetic acid, or acetone.

4·6-Dinitrostilbene-2-diazonium sulphate.

Dinitroaminostilbene (2 grams) was dissolved in alcohol, and concentrated sulphuric acid (1·1 c.c.) was added gradually with shaking and cooling. The sulphate remained in solution. About 1·5 c.c. of amyl nitrite were poured drop by drop into the cold solution, which was shaken thoroughly during the addition. On allowing the solution to remain at the room temperature for some hours, the diazo-derivative was precipitated as a red solid, which on crystallization from glacial acetic acid gave orange-red acicular prisms, decomposing at about 230° C.

In conclusion, we wish to state that this investigation was undertaken at the request of the research section of Nobel's Explosives Company, and that we are also indebted to the Department of Scientific and Industrial Research for a grant in aid of the investigation.

XI.

THE ACTION OF NITROUS ACID AND NITROUS FUMES ON URETHANES AND OTHER BODIES.

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[Read February 25. Published May 23, 1924.]

In previous communications from this laboratory the action of nitrogen peroxide and nitric acid on some secondary amines, urethanes, ethers and ureas has been described (Proc. R.I.A., xxxiv, B Nos. 8, 10, and 12; Proc. R.D.S. xvii, N.S., Nos. 14-19, 36-40). The reactions were studied more especially at the ordinary temperature and at low concentrations of the bodies. The behaviour of these substances towards nitrous acid was not, however, examined.

The present communication deals with the action of nitrous acid and nitrous fumes on the more important of these substances, and in this respect completes the series of investigations already published.

In our experiments, butyl nitrite was the source of the nitrous acid, in nearly every case; the acid was set free by hydrochloric or glacial acetic acid. The action of nitrous fumes on five or ten per cent. solutions of some of the above-mentioned substances in the common organic solvents at 0° C., and at the ordinary temperature, was also investigated.

By the action of nitrous fumes on an ethereal solution of *phenylurethane*, Behrend [Liebig's Annalen der Chemie, ccxxxiii (1886), p. 9] obtained 4-nitro-phenylurethane. Willstätter [Ber. der Dtsch. Chem. Ges., xlii (1909), p. 4876] prepared by the same reaction, using glacial acetic acid as solvent, a very unstable phenylnitroso-urethane in the form of light, yellow needles, melting at 61°-62° C. We found that nitrous fumes readily converted phenylurethane (five or ten per cent. solutions) in ether, carbon tetrachloride, glacial acetic acid, and in petroleum ether solution into 4-nitro-phenylurethane. Attempts to isolate Willstätter's compound by allowing the reaction to proceed for shorter periods, and otherwise varying the conditions of the experiments, were unsuccessful. Phenylurethane, dissolved in alcohol, or in glacial acetic acid, did not react with nitrous acid, even when the mixture had been allowed to remain at the room temperature for two months in each case. In carbon tetrachloride solution, nitration proceeded slowly, however, the urethane being completely converted into the 4-nitro compound after three months. As in the experiments with nitrous fumes, the formation of an intermediate product seemed likely, and in order to isolate any such compound the reaction was allowed to proceed for only fourteen days, when the 4-nitro derivative and unchanged phenyl urethane were the sole products.

T. Nolan (private communication from Nobel's Explosives Company) obtained nitroso-phenylurethane melting at 147° C. by the action of sodium nitrite on a sulphuric acid solution of phenylurethane at a low temperature (- 15° C.).

The reactions of *o-tolylurethane* with the oxides and oxyacids of nitrogen at low concentration of the substances have not yet been investigated, though its nitro derivatives have been prepared synthetically from the corresponding nitro toluidines and also in this laboratory [H. Ryan and N. Cullinane, Proc. R.D.S., xvii, No. 15], by the action of nitric acid and nitrogen peroxide on ethyl-o-tolylurethane. This substance reacted with nitrous acid and nitrous fumes in a similar manner to the phenyl compound. The urethane was converted by nitrous acid in carbon tetrachloride solution into 4-nitro-o-tolylurethane melting at 135° C, which had been already obtained from 4-nitro-o-toluidine and chlorocarbonic ester. Nitrous fumes also converted a cold ten per cent. solution of o-tolylurethane in carbon tetrachloride into this body.

In experiments carried out with *diphenylurethane* [H. Ryan and P. Donnellan, Proc. R.D.S., xvii, No. 14], no reaction took place when this body was allowed to remain for a long period with nitric acid in glacial acetic acid solution at the ordinary temperature. Three molecular quantities of nitric acid converted the urethane in five per cent. carbon tetrachloride solution into 4-nitro-diphenylurethane after four weeks, while four and six equivalents of nitric acid yielded dinitro derivatives under the same conditions. In our experiments, six molecular quantities of nitrous acid were without action on five per cent. solutions of diphenylurethane in acetic acid, alcohol, and carbon tetrachloride, even when the mixtures were allowed to remain at the ordinary temperature for lengthy periods. Nitrous fumes reacted, however, with cold ten per cent. solutions of the urethane in carbon tetrachloride and glacial acetic acid, with formation of 4-10-dinitro-diphenyl-urethane in each case; while from a similar solution in glacial acetic acid which was treated with nitrous fumes for a shorter period, the product was 4-nitro-diphenyl-urethane.

Phenyl-benzylurethane was found [H. Ryan and J. L. O'Donovan, Proc. R.D.S., xvii, No. 17] to react readily with both nitric acid and nitrogen peroxide, when carbon tetrachloride and glacial acetic acid were used as solvents. The main product of the reactions was 4-nitro-phenyl-benzylurethane melting at 70°–71° C., and a trinitro derivative. We recovered the urethane unchanged from solutions in glacial acetic acid, alcohol, and carbon tetrachloride, after these had been mixed with butyl nitrite and an acid for prolonged periods. Nitrous fumes converted 10 per cent. solutions of phenyl-benzylurethane in glacial acetic acid into the 4-nitro compound already obtained by Ryan and O'Donovan. A dinitro derivative was not obtained under the same conditions as those in which diphenylurethane yielded 4-10-dinitro-diphenylurethane.

When the reactions of *ethyl-phenylurethane* were examined in this laboratory [H. Ryan and A. Connolly, Proc. R.D.S., xvii, No. 16], nitric acid was found to have but a slow action on its solutions. With one and two equivalents of nitric acid, the urethane was recovered unchanged from a five per cent. acetic acid solution after five months. Three equivalents of the acid gave 4-nitro-ethyl-phenylurethane, and four and five equivalents dinitro-ethyl-phenylurethane. We found that six molecular proportions of nitrous acid were without action on ethyl-phenylurethane in glacial acetic acid, alcohol, or carbon tetrachloride solution, even after long periods.

Nitro derivatives of o-tolylurethane were obtained, as already mentioned [*loc. cit.*], by the direct action of nitric acid or of nitrogen peroxide on *ethyl-o-tolylurethane*, the ethyl radical being eliminated. Nitric acid did not yield crystalline derivatives in presence of cold solvents. In our experiments, the urethane was recovered unchanged after periods of two to three months, when its solutions in alcohol, acetic acid, and carbon tetrachloride had been treated with nitrous acid.

H. Ryan and J. Keane examined [Proc. R.D.S., xvii, No. 36] the reactions of *phenyl-benzyl ether* with nitric acid, nitrogen peroxide, and nitrous fumes. They found that nitrogen peroxide converted the ether in 4 per cent. carbon tetrachloride solution into 4-nitro-phenyl-benzyl ether, melting at 104°–106° C., which they also obtained synthetically from potassium, 4-nitro-phenolate, and benzyl chloride. After four months standing, the product obtained by the same reaction was 4-10-dinitro-phenyl-benzyl ether, melting at 184°–186° C. When nitrous fumes were passed into a four per cent. solution of the ether in acetic acid for half an hour, and the product was allowed to remain in a stoppered vessel for six weeks, they obtained the 4-nitro compound already mentioned, and benzoic acid. Two, three, and four equivalents of nitric acid gave decomposition products of the ether when allowed to remain mixed with its acetic acid solution for long periods, while the same quantities of acid gave 4-nitro-phenyl-benzyl ether in carbon tetrachloride solutions. Phenyl-benzyl ether was recovered unchanged from its solutions in glacial acetic acid and carbon tetrachloride after these had been treated with nitrous acid for lengthy periods.

We found that nitrous fumes reacted with a cold ten per cent. solution of the urethane in carbon tetrachloride solution, yielding 4-nitro-phenyl-benzyl ether. When the reaction was allowed to proceed for a longer period, 4-10-dinitro-phenyl-benzyl ether was the main product.

In contrast with the other bodies examined, nitrous acid reacted quickly with *diphenylamine* in both acetic and carbon tetrachloride solutions; 4-nitro-diphenyl-nitrosamine [*cf.* H. Ryan and P. Ryan, Proc. R.I.A., vol. xxxiv, Nos. 10 and 12] was obtained in quantity after six weeks from a five per cent. solution of diphenylamine in glacial acetic acid to which butyl nitrite had been added, and which had been allowed to remain at the room temperature for six weeks. From a similar solution in carbon tetrachloride, this compound was also obtained together with a mixture, the constituents of which were not separated.

EXPERIMENTAL.

A.—*Action of Nitrous Acid and Nitrous Fumes on Urethanes.*

I. *Phenylurethane.*

(*a*) *Nitrous Acid.*—1. Six molecular amounts of butyl nitrite were added to a solution of 5 grams of phenylurethane in 100 grams of glacial acetic acid, and the solution was allowed to remain in a stoppered flask at the temperature of the room for two months. The mixture acquired a slight yellow colour, but otherwise its appearance did not change appreciably. It was poured into twice its volume of water. The upper, oily layer was separated, and from it, by evaporation at the room temperature, a crystalline solid was got, which after recrystallisation from alcohol, proved to be *unchanged phenylurethane.* A further quantity of phenylurethane was extracted by ether from the lower, aqueous layer.

2. In another and similar experiment in which alcohol was the solvent, butyl nitrite and hydrochloric acid gave after two months a mixture from which the only substance isolated was *unchanged phenylurethane.*

3. Nitration took place, however, in a third experiment which was similar to the other two, but in which carbon tetrachloride was the solvent. After remaining at the room temperature for about two months some crystalline matter with a little oil floated on the surface of the carbon tetrachloride. The solid matter did not increase in quantity appreciably when the reaction was allowed to proceed for another month. The colourless, tabular crystals melted at 128–130° C. On recrystallisation from diluted alcohol, colourless needles were obtained melting at 131°–132° C. The melting point was not changed

by mixing the substance with an equal quantity of *4-nitro-phenylurethane.* The carbon tetrachloride was neutralised with barium carbonate, filtered, and distilled. The residue which solidified on standing consisted of slightly impure *4-nitro-phenylurethane*, which was recovered in a pure condition by recrystallising it from carbon tetrachloride.

4. Even in carbon tetrachloride solution, the nitration of the urethane by the nitrous acid proceeded slowly, the mixture after fourteen days containing *unchanged phenylurethane* in addition to some *4-nitro-phenylurethane* from which it was separated by means of petroleum ether.

(*b*) *Nitrous fumes.*—1. Nitrous fumes, obtained by the action of nitric acid on arsenious oxide, and dried by means of calcium chloride, were passed into a solution of 2 grams of phenylurethane in 20 grams of glacial acetic acid for about forty minutes. The dark green solution was poured into water, and the green oil which separated was dissolved in ether, its colour changing to deep red. The ether was evaporated in a vacuum, and the reddish oily crystals which remained were boiled with alcohol and animal charcoal. From the hot liquid pinkish acicular crystals, melting at 126°–130° C., separated on cooling. These, after recrystallisation, melted at 130°–131° C., and were found to be *4-nitro-phenylurethane.*

In another experiment in which the nitrous fumes were passed through the solution for only twenty minutes, the mixture, which had a deep red colour, gave, when poured into water, a yellow oil, which solidified, forming pale yellow crystals. The latter after recrystallisation from petroleum ether were identified as *phenylurethane.*

2. A five per cent. solution of phenylurethane in glacial acetic acid was cooled in a freezing mixture (the acetic acid solidifying), and then treated with nitrous fumes for fifteen minutes. The mixture when poured into water again gave a readily solidifying oil, which proved to be *phenylurethane.*

3. A solution of 1 gram of phenylurethane in 10 grams of carbon tetrachloride was cooled in ice and salt, and a current of nitrous fumes was passed through it for twenty minutes. The solution became green in colour, and a yellow oil separated from it. The oil solidified on standing, and after recrystallisation from carbon tetrachloride was found to be *4-nitro-phenylurethane.*

In similar experiments in which ether, at the ordinary temperature and below 0° C., was employed as the solvent 4-nitro-phenylurethane was also got. The same product was found when dry nitrous fumes were passed into an ice-cold solution of 5 grams of phenylurethane in 250 c.cs. of petroleum ether.

II. *Ethyl-phenylurethane.*

Five per cent. solutions of ethyl-phenylurethane in glacial acetic acid, alcohol, and carbon tetrachloride were mixed with butyl nitrite and acetic or hydrochloric acid and allowed to remain at the temperature of the room for periods varying from seven weeks to three months. Yellow oily products were obtained in each case, but from these no crystalline substances were isolated.

III. *o-Tolylurethane.*

(*a*) *Nitrous Acid.*—1. Six molecular amounts of butyl nitrite were added to a solution of 5 grams of o-tolylurethane in 100 grams of glacial acetic acid. The mixture was allowed to remain at the temperature of the room for two months, but from it the only substance isolated was *unchanged o-tolylurethane.*

The urethane was also recovered unchanged in a somewhat similar experiment (but at a lower temperature), in which the butyl nitrite was replaced by sodium nitrite.

2. The urethane was also unaffected when its alcoholic solution, to which butyl nitrite and hydrochloric acid had been added, was allowed to remain for nine weeks at the ordinary temperature.

3. To a solution of 2·5 grams of o-tolylurethane in 50 grams of carbon tetrachloride, 6 molecular amounts of butyl nitrite and 8 molecular amounts of glacial acetic acid were added. After one month the solution had acquired a reddish colour, and after two months, colourless crystals and some oily matter floated on the surface. When the mixture had remained for three months at the temperature of the room, it was examined. The crystals melted at 132°–134° C., and since a mixture of them with *4-nitro-o-tolylurethane* melted at the same temperature the two substances must have been identical.

The carbon tetrachloride layer was neutralized with barium carbonate filtered and distilled. The reddish oily residue solidified on standing. It was freed from unchanged o-tolylurethane by warm petroleum ether, and then dissolved in hot alcohol. After boiling the alcoholic solution with animal charcoal, filtering and cooling, a good yield of *4-nitro-o-tolylurethane* was obtained.

4. As in the case of phenylurethane, a solution of o-tolylurethane in carbon tetrachloride, which had been treated with nitrous acid for a shorter time, about fourteen days, contained *4-nitro-o-tolylurethane* mixed with *unchanged o-tolylurethane.*

(*b*) *Nitrous fumes.*—Dry nitrous fumes were passed for thirty minutes through a well-cooled solution of 1 gram of o-tolylurethane in 10 c.cs. of carbon tetrachloride. The yellow oil which separated solidified after some days. The product was recrystallised from carbon tetrachloride, and melted at 135° C. Since a mixture of it with *4-nitro-o-tolylurethane* also melted at the same temperature, the two substances must have been identical.

IV. *Ethyl-o-tolylurethane.*

Ethyl-o-tolylurethane, like ethyl-phenylurethane in five per cent. solution in glacial acetic acid, alcohol, and carbon tetrachloride, gave with butyl nitrite and acetic or hydrochloric acid, oily products from which no crystalline substances were isolated.

V. *Phenyl-benzylurethane.*

(*a*) *Nitrous acid.*—Five per cent. solutions of phenyl-benzylurethane in glacial acetic acid, alcohol, and carbon tetrachloride, were mixed with six molecular amounts of butyl nitrite and acetic or hydrochloric acid. The solutions were allowed to remain at the temperature of the room for eight to twelve weeks. In no case could the oily substance, finally isolated after removal of the solvent, be obtained in a crystalline condition.

(*b*) *Nitrous fumes.*—A solution of 1 gram of phenyl-benzylurethane in 10 c.cs. of glacial acetic acid was cooled in ice, and nitrous fumes were passed through it for thirty to forty-five minutes. The reddish-yellow solution was allowed to remain at the temperature of the room for a couple of days, and was then poured into water. The solution was decanted from the yellow oily solid which had separated. The latter, on recrystallisation from alcohol, gave beautiful acicular prisms which melted at 70°–71° C. A mixture of it with phenyl-4^1-nitro-benzylurethane melted about 60° C., while a similar mixture of it and 4-nitro-phenyl-benzylurethane melted at 70°–71° C. The substance was therefore *4-nitro-phenyl-benzylurethane.*

VI. *Diphenylurethane.*

(*a*) *Nitrous acid.*—From solutions of diphenylurethane in glacial acetic acid, alcohol and carbon tetrachloride to which nitrous acid, butyl nitrite and an acid, had been added, and which had been allowed to remain at the ordinary temperature for intervals up to three months, the urethane was in all cases recovered unchanged.

(*b*) *Nitrous fumes.*—1. Diphenylurethane (2 grams) was dissolved in carbon tetrachloride (20 c.cs.); the solution was cooled in iced water, and nitrous fumes were passed through it for fifteen minutes. The solvent was allowed to evaporate at the ordinary temperature, and the solid was recrystallised from carbon tetrachloride. It consisted of colourless acicular prisms which melted at 134° C., and was found to consist of pure *4-10 dinitro-diphenylurethane.*

2. Nitrous fumes were passed for fifteen minutes through a similar solution of diphenylurethane in glacial acetic acid at the ordinary temperature. The solution was allowed to remain in a stoppered flask for two days, and was then poured into water. The yellowish crystals which separated were filtered, and recrystallised from methylated spirit. The purified substance melted at 69° C., and a mixture of it with 4-nitro-diphenylurethane also melted at this temperature. Under these conditions, therefore, nitrous fumes converted the urethane into *4-nitro-diphenzylurethane.*

In another experiment in which nitrous fumes were passed into the solution, cooled in ice for thirty minutes, the yellow oil which separated on pouring the mixture into water, was recrystallised from alcohol and was then found to consist mainly of *4-10 dinitro-diphenzylurethane.*

B.—*Action of Nitrous Acid and Nitrous Fumes on Phenyl-Benzyl Ether.*

(*a*) *Nitrous acid.*—1. A five per cent. solution of phenyl-benzyl ether on glacial acid, to which six molecular quantities of butyl nitrite had been added, was allowed to remain in a stoppered flask at the ordinary temperature for three months. On evaporation of the butyl nitrite from the upper layer, which separated on pouring the mixture into water, the oily residue solidified after some time, and the product thus obtained, after recrystallisation from methylated spirit, proved to be *unchanged phenyl-benzyl-ether.* When the lower aqueous layer was extracted with ether, the ethereal solution gave, on evaporation at the room temperature, a small quantity of colourless crystalline matter melting at 104°–107° C., which was found not to consist of 4 nitrophenyl-benzyl ether, or 4-nitrophenol. We had not sufficient of the substance to establish its identity.

2. In a similar experiment to the above, in which the ether was dissolved in alcohol, the only product obtained after removal of the solvent was a brown tarry substance. This was dissolved in most of the ordinary organic solvents, but from none of the solutions could a crystalline substance be isolated.

3. Two and a half grams of phenyl-benzyl ether were dissolved in 50 grams of carbon tetrachloride to which 6 molecular quantities of butyl nitrite and 8 molecular quantities of glacial acetic acid had been added. After three months a very small quantity of colourless platy crystals had separated on the bottom of the reaction flask.

They melted at 99°–100°C., and dissolved in water, the solution giving a white precipitate, with calcium chloride.

The carbon tetrachloride solution was neutralised with barium carbonate, and on evaporation of the filtrate red oily crystals were obtained. They melted at 32°–36° C., and were found to consist of *unchanged phenyl-benzyl ether*, which was obtained pure by recrystallisation of the product from methylated spirit.

(*b*) *Nitrous fumes.*—1. Dry nitrous fumes were passed for ten minutes into an ice-cold solution of 2 grams of phenyl-benzyl ether in 20 grams of carbon tetrachloride. The colourless solution became first red and then bluish. The product was allowed to remain in an open vessel overnight, and a dark red solid separated. It was dissolved in hot carbon tetrachloride, and obtained on cooling the solution as red oily crystals, which, when pressed out on filter paper and dried, melted at 80°–98° C. On redissolving the substance in alcohol and boiling with animal charcoal, colourless leafy crystals were obtained, melting at 104°–106° C., which were found to consist of *4-nitro-phenyl-benzyl ether.*

2. When dry nitrous fumes were passed into a similar solution to the above for a longer period—about thirty minutes—a thick red solid separated from the bluish-red solution. The red crystalline product which was obtained after evaporation of the solvent at the ordinary temperature was heated with carbon tetrachloride, in which a portion of it was insoluble. This fraction consisted of reddish, scaly crystals which, when dry, melted at 182°–186° C. After recrystallisation from boiling xylene, fine, shining prismatic needles were obtained. When mixed with an equal amount of *4-10 dinitro-phenyl-benzyl-ether* (m. p. 186°), the melting point was 184°–186° C., while a mixture with 2-4-2′-trinitro-phenyl ether (m. p. 187°) melted at 148°–170° C. It must therefore be *4-10-dinitro-phenyl-benzyl ether.*

The carbon tetrachloride solution on cooling deposited white acicular prisms melting at 136°–164° C. It was not possible by repeated fractional crystallisations of this mixture from alcohol and carbon tetrachloride to separate its constituents.

C.—*Action of Nitrous Acid on Diphenylamine.*

1. Six molecular amounts of butyl nitrite were added to a solution of 2·5 grams of diphenylamine in 50 grams of glacial acetic acid, and the mixture was allowed to remain for six weeks in a stoppered flask at the temperature of the room. The yellow-coloured solution was poured into water, and the upper oily layer was separated. It solidified completely in a few minutes, and when the butyl nitrite was removed in a vacuum, the yellow crystals obtained melted at 102°–115° C. After recrystallisation from methylated spirit, the pale yellow prismatic crystals proved to be 4-nitro-diphenyl-nitrosamine melting at 133°–134° C.

A minute quantity of a green, oily substance was got by extraction of the aqueous layer with ether.

2. A 5 per cent. solution of diphenylamine in carbon tetrachloride, to

which 6 molecular amounts of butyl nitrite and glacial acetic acid had been added, quickly acquired a dark brown colour. After a month the solvent was distilled under reduced pressure, and the residue was washed with water and dried. The solid was shaken with ether and filtered. It melted at 133° C., and proved to be *4-nitro-diphenylnitrosamine.* The ethered filtrate left on evaporation a brown impure mixture of crystals, which melted over a wide range of temperature, from 60° to 120° C., but whose constituents could not be separated by fractional crystallisation from alcohol and carbon tetrachloride.

SUMMARY.

1. Nitrous acid, unlike nitric acid, has no apparent nitrating action on diphenylurethane, phenylbenzylurethane, ethylphenylurethane, ethyl-o-tolyl-urethane, or phenylbenylether, at the ordinary temperature and at low concentrations.

It converted phenylurethane and o-tolylurethane into their mononitro derivatives.

It reacted easily with diphenylamine forming 4-nitrodiphenyl-nitrosamine, and a mixture of more highly nitrated diphenyl-nitrosamines.

2. Nitrous fumes, more especially in carbon tetrachloride solution, converted diphenylurethane into 4-nitro- and 4·10-dinitro-diphenylurethane. From phenylbenzylurethane its 4-nitro derivative was obtained.

Nitrous fumes converted phenylbenzylether into the 4-nitro- and 4·10-dinitro derivatives of the latter substance.

XII.

THE GLACIAL GEOLOGY OF THE NORTH-WEST OF IRELAND.

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(Plates VIII-IX.)

[Read January 14. Published September 26, 1924.]

Contents.

I.—Introduction.

In the present paper it is proposed to describe the results of an investigation of the glacial phenomena exhibited in the extensive region lying to the west of the longitude of Cookstown,[1] and to the north of the latitude of Clones,

[1] The area to the east has been fully described by Dr. A. R. Dwerryhouse, (The Glaciation of North-Eastern Ireland. Quart. Journ. Geol. Soc., lxxix (1923), pp. 352–422.)

excepting the hilly tract lying south and west of the River Erne, Lough Erne and Upper Lough Erne. It includes the whole of the county of Donegal, the greater parts of the counties of Tyrone and Londonderry, and small portions of the counties of Fermanagh and Monaghan. It embraces some 4,300 sq. miles.

The field work occupied portions of four successive summers, and many odd weeks at other seasons of the year, amounting in all to close on 80 weeks. It is not suggested that this work by any means exhausts the glacial geology of the north-west of Ireland. It may, however, be claimed that the leading features of the glaciation and the movements of the different ice masses in space and time have been determined. The outlining of this framework now renders possible the intensive study of any small part of the country.

A preliminary account of the main conclusions arrived at in this work was given at the Cardiff Meeting of the British Association in 1920 ("Report," p. 357.)

The research was entered upon because of the difficulty which I experienced in accepting the current theories of the glaciation of the north-west of Ireland as originally enunciated by E. Hull [1] and J. R. Kilroe [2]—a scepticism due in part to a recognition of the empirical manner in which those results had been arrived at, and in part to the impossibility of reconciling them with my cursory and meagre knowledge of the glaciation of Donegal; a more extensive knowledge of the country and its glaciation has amply confirmed the suspicions then entertained.

It was at first intended to confine the examination to the Highlands of Donegal as the crucial area where these glacial theories could be put to the test. As the work progressed, however, and the importance of the Donegal ice gradually revealed itself, it was found necessary to thrust the limits of the research ever eastward and southward.

II.—BIBLIOGRAPHY AND CURRENT THEORY.

The literature dealing with the glaciation of the north-west of Ireland is singularly scanty. The drifts of the local districts have been very briefly described in the Memoirs of the Geological Survey of Ireland dealing with these areas, to which reference will be made in this paper as occasion arises. The wider problems and correlations have been considered by but few writers, prominent among whom are Maxwell Close, Carvill Lewis, J. R. Kilroe and E. Hull.

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[1] Physical Geology and Geography of Ireland, 3rd ed., 1891.

[2] Directions of Ice-Flow in the North of Ireland, as determined by the Observations of the Geological Survey. Quart. Journ. Geol. Soc., xliv (1888), pp. 827–833.

The principal contribution of the last-named to the subject was his postulate of a huge mass of ice lying to the north of the Central Plain, which he designated the "Central Snowfield." A few short extracts from his writings will show his conception of the location and function of this axis of dispersion. On page 260 (*op. cit.*) he writes:—

> "It [the "Central Snowfield"] occupies the tract lying between Lough Corrib and Lough Mask on the west, and Lough Neagh on the east—a tract coinciding with the northern portion of the Central Plain of Ireland, and bordered along the north by hills and uplands, over which the ice has moved in its efforts seawards."

On a later page (290) he extends this "axis" in an easterly direction, as is expressed in the following;—

> "This axis probably terminated not far from the present coast of Antrim."[1]

The following sentence (p. 258) gives the physical character of the country along the supposed "axis":—

> "The average elevation of the central reservoir and source of the streams [glaciers] is probably not more than 400 or 500 feet above the sea; and from this the ice moved northwards and southwards."

He recognised that this peculiar localisation of a glacial centre in a lowland region required some equally special explanation, which he sought in a naïve assumption of higher precipitation along this line during the glacial period and even at the present day. The position of this "Central Snowfield" as given in the map in this book is by no means coincident with that assigned to it in J. R. Kilroe's paper: in the former work the "axis" is represented as passing across the southern end of Upper Lough Erne, and as lying entirely to the south of Lough Allen; in the map illustrating J. R. Kilroe's paper it crosses the River Erne in the neighbourhood of Enniskillen, while Lough Allen is represented as lying completely to the south of the "axis." Though both maps are on a very small scale, such a discrepancy of approximately 15 miles is a matter of some importance, and shows how little these theories rested upon actual field observation.

To Maxwell Close has sometimes[2] been attributed the idea of the "Central Axis." I have studied his writings very carefully, including his classic paper

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[1] J. R. Kilroe (*op. cit.*, p. 8) supposes an extension of this "axis" still further east beyond the Antrim coast, "perhaps beyond it towards the Scottish coast opposite."

[2] *E.g.*, E. Hull, *op. cit.*, p. 225; J. R. Kilroe, Proc. Belfast Nat. Field Club, Ser. II, vol. vi, Pt. iv (1912-3), pp. 647 and 649; Geology of the Country around Londonderry, Mem. Geol. Surv., p. 54, foot-note.

of 1866,[1] and though his meaning is in places somewhat obscure, I have failed to discover any passage which could be allowed this interpretation. One is indeed forcibly struck with the fact that this pioneer of Irish glacial geology recognised with true insight the extreme complexity of the ice movements.

A line of dispersion traversing south Donegal was noted by J. R. Kilroe, who imagined it as a "spur or projection from the central snow field."[2] The same view was expressed by E. Hull.[3]

J. R. Kilroe (*op.cit.*, p. 831) added to this glaciation from the "Central Snow-field," an earlier glaciation by an ice-sheet which, proceeding from Scotland, flowed across North Ireland from the east coast to the Atlantic seaboard. He writes: "Hence the ice-sheet which off the Wigton and Ayrshire coast flowed on to Irish soil, and urged its way across the country, bearing previous accumulations before it, to escape on the western coast by the various bays of Donegal, Sligo, Mayo, and Galway, and over mountain groups which were unable to command an independent glacial system sufficient to obstruct or divert its flow."

In a paper published at a much later date, Kilroe[4] states he has "found it necessary to add another important ice-flow" intermediate in time between the Scottish glaciation and the later period of the "Central Snowfield," and which moved "southwards over parts of Ulster . . . . from an ice centre situated over the area of the Inner Hebrides." To the evidence upon which this intermediate glaciation is based it will be necessary to return at a later page.

J. E. Portlock, in the "Report on the Geology of Tyrone and Londonderry" of 1843, has several allusions to the glaciation of these parts of Ireland, to which reference will be made in the proper places.

H. Carvill Lewis, in his "Glacial Geology of Great Britain and Ireland," did not propound any large views of the glaciation of North Ireland: his sojourns in this part of the country were too brief. Yet this keen observer made many very apposite remarks on individual glacial occurrences, to which reference will be made as occasion arises. He would appear to have been strongly impressed with the idea of an ice-sheet in the interior of Ireland, which radiated in all directions to the coast. He started, however, with quite different views, based on the general association of glaciers with highland regions; these ideas, as it will be shown in this paper, approximated more

[1] Notes on the General Glaciation of Ireland, Journ. Roy. Geol. Soc. Ireland, vol. i, p. 207.

[2] *Op. cit.*, p. 832.   [3] *Op. cit.*, p. 272.

[4] Outlines of Geological Observations in North-east Londonderry, Belfast Nat. Field Club, Ser. II, Vol. vi, Part iv, pp. 634-663.

closely to the truth than those which he later adopted as the result of a perusal of the literature and of hurried traverses of the country.

That these views are still part of the creed of Irish geologists will be evident from the few following quotations from recent publications[1]:—

T. Hallissy, in a Memoir of the Geological Survey of Ireland,[2] of 1914, speaks (p. 29) of an

> "Irish snow-field occupying an axis running north-east and south-west, and extending right across the country to the south of the Ox Mountain range."

And again, in the Proceedings of the Royal Irish Academy of the same year[3]:

> "The great central Irish snow-shed occupied comparatively low ground, south of the Ox Mountain range, and extended along an axis running north-east and south-west from Lough Neagh to Lough Corrib. From this axis the ice moved towards the sea in all directions, swamping the whole of the present Irish area, and passing at its north-eastern and eastern margins into the Scottish glacier."

He recognises, however, the comparatively small part played by the Scottish glaciation in Ireland, for he says[4]:—

> "The Scottish ice was, however, unable to extend far into the country, and it probably never reached the western coast. The increasing accumulations of snow in the central Irish snowfield soon produced ice sufficiently massive to arrest the progress of the Scottish glacier and to deflect it westwards to the Atlantic and southwards into the Irish Sea."

As will be shown in the sequel, the onward march of the Scottish ice was stopped, not by "the accumulation of snow in the central Irish snowfield," as Mr. Hallissy suggested, but by the great ice-streams that proceeded from the Highlands of Donegal.

Professor Grenville A. J. Cole, F.R.S., in his description of the "Geology of Ireland," in the "Handbuch der Regionalen Geologie,"[5] writes of the local Irish glaciation as follows:—

> "It is now generally recognised that the principal deposition of snow occurred along an axis extending from near Galway to Lough Neagh."

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[1] The two maps illustrating J. R. Kilroe's paper, in the Journal of the Geological Society, are reproduced in the latest edition of A. J. Jukes Brown's The Building of the British Isles, 3rd edit. (1911), figs. 74 and 75.

[2] The Geology of Clare Island, County Mayo.

[3] Vol. xxxi. Pt. 7, p. 9.

[4] *Ibid.*, p. 30.

[5] Geology of Ireland, in Steinmann's Handbuch der Regionalen Geologie, 1916, p. 328.

Referring to the earlier Scottish glaciation, he remarks (p. 328):—

> "A general trend and distribution of boulders from east to west is noticeable in the north, and is doubtless connected with the epoch of maximum glaciation, when ice crossed over from Scotland."

Mr. W. B. Wright, in his book "The Quarternary Ice Age," published in 1914, clearly recognised the fact that the Donegal hills had been a centre of ice radiation; indeed, his observations and conclusions on the glaciation of North Ireland are, in their larger features, singularly accurate. Yet the error of the "Central Axis" would seem to persist in this excellent work. He writes:—

> "The mountains of Donegal appear to have given rise to a minor centre of dispersion, which formed a sort of offshoot of the great central axis of dispersion of northern and western Ireland." (p. 60.)

Thus summarily it may be stated that two basic theories of the glaciation of North Ireland have in the past found general acceptance; one, an extensive Scottish invasion of the country from the Antrim coast to an uncertain line which by Mr. T. Hallissy was drawn to the south of Lough Foyle, but by J. R. Kilroe was regarded as coincident with the Atlantic coast; the second, the overriding of this region by an ice-sheet moving northward from a central axis stretching for a distance of upwards of 100 miles from Lough Corrib in the W.S.W. to Lough Neagh, and possibly the Antrim coast, in the E.N.E.—the "Central Snowfield" of E. Hull.

It may perhaps at this place be stated that the area in this part of the country which was covered by the ice proceeding from Scotland has, as a result of these investigations, been restricted to within comparatively small limits. The "Central Snowfield," over the 80 odd miles of country assigned to it and examined by Dr. A. R. Dwerryhouse and the writer, has been shown to have no basis in the field; the character of the glaciation of the remaining, western part of the "axis," which is situated in the Sligo hills, it is hoped to investigate in the near future.

It cannot, I think, be too strongly emphasized that the "Central Irish Ice" of Mr. G. W. Lamplugh, F.R.S., which occupied the great Central Plain of the country, was completely indebted to the ice-flows, of huge size and considerable number, which streamed into the depression from the centres of radiation situated in the larger mountain masses on its borders, and of which the glaciers issuing from the Donegal Highlands were doubtless the most powerful. Escape from this pool of ice was only possible by gaps between the mountain groups. There would appear to be no evidence whatever that the ice in this pool ever assumed such thickness and dimensions as to raise its surface above that covering the rim of hills and to cause the reversion of the ice-flow.

III.—Geological Structure and Physical Features.

The map (Pl. IX) attached to this paper shows the leading physical features of the region. The reader is referred to the Geological Map of the British Isles (scale 25 miles = 1 inch) for the general geological structure.

The Donegal granite[1] forms a twin-range of mountains trending N.E.–S.W., and separated by the deep and narrow "Gweebarra Rift." To the south lie the Glendowan Mountains, to the north, the Derryveagh Hills, falling steeply to the granite plain of the Rosses. These granite ranges are flanked by parallel ridges, composed chiefly of quartzite, the northern, the Muckish-Errigal Ridge, falling almost precipitously to the schist country of the north-west, the southern, extending from near the town of Glenties, by Aghla Mountain, Scraigs, Knock Salt (1646),[2] and continuing as the Knockalla ridge of Fanad and the Raghtin More range of Inishowen. A still more southerly ridge is found in Inishowen, culminating in Slieve Snaght.

The greater part of the remainder of Donegal is composed of schist. This rock generally underlies the larger depressions and valleys of the country, though to the east of Donegal Bay it forms part of the main watershed of north-west Ireland, and further east the Sperrin Mountains and the hills extending south-west from Omagh. Associated with the schist are occasional bands of limestone, intruded sills of diorite and epidiorite, and, in certain areas, light-coloured acid dykes.[3]

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[1] This granite is red or white in colour and distinctly foliated. Detailed accounts of its petrology are given in an appendix to the Geological Survey Memoir, descriptive of sheets 3, 4, 5, 9, 10, 11, 15, 16.

[2] The figures in brackets throughout this paper indicate the altitude of the summits of hills above sea-level.

For the convenience of the reader unacquainted with the detailed geography of the country, the use of little-known place-names has been avoided, as far as consistency with the value of the paper for future workers permitted. The most important of the names employed are inserted on the accompanying maps and sketches; and throughout the paper, names to be found on the 6-inch maps, but not engraved on the 1-inch maps of the Ordnance Survey, have not been used.

[3] As the terms "felstone" and "felstone porphyry" have been used for these dykes in the Memoirs of the Geological Survey of this region, it is here deemed advisable to retain this nomenclature in order to avoid confusion, though under these terms are included rocks which, though of similar external appearance, are of very different petrological composition. They possess usually porphyritic crystals of grey and pink felspar, biotite and black prisms of hornblende and less commonly blebs of quartz, all embedded in a crypto- or microcrystalline groundmass. Though occurring singly in other areas, they are more particularly characteristic of the Dunfanaghy, Horn Head, Rosguill, Inishfree Bay, and Gweedore regions.

The Barnesmore Hills, north of Lough Eske, are composed chiefly of granite.

The town of Ballyshannon, at the mouth of the River Erne, stands at the apex of a triangular outcrop of Archaean gneissic rocks,[1] bordered on either side by beds of Carboniferous age, and with its base to the N.E. of Lough Derg. While gneisses predominate, the complex also includes granulites, granites, pegmatites, schists, eclogites, and epidiorites.

Rocks of Carboniferous age, chiefly sandstones and shales, form a strip of country surrounding Donegal Bay. They also underlie the greater part of the basin of the River Roe and the low-lying region of Draperstown, the recess in the hills east of Newtownstewart, the plain drained by the Fintona River, the Clogher and Erne valleys, and the plains of Monaghan and Cavan to the south of Slieve Beagh. The latter is composed chiefly of "Millstone Grit." Sandstones and conglomerates of O.R.S. age form the Fintona hills, separating the Clogher Valley from the Fintona Plain.

The steep face of the north-western edge of the Antrim Basalt Plateau, which rests on Chalk, Lias, and Trias, overlooks Lough Foyle, while to the east the surface of the plateau slopes out of the area under review towards the valley of the Bann.

Stretching from Omagh to Draperstown and to the south of the Sperrin Mountains is a broad, flat strip of country, designated for the purpose of this paper "the Omagh-Draperstown Corridor." It is bounded on the north by a great fault, running N.E.-S.W., and extends as a dreary expanse of turf and moorland. On the south it is closed in by a range of hills, attaining at its north-eastern end considerable altitudes, of which Oughtmore, Beleevnamore, Fir Mountain, and Slieve Gallion (just outside the area of this paper) are the chief. The trend of this range of hills is generally W.S.W.-E.N.E., coincident more or less with the prevailing strike of the rocks. These, like the rocks of much of the corridor to the north, are chiefly aphanites, schists, and gneisses, which by reason of their hardness have imparted a stern and rugged character to the scenery; even where thick turf abounds, hummocks and crags of these materials project above its surface. The sills and bosses of gabbro have been altered to epidiorites, etc.

Towards the western end of this flat country lies a small, roughly triangular tract of Ordovician and Silurian rocks,[2] near the town of Pomeroy. These

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[1] For a description of these and their relationships, see Professor G. A. J. Cole's paper, On Metamorphic Rocks in Eastern Tyrone and South Donegal, Trans. Roy. Irish Acad., vol. xxxi (1900), p. 431.

[2] W. G. Fearnsides, The Lower Palaeozoic Rocks of Pomeroy, Proc. Roy. Irish Acad., vol. xxvi B (1906-7), p. 97.

consist of thin-bedded, green or dark-coloured slates, flaggy sandstones, and coarse conglomerates.

Dotted over this area of Tyrone occur a few small patches of granite, which have been described by Professor Grenville A. J. Cole, F.R.S.[1]

Such in brief is the geographical distribution of the various types of rock in the north-west of Ireland; the countless complications, not necessary for our immediate purpose, have for the sake of clarity been omitted, though it will be readily understood that these could not be ignored in the actual field research. Thus the frequent occurrence of schist bands in the quartzite series of Donegal and the perhaps still more frequent association of quartzites with the true schist belts have exercised considerable influence upon the distribution of the erratics of these two rock-types.

IV.—Signs of Glaciation and General Character of the Drift Deposits.

Evidence of the severe glaciation of the north-west of Ireland is everywhere apparent; the beautifully rounded slopes, the dome-like hills, the moulded ridges and outcrops, and the abounding *roches moutonnées* alike attest this. The almost entire absence of arêtes, and the occurrence of erratics and striated surfaces on the summits of the highest hills, suggest that the whole country was completely buried beneath a sheet of ice, and that at the period of maximum glaciation not even the highest peaks projected as nunataks above the ice-surface.

The record of the march of the glaciers is chiefly presented, as in other areas, by striae, *roches moutonnées*, and erratics. The correlative phenomena of sub-glacial erosion and deposition agree in their indications of directions of ice-flow.

As in other centres of radiation located in mountainous regions, excess of erosion characterizes the central hilly area, excess of deposition the peripheral belt—e.g., the low-lying country of schist west of the River Foyle, the lowlands of County Tyrone and of Gweedore, and the low strip of carboniferous country which sweeps round Donegal Bay on its northern and eastern shores.

Drift is also thickly laid down in the bays of the western coast, where it probably furnished the material for the building of the magnificent sand-dunes which in so many cases fringe this coast and swing across its larger indentations. Much was doubtless carried beyond the present coasts, so that the

[1] The Geology of Slieve Gallion, in the County of Londonderry, Trans. Roy. Dublin Soc., vol. vi (Ser. II) (1897), p. 213; On Metamorphic Rocks in Eastern Tyrone and Southern Donegal, Trans. Roy. Irish Acad., vol. xxxi (1900), p. 431; see also Mem. Geol. Surv., Sheet 34, pp. 14–17.

glacial material on the land is probably to be regarded as merely an insignificant remnant of the total amount eroded and transported by the seaward-moving glaciers.

In the highlands of Donegal, the granite and quartzite outcrops which form ridges are practically destitute of drift, while the relatively low-lying strips of schist country serve as the principal receptacles of the glacial deposits.

The boulder-clay seldom, if ever, assumes a level surface, for the ice in its passage has induced the drumlin or subdued drumlin type of scenery. The major axes of these drumlin mounds present, as usual, a general parallelism with the direction of ice motion, and serve as unmistakable indicators of direction, where striae are neither preserved nor exposed. These drumlins are necessarily confined to the areas of thick drift, and are most typically and abundantly encountered in the neighbourhood of Donegal Bay.[1]

From the larger spreads of drift, long tongues run up the smaller valleys. It clings in gradually thinning sheets to the hillsides, and finally dies away, leaving only detached patches in sheltered spots, such as small hollows between bosses and ridges of solid rock, and the bottoms of little ravines and stream gullies. Generally speaking, the drift has been removed from the higher ridges and steeper faces, where the slopes were too abrupt for its permanent lodgment.

Opportunities for the examination of the drift are not abundant. Good exposures are relatively few, and are practically confined to stream and river banks and to coastal sections; the slopes of railway cuttings are usually soiled over and grass-grown, so that little or no information can be gleaned from them; while, under the extensive peat moors, the drift deposits are a sealed book. In general, the drift, as elsewhere, partakes largely of the character of the rocks upon which it immediately rests; on granite, it is chiefly granitic, on quartzite, quartzitic, and on schists is largely composed of these rocks. It seldom assumes the character of a true boulder clay, since argillaceous material for the formation of a clayey matrix is not largely available; any such matrix present has to a very great extent been formed by the breaking down of the softer schists, and is present in this form in practically all the area examined, except where Carboniferous rocks play the leading part in the build of the country. For this reason there is a sameness in the matrix of the drift, both in texture and in colour, throughout much of the highland region of Donegal, Inishowen, and the Sperrin Mountains.

On the higher hill slopes, the drift is a stony accumulation, practically

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[1] Representations of some of these features around Donegal Bay are given by W. B. Wright in The Quarternary Ice Age, figs. 15–18.

devoid of a matrix, so that in many places where "foreigners" are not present, it becomes almost indistinguishable from weathered rock *in situ.*

In the drifts of the lowland areas, lamination and stratification are seldom seen, except in those cases where the impounding of late-glacial marginal drainage with the formation of lakes has given rise to deltaic terraces. Any departures in the drifts of the plains and valleys from a uniformly stiff and tenacious deposit, in the form of lenticular bands of sand and gravel, are quite local, and any arrangement of such is generally altered or reversed in adjacent sections, when such are exposed. I have in consequence refrained from inserting any drawings or sketches of such sections, as these would serve no useful purpose. Moreover as the drift maintains the same general character over large areas, I have deemed it unnecessary to give detailed descriptions of sections, as these would involve constant repetition, incidentally swelling this paper to unmanageable proportions.[1] Mention will be made of those exposures only where the general characters are departed from.

On account of the complexity of the outcrops of the metamorphic rocks, and the large areas frequently covered by strata of a single type, it has been found difficult to pick out definite rock trains of the members of this series; boulders may have travelled great distances, or may have been derived from localities close at hand. Thus schists are usually useless for the purpose of erratic tracking; their outcrops are too great, their variations too small. The wide and irregular distribution of the diorites and epidiorites, the rapid variations in texture to which they are prone, both in parent rock and drift boulder, and the great and almost equally rapid variation in the amount of foliation and metamorphism, which can be observed on specimens derived from the same rock mass, militate against their successful employment as indicators of the direction of ice-transport. The attempt was made in all the earlier work, but had to be finally abandoned, as but little confidence was felt in the results. Yet it may in general be said that to the lee of any diorite outcrop—the direction of ice-motion having been ascertained from other data—a very pronounced increase of the diorite erratics in the drifts is noticeable. The erratics in these cases are clearly referable in bulk to such a diorite mass, and are confirmatory of the trend of the glaciation in the immediate vicinity.

When rocks occur of sufficiently distinctive type to be readily recognisable, they are unfortunately frequently useless as indicators of ice-direction, for

[1] It may here be mentioned that this paper, when it was accepted three years ago by the University of Leeds for the D.Sc. Degree, was almost twice its present size. The reduction, necessary in these days of expensive publication, has involved the ruthless sacrifice of much of the detailed observation upon which these conclusions are based.

many are situated just where the ice passed off the land on to the sea. As examples may be cited the granites outcropping at the extremities of the northern peninsulas, e.g. the deep red hornblende granite of Rosquill, a rock recognized in the field with the greatest facility, and the granites of Fanad, Dunaff Head, Malin, and Ardmalin.[1] Equally useless from this point of view are the hornblendic gneissic rocks of the islands of Torbeg, Tormore, and Inishtrahull, which differ in appearance and character from the rocks of the mainland. The chocolate-coloured sandstones and conglomerates of O.R.S. age, which lie at the northern foot of Knockalla in Fanad, are also virtually valueless for this purpose.

From these considerations it follows that rocks whose erratics are easily recognisable and traceable to their source are relatively few; notable exceptions are the granites of Donegal, Barnesmore, and Tyrone, whose fans of dispersal will be fully described in the sequel.

If, for the reasons just briefly outlined, erratics do not, with certain notable exceptions, very often afford much indication of the direction of ice-flow, the rocks fortunately are generally of a nature to retain ice-striations. In many districts, more especially in the central area of erosion, striae are remarkably common; of those observed only a small minority are inserted on the map (Pl. IX).

The various kinds of rock have behaved differently in this respect. Coarse diorite, though frequently *moutonnée*, is seldom grooved or striated; especially is this true of the coarser varieties, which have weathered badly, and of those which are highly jointed. Schist, which is soft and easily decomposed, is not frequently striated, for, though to a certain extent receptive of such scratches, these are readily removed by its rapid disintegration. Thus in the Sperrin Mountains, where bare schist covers a not inconsiderable area, not a single striated surface was observed, either by myself or by the officers of the Geological Survey. Yet where striated schist is encountered, the scratches and grooves are extremely distinct. Granite is usually too coarsely crystalline and too readily decomposed to admit of striae preservation. Hence in the Rosses, striations are relatively rare, though bare granite covers virtually the whole region.[2]

Quartzites have commonly preserved the finest ice-polish and the most delicate ice-markings.

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[1] The granites of Ardmalin and Malin are red and coarser than the grey Dunaff Head granite, and, unlike the latter, show clear evidence of metamorphism. The Fanad granite is also red, and in places foliated.

[2] On the map (Pl. IX) all the striae observed on the granite outcrops are inserted.

The younger Palaeozoic rocks, i.e. the different members of the O.R.S. and Carboniferous systems, very rarely indeed show signs of ice-scratches; and this fact, together with the great thickness and abundance of the drift deposits in the peripheral areas where these rocks occur, explains the virtual absence of striae in this part of the country—a feature which the accompanying map (Pl. IX) renders strikingly apparent. Yet at Muckros, north of Donegal Bay, the coarse Carboniferous conglomerate has preserved its striations both on the constituent boulders of quartz and quartzite, and on the enclosing matrix.

Roches moutonnées of all sizes occur in the greatest profusion, especially in the Donegal mountains, ranging from some of the largest hills in the country down to the small rounded knobs of which hundreds may dot the floor of a small valley.[1]

The striae and *roches moutonnées* afford an extremely complete and satisfactory body of evidence as to the direction of movement of the ice-masses in the region under review, and throw considerable light upon the general character of the glaciation. They bear witness to the intensity and persistence with which the ice performed its work. Striae and grooves occur at all altitudes up to the summits of the highest mountains. Generally speaking, they are most plentiful on the flanks and summits of the ridges and hills, and rarer in the bottoms of the valleys and glens.

Boulder transport and striae directions are also in striking agreement, together forming a consistent system. In all the larger Donegal valleys, with but few exceptions, the direction of the striae and the boulder trains shows that the movement of the ice was along their lengths and generally parallel with the trend of the larger ridges. In some instances the striae indicate the turning aside of the ice, as the result of the deflecting influence of the local topography, the deviation from the general direction being such as a study of the local relief would suggest. On the ridges evidence is occasionally found of the oblique passage of ice across the axes of the valleys, suggesting the movement of the upper portions of the ice in a direction differing from that of the lower parts which were hemmed in between the valley sides.

Terminal curvature was observed in a number of places.

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[1] Where almost every irregularity in the surface is a *roche moutonnée,* the use of a special symbol to indicate such would no longer have any particular utility, and such a sign has therefore not been used on the accompanying map.

V.—The Earlier Scottish Glaciation.

Three more or less distinct glacial episodes are distinctly recognisable in the region under review; the first, an early invasion of the eastern parts by Scottish ice, advancing from the east, followed by a severe glaciation of the whole area by ice proceeding from the Donegal Highlands, and lastly a retreat of the local ice and a re-advance of the eastern ice. These successive phases will be described in the order of their occurrence.

Dr. A. R. Dwerryhouse has shown that the Scottish ice invaded the north-east of Ireland, and, transporting the rocks from those parts of Scotland which lay in its path, both from the mainland and the adjacent islands, proceeded in a general south-westerly direction over the counties of Antrim and Londonderry. Further south, it progressed in a more southerly direction to the Mourne and Carlingford Mountains, overriding these hills and passing out to sea.

The whole of that country examined by him was covered by the Scottish ice, and the limits of the invasion are therefore to be sought in the region dealt with in this communication.

There are two quite distinct areas of Scottish or eastern drift in this country, one situated in Inishowen and to the north of the Sperrin Mountains, the other to the south of these mountains in the counties of Tyrone and Monaghan.

The evidence for this earlier Scottish glaciation is furnished by the presence in the drifts of erratics referable to Antrim or eastern sources, e.g. chalk-flints, chalk, and basalt, and occasionally to some Scottish parent rock, as the striae of this phase have, except in a few instances, been effaced by the later ice proceeding from the south and south-west.

Flints are very common in the drifts of all the valleys of Inishowen, and may be found on almost any surface on the intervening tablelands and moors. In the Bredagh river, an echinoderm was found loose in the drift. In the west of the peninsula, flints up to 4 inches in diameter and associated with occasional boulders of basalt were obtained in many places in the thick drifts of the Owenerk, Crana, Mill, and Owenkillew rivers. They were even observed in the Lough Swilly area, namely in the fine sections in the streams draining the western flanks of Raghtin More.

Fragments of chalk, though generally distributed, are far less plentiful. "Chloritic Chalk" was found in a few places in the east of the peninsula, e.g in the Bredagh Glen, and in the stream W. of Greencastle.

Basalt boulders and pebbles are not uncommon, especially in the drifts of east Inishowen. As the tertiary basalt dykes traversing the rocks of this peninsula are indistinguishable from those of like age in the counties of Antrim and Londonderry, it might be supposed that the occurrence of basalt erratics and boulders in the drifts of Inishowen could not be regarded as clear proof of transportation by ice from the east; but the great rarity of these dykes in Inishowen itself (only four occur in the whole peninsula of over 300 square miles, though the possibility of the existence of others concealed by drift and peat may not be lost sight of), together with the undoubted flints and chalk fragments of the drifts, would seem very strongly to suggest an Antrim or Londonderry origin for these basalt erratics.

Though these eastern erratics are universally distributed throughout Inishowen, they show a distinct tendency to decrease in size and numbers, as the drifts are traced westwards from the Foyle to the Swilly—a decrease the more distinctly noticeable if sections in the extreme east and west are compared. This distribution indicates a western transportation. This feature in the distribution is still readily recognizable, despite the ploughing action of the later ice, which must have swept along the earlier-formed deposits and modified the distribution of their erratic ingredients.

The most south-westerly occurrence of this drift is at the Burnfoot brickfield in the "Pennyburn depression." It is described in the Geological Survey Memoir,[1] which records the finding of a well-preserved *gryphaea incurva* from the Lias of the north-east. A very fine section in drift of similar composition is also to be seen in the Low Moor Road quarry, Londonderry City, and is described in the same Memoir (p. 38).

The Scottish drifts of Inishowen, as indeed wherever they occur within the limits of the country investigated in this work, have been churned up and greatly modified by the later ice-sheet from Donegal, which has added its quota of erratics to the boulder-clay. In the area lying immediately to the south of the Foyle estuary, however, a pure, unmixed eastern boulder-clay is still preserved in places. Its occurrence is restricted to the lower parts of the valleys where it was more or less shielded from the ploughing action of the later northward-moving ice. In all the localities where this boulder-clay is to be found it possesses similar characteristics, being a highly calcareous and argillaceous deposit, derived largely from the disintegration of chalk and basalt. The enclosed pebbles and fragments are chiefly of these two rocks, with great numbers of chalk-flints and a few pieces of mica-schist. It is exposed in the banks of the Sheskin river at Eglintin, and in the lower part of a steep face in the banks of the same river, some three quarters of a mile south of Faughanvale Bridge; in the Gresteel Burn, where the sections

[1] Geology of the Country around Londonderry, 1908, p. 29.

are largely overgrown with vegetation and obscure; and in the banks and bed of the Castle River.

In a stream bounding Ardinarrive, two miles west of the River Roe, this eastern drift also occurs as a hard compact brown boulder-clay, composed almost wholly of basalt boulders and pebbles, but containing also some chalk-flints and chalk-fragments.

The location of these occurrences of pure eastern boulder-clay is indicated by asterisks on the map (Pl. IX).

The great chalk-basalt escarpment of the Antrim plateau lies well to the east of all these localities, so that this boulder-clay is to be regarded as the deposit of an ice-sheet moving off the plateau westerly or south-westerly. As J. R. Kilroe has expressed it:—

> "That a westward ice-movement existed prior to the latest glaciation, is at least consistent with the occurrence of Scottish boulders on the ground, and of a boulder-clay in the glens, with stones from easterly sources. The sparse yet general occurrence of this boulder-clay, its preservation only in glens, the presence in water-worn gravels washed from the glens of such travelled stones as the boulder-clay is known to contain, and the present prevalence of grey boulder-clay of local origin, are all facts consistent with the supposition that the purple clay once enjoyed a wide distribution, to be since almost entirely swept from the ground by the ice-sheet which, as we have seen, moved from the south and south-west later in the period." (Londonderry Memoir, p. 54.)

This view of an easterly or north-easterly origin is confirmed by the presence of shells in the deposits. These shells scattered promiscuously throughout the matrix are generally comminuted, though a few whole ones are to be met with; some are in fair condition and quite recognizable. Those collected by the Geological Survey were identified as *Tellina baltica*, *Leda pernula*, *Mya truncata*, *Saxicava*, and the crustacean *Balanus*. I have been unable to add to this short list.

At Bovevagh and other places in the valley of the Roe, a *Turritella* bearing-clay occurs; *Turritella*, as Portlock observed, has been dredged in large numbers from Lough Foyle. These shells were without doubt scooped up from the bottom of the adjacent seas by the invading ice and dumped on the land in the sub-glacial deposits, as has now so often, in the study of the British drifts, been shown to have obtained where ice moved from sea to land. These shelly clays were discovered by Portlock, but were assumed by him [1]

[1] Report of Londonderry and Tyrone (1843), p. 157.

to represent marine deposits of tertiary age, and the shells therefore to have been buried *in situ*.

The distribution of these shelly localities is indicated in the accompanying map (Pl. IX) by the letter S.

Two ounces of the shell-bearing clay from Eglinton were submitted by the Geological Survey to Mr. Joseph Wright, F.G.S., of Belfast, who identified some seventeen species of foraminifera, a list of which is given in the Londonderry Memoir (p. 55).

The finding of the riebeckite paisanite of Ailsa Craig, by members of the Belfast Naturalists' Field Club at Limavady and at Moys,[1] is strong confirmatory evidence of a westerly moving ice-sheet, though these erratics, as others of similarly easterly origin, may have been slightly removed to their present sites by the subsequent south-north glaciation from points situated higher up the valleys and more south-easterly. No pebbles of this Ailsa Craig rock were discovered by the Geological Survey in the drifts west of these two localities; nor were my own diligent and deliberate searches for fragments of this very conspicuous rock better rewarded.

A question of some interest and importance is the possibility of the derivation of these Antrim erratics by a rather more circuitous route from an older flint-bearing drift that lay to the south of the path of the Donegal ice. In my earlier efforts at reconstructing the glacial events of Inishowen, I adopted this view, feeling that the elimination of a glaciation was due to the principle of economy. The arguments against such a circuitous origin are, however, too weighty. Apart from the insuperable and fatal difficulty encountered at the outset in the total absence of flints, etc., in the drifts of the country to the south, namely, in south Londonderry and north Tyrone, whence they would be supposed on this view to have been derived by the northward-moving ice, the presence of the shells in the drift, and more especially the distribution of this shelly drift, also the occurrence of two totally distinct boulder clays in the country south of the Foyle estuary—an older and lower containing only eastern material, a newer and upper containing only western rocks—militate against this possible source of the flints. Moreover, the quite appreciable decrease of the flints, in size and numbers, as traced westwards across Inishowen, though not necessarily contradictory of this hypothesis, is more in harmony with the view of the transport from a direct eastern source as here presented and as maintained by all the earlier workers in the area. Thus it would seem that the drifts were deposited by a westerly moving ice-sheet, and were later removed from the exposed higher ground and preserved only in the deeper and more sheltered glens.

[1] Proc. Belfast Nat. Field Club, Ser. II, vol. vi (1913), pp. 581, 582.

The whole of Inishowen, therefore, with the probable exceptions of its higher parts, e.g. Slieve Snaght and Raghtin More, would appear to have been overridden at this stage by the Scottish or eastern ice. In the north the ice passed in a general westerly direction along the great depression, extending from Culdaff to Lough Swilly; the striae and grooves running slightly south of west, observed at Fegart at the eastern extremity of Doagh Island, may have been produced at this time.

Further south, this ice-sheet would tend to bear in a more southerly direction, and overriding the northern foot hills of the Sperrin Mountains, impinge on the slopes of these mountains in a direction almost at right angles to their course.

The entire absence of any trace of Antrim or eastern erratics in the Donegal drift west of the Swilly suggests, in view of their abundance on the Inishowen side of that inlet, that the highlands of Donegal were never invaded by the Scottish ice, but that its western limit was roughly coincident with the line of Lough Swilly.

As already pointed out, J. R. Kilroe postulated a glaciation from the north, intermediate between the Scottish and later local glaciations; the shelly drift just described, more particularly, however, that occurring some 12 miles inland at 500 feet O.D. in the bank of a stream bounding Gortnarne, is part[1] of the evidence upon which he bases this additional glaciation. He writes[2]:—

> "The ice-sheet bearing these materials must have flowed southward with a fair measure of directness, else it could scarcely have borne the materials to such a height on the *east* side of the valley [Roe.] On the sea-floor it would have found shells, mingled with marly clay and rounded *débris* of the basalt, as well as splinters of chalk and chalk-flints, many of which stud the Boulder-clay."

It is, however, scarcely necessary to have recourse to a separate glaciation to explain these shelly boulder-clay occurrences. They are but part of the basalt and flint-bearing drift whose distribution in this northern area has just been traced, and are therefore to be conceived, equally with this, as the product in this area of the Scottish ice of the north-east of Ireland and not of a glaciation distinct from this in area and in date.[3]

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[1] The remaining part will be dealt with in a later section.

[2] Proc. Belfast Nat. Field Club (1913), p. 651.

[3] We may, perhaps, quote Mr. Kilroe against himself. In the "Londonderry Memoir" (p. 56), referring to these shell-bearing deposits in the Roe Valley, he says:—These are "suggestive of an ice-movement across the County of Antrim, which would be in accord with the east-to-west striae above mentioned. There is no record of striation along the Roe Valley indicative of an ice-flow towards the south."

The evidence of the Scottish glaciation of the southern area, south of the Sperrin Mountains, is not exclusively based on the flints and other rocks of County Antrim origin, for the biotite granites of County Tyrone are also involved. Space forbids a detailed description of their distribution. A few localities on the outer margin of their occurrence may, however, be mentioned; the others may be comprehensively dismissed by the statement that within the boundary so delineated flints and other eastern erratics occur sporadically in the drift sections.

To the west of Donaghmore, along the foot of the O.R.S. hills, flints begin to appear. They are present in sections at Greystones with local Carboniferous rocks. The flints are baked and unbaked, and are accompanied by a few granite boulders. At Upper Kerrib (and in other sections in gravels in its vicinity and to the south of the railway) flints occur in extraordinary abundance, both baked and unbaked varieties, with a few pieces of chalk and boulders of granite. In the Donaghmore area flints are plentiful. They were also found in gravel sections near Cavanacaw Lough, with some pyroxenic rocks and granite from Tyrone. A similar assemblage was observed in the drift near Moree House, some 3½ miles east of Pomeroy. At Smotan Bridge on the eastern slopes of Slieve Beagh, at an altitude of ca. 500 feet O.D., very good exposures show drift containing—besides pebbles and boulders of local Carboniferous limestone and grits and a few porphyries from the O.R.S. tract to the north—one granite boulder and a few flints.[1] The paisanite of Ailsa Craig has been found at Monaghan and near Cookstown.

The abundance of the flints in this area is doubtless due to the largeness of the outcrop of chalk to the south-east of Lough Neagh. This outcrop, as other evidence shows, lay directly in the path of the Scottish ice which overrode the country around Donaghmore. The possibility of unknown outliers of chalk concealed beneath these thick drifts may not, however, be ignored.

The western limit of the eastern erratics may now be briefly sketched, proceeding from north to south. Coincident with the line of Lough Swilly to the west of Inishowen, it runs roughly along the Pennyburn depression, which separates the hills of Inishowen from those to the south—flints are absent from the drifts S.W. of this valley. Including the city of Londonderry in the area covered by the eastern drifts, it swings across the foot hills of the Sperrin Mountains to the hill of Loughermore,[2] along the east side of

[1] Chalk and chalk-flints have been observed in the country to the south of this, among other places at Annyart, near Castleblayney. (Mem. Geol. Surv., Sheet 59, p. 24.)

[2] The erratics of green schist, coarse epidiorite, and lamprophyre noted by Professor Seymour (Londonderry Memoir, p. 73) in the district south of this line are far more

Altahullion, across the Owenbeg and Owenreagh Rivers, and along the southern slopes of the Benady Glen. Farther east it was found impossible to trace the boundary, as the drift becomes a purely local stony accumulation —e g., at Eden Lodge and in Glenshane Pass—formed almost entirely of basalt *debris* and without doubt the product of both the Scottish and Donegal ice-sheets in this upland region.

In the country lying generally to the south of the Sperrin Mountains, the boundary again becomes fairly distinct. It runs south from east of Draperstown, along the eastern slopes of the Beleevnamore range, and to the south-east of Pomeroy, continuing along the southern slopes of the O.R.S. ridge and across the Clogher valley on to the eastern flanks of Slieve Beagh, and to the neighbourhood of the town of Monaghan.

The western limit of this glaciation is approximately laid down on the map (Pl. IX).

It is significant that, especially in the southern area, the eastern erratics are frequently to be found in moraine accumulations and outwash sands and gravels formed during the retreat of the Donegal ice. This association indicates the redistribution of these erratics at a later period by the Donegal glaciers, though to what extent this has taken place it is impossible to determine. As these glaciers were, in general, moving in a direction contrary to that taken by the Scottish ice, the true limit of the eastern drift, when first deposited, and therefore of the Scottish ice-sheet, must have lain to some extent *outside* the limit of the present distribution of the erratics as just delineated.

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probably derived from local sources, just S.W. of their outcrop, than from more distant sources, such as the metamorphic complex of N.E. Antrim, as suggested by this writer. This supposition of a local origin is strongly borne out by the huge "Meskan erratic" (10 × 6 × 6 feet) occurring ca. 1 mile W. of Claudy, and petrographically described in the Memoir. Here this large erratic is said petrographically to be "quite unlike any rock hitherto found in Ireland." It can, however, have had only a local origin. That the outcrop of this rock, as of many others found as erratics in the drifts, has not been discovered is not surprising in view of the great thickness and extent of the boulder-clay and the terracic deposits.

The absence of chalk or chalk-flints from the glacial deposits south of this line, none being recorded by Professor Seymour or having been found by myself, would be difficult of explanation had this area been earlier overridden by ice from the east. (The "large flake of white flint" found by Professor Seymour "on the hill-slopes" of Curryfree Hill (Londonderry Memoir, p. 75) can scarcely be regarded as sufficient proof of this earlier glaciation.) Should flints, chalk, or other undoubted eastern erratics be later discovered in the actual glacial deposits in the area south of the approximate line represented on the map (fig. 1), a southward shifting of this margin in conformity with the find or finds would have to be made. Any such slight adjustment of the boundary would, however, not make any fundamental change in the scheme of glaciation as elaborated in this paper.

This line, as a glance at the map shows, possesses two great salients, to the north and south respectively of the Sperrin Mountains. They are in part to be attributed to the barrier of local ice centring in these hills, which probably deflected the invading ice to the north-west and south-west, in part to the directions of principal thrust of the Scottish ice. This was split off the north-east coast of Antrim into two great streams, the one proceeding, as Dr. A. R. Dwerryhouse has shown, in an approximately east-west direction, as on Rathlin Island and Fair Head, the other roughly south-west and south over the counties of Antrim and Down. This ice, after surmounting the Antrim plateau, would find to the south-west in the direction of Lough Neagh and Monaghan no hilly barrier to its progress. Obstructed by the Sperrin Mountains and their glaciers, it would therefore find relief by pressing down towards the Clogher valley and by fanning over the Monaghan region.

Mr. W. B. Wright[1] has clearly recognized the comparatively restricted area covered by the Scottish ice in North Ireland; indeed his map (fig. 27) depicting the directions of ice-flow in Britain errs rather on the side of representing that area as somewhat smaller than it actually was—an error doubtless due to the conflicting evidence of the later glaciation. Of other writers, Mr. T. Hallissy alone has expressed views as to the western limit of the Scottish ice which are at all in agreement with the results obtained in this investigation. In his paper on the Geology of Clare Island he writes[2] with reference to this question:—"Judging from the distribution of these foreign boulders, it seems likely that a line running south-east from the mouth of the river Foyle marks approximately the limit to which the Scottish glacier penetrated into the country"—though in the same year (1914), in the Memoir of the Geological Survey descriptive of the Monaghan area, he doubtfully attributes the N.E.–S.W. drift ridges of that district to this same Scottish ice (p. 16).

The relationship of this invading ice to the Donegal glaciers is very obscure. In the south, no evidence was obtained on this point.

In the north, evidence of a kind is not lacking. A crucial section would appear to be that of Low Moor Road quarry in the city of Londonderry, to which reference has already been made, and which has been fully described in the Londonderry Memoir (p. 38) from which the following has been taken:—

> "A fine section of gravel and sand, resting on solid rock, with later boulder-clay covering it, is laid open to view. In the bottom of the pit over fifty feet of reddish sharp sand, with coarse and fine irregularly

[1] Quaternary Ice Age (1914), fig. 27.
[2] Proc. Roy. Irish Academy, vol. xxxi (1914), Pt. 7, p. 9.

stratified gravel, are seen to overlie a boss of water-worn schistose rock. The red sand and gravel deposit is overlain by 25 to 30 feet of the usual yellowish boulder-clay of the country [the Donegal boulder-clay]. This gravel deposit is evidently connected with the early or Scottish ice-sheet, for the stones in it [chalk-flints, chalk, triassic, and carboniferous sandstones, tertiary dolerites, schists, and local rocks] are such as would be derived from the washing of the older boulder-clay deposits."

It will be noticed there is no true Scottish boulder-clay, and the question naturally suggests itself, whether these sands and gravels of the lower part of the section may not represent the water-worn sands and gravels formed as outwash sheets along the front of the Scottish ice. Significantly, the location of the deposit is just on the line where, from the other data already presented, the edge of the ice is presumed to have stood. This would indicate that a tract of ice-free country, of unknown extent, lay to the south, where the outwash gravels from the ice-face could be spread, and so furnish evidence to the effect that the Scottish and the Donegal ice-sheets were at any rate at this period discontinuous. The very large pre-glacial valley, now virtually streamless and floored with drift, which runs from Carrigans on the Foyle to the Swilly, may have been the course of the diverted waters of the Foyle, swollen by the melt waters of the ice at Omagh and in Donegal. Ice advancing along the north Antrim coast would doubtless thrust a lobe into the Foyle estuary, probably as far as the site of Londonderry, where the hills come together, long before it covered the adjacent bounding hills of Inishowen and the Antrim plateau. At this stage some of the shelly boulder-clay south of the Foyle estuary may have been laid down, the sands and gravels of the Low Moor Road section swept out of the ice as outwash gravels, and the flood waters of the Foyle diverted by the valley containing Port Lough into the Swilly. The Donegal ice at this stage would be well to the west. Probably the Donegal and Scottish ice-masses waxed simultaneously, the invading somewhat faster than the local ice.

The import of the river sections near Draperstown, however, would seem to be that in this area resistance was offered to the Scottish by the local ice. In a few places in the banks of the White Water, south-west of Draperstown, extremely fine sections of boulder-clay are exposed. This is seen to rest on rock, and consists throughout from bottom to top of a homogeneous clay, charged with boulders from western sources. No erratics indicative of an eastern source were discovered by Dr. A. R. Dwerryhouse or myself. These sections are less than 300 feet above sea-level.

The overriding of much of Inishowen by Scottish ice seems quite irreconcilable with the halting of the same ice-sheet at Draperstown at but a small elevation above the sea, unless it be supposed that a barrier existed here in the shape of a great mass of local ice. Against the obvious objection that suggests itself, that the earlier Scottish drifts may have been cleaned out by the later ice advancing from the south-west, it may be remarked that had this taken place, some evidence should be forthcoming of the incorporation of these eastern erratics in the newer drifts, to form a composite boulder-clay, as is invariably the case in Inishowen, where, as we have already seen, such a succession of events actually took place. Moreover, the sites of these sections are very similar to those in the country south of Lough Foyle, where the earlier drift has been preserved intact as a pure and unmixed eastern boulder-clay. Thus it would seem that to the east of Draperstown the local and the invading ice sheets were actually in contact, the former being chiefly ice centring in the Sperrin Mountains, though reinforced possibly by ice from the west.

VI.—The Donegal Glaciation during its Maximum Phase.

While the Scottish ice was gradually encroaching on the eastern parts of the region, and slowly thrusting its ice-front towards the west, a series of glaciers, centring in the Highlands of Donegal, was growing outwards and creeping in the direction of the invader. Of this early phase no trace now exists. The great erosive action of the prolonged ice-movement that followed has swept away all its products and completely effaced all the effects of its glaciation, save one—the corries.

If the early stages of the glaciation of Donegal are wrapped in obscurity, the story of the ice at its maximum phase is, on the other hand, in its broad outlines by no means difficult to decipher, for the approximate direction followed by the lower and even upper currents of the great ice-sheet can be very readily ascertained. The striae are of sufficient abundance to prove a general divergence of the ice from the central portion of the mountainous district. The erratics furnish confirmation of this outward flow, the boulder streams participating in the dominant movement and passing radially down the larger depressions towards the peripheral belt of deposition.

The principal line of ice-shedding shown on the general map (Pl. IX) was in the main coincident with part of the present principal watershed of Donegal. It ran roughly from Clogher North, in the north-west, passed Croveenananta, Lavagh More, Blue Stack, to the south of Binmore, Croaghbarnes, Croaghanimore, Croaghconnellagh, to Barnesmore in the south-east. This great rounded Donegal ice-shed continued to the south-east of the high granite hills of Barnesmore, along the mountains to Lough Derg. On this part of the ice-shed lay the summits of Croaghnameal and Ardmore Hill.

The accuracy with which this line can be fixed varies over different parts of its length; in some places, as in the valley of the Barnes river, it can be laid down within a few yards; in others a strip of indeterminate country exists within which its position cannot be definitely located. As over the whole length the rocks on either side of the ice-shed are of one kind, either granite, as in the central part, or schist, as in the terminal portions, erratics of these are quite useless for fixing its position. The *roches moutonnées,* however, serve as a very clear and infallible guide.[1]

In places the ice-shed would appear to have been eccentric and to have lain somewhat to the north, though only slightly, of the present watershed. This eccentricity was probably due to the more favourable conditions on the southern side for the ready descent to the sea, the distance being much shorter and obstructing hills absent, while the resistance of the Scottish ice to the east and north-east may have been a contributory cause.

Lough Derg, situated astride the watershed towards one extremity of this ice-shed, was the site of a pool of ice on the line of parting, from which glaciers moved away to the north-east and to the south-west. From this great gathering-ground, located chiefly in the granite hills of Croaghgorm, Bluestack, and Barnesmore, the ice proceeded irresistibly outward and forward, occasionally ignoring mountains and ridges in its course, yet in general conforming with the valley-lines. It overrode the hills of Inishowen on the north-east, the Sperrin Mountains on the east, and the Fintona and Slieve Beagh hills on the south-east. Only to the west was the advance of the ice unimpeded by any great hilly barrier, so that here it was able to proceed unhindered far west over the low-lying land of south Donegal and over Donegal Bay to the open Atlantic and the 100-fathom line.

As there can be little doubt that some relationship exists between the height and size of a mountainous mass acting as a radiation centre and the extent of the country covered by the glacial streams proceeding from it, it is not surprising to find that the Donegal hills, though much smaller than the congeries of mountains which formed the glacial centres of the Scottish Highlands and the territory covered by their glaciers, should have given rise to an ice-sheet which buried a very large region, whose great extent, prior to

[1] As observed in the Geological Survey Memoir (Sheet 24, p. 38), "flatly worn pieces of mica-schists" are found occasionally on the highest parts of the Croaghbarnes hills, at a level of about 1600 feet. Though some of these are most probably not erratics, as is there suggested, but residual pieces of the probably once continuous roof of schist which covered over the granite dome, the majority are doubtless proof of eccentricity of the ice-shed.

the investigations of Dr. A. R. Dwerryhouse and myself, had not been suspected. At a moderate estimate some six to seven thousand square miles of country must have been covered by ice that had its immediate origin in the Donegal hills.

The direction of ice-motion was profoundly affected by the two mountainous masses of Derryveagh on the north and of Sligo on the south, the former, by obstructing the free flow of the ice, being in part responsible for the great extension of the Donegal glaciers to the north-east, and for the overriding of the Sperrin Mountains; the latter, for a like reason, for the glaciation of Slieve Beagh and of Monaghan, and also for the great glaciers that poured in the extreme north-east down the valley of the Bann, and in the south that fed the "Central Irish Ice."

The Sligo hills, crowned by a local ice-cap, served as an effective dam to the Donegal ice, causing it to be deflected along their northern face westwards into Donegal Bay, and eastwards and south-eastwards into the northern part of the Central Plain.

The mass of the Sperrin Mountains, with its local radiation, without doubt also barred the progress of the ice in the earlier stages, though later the glaciers piled up along its western flanks, and finally overflowed its summits. This obstructing action of the Sperrins would tend to produce a huge ice-sheet of practically level surface, just as on a far larger scale the Jura Mountains evened up the great Swiss glaciers.

In the sketch of the glaciation which follows it is proposed, after considering the effects of the ice in the country situated along the ice-shed, to give the salient features of the glaciation in the different areas, beginning with the south-west, and working round in a clock-wise direction to the south-east. The order of treatment will therefore be the following:—

1. Country along the Ice-shed.
2. Drumlin Belt around Donegal Bay.
3. Glengesh Plateau.
4. Derryveagh and Glendowan Mountains.
5. Errigal-Muckish Ridge.
6. Rosses and Bloody Foreland.
7. Northern Peninsulas.
8. Valleys of the Finn and Foyle.
9. Inishowen.
10. Sperrin Mountains and Foyle Estuary.
11. Barnesmore granite boulder dispersal.
12. South-eastern area.

1. *The country along the Ice-shed.*

The Bluestack and Barnesmore granite hills situate in the central section of the ice-shed, exhibit smooth *moutonnée* summits, beautifully rounded shoulders, and steep glaciated sides which descend sharply into broad U valleys. The striae bear generally N.E.-S.W.—i e., parallel with the axes of the valleys.

On the south side of the granite massif, where the surface falls steeply to the country occupied by the sedimentary and schistose rocks, a series of rock-basins—e.g., L. Aderry, L. Ankeeran, L. Gulladuff—were excavated in the floors of the smaller steps by which the big break is accomplished while the vertical rock faces of the steps are frequently striated.

In the elevated country of schist which stretches to the south-east of the Barnesmore hills, the same parting of the ice is also recognisable. Moorland country for the most part, the evidence is not so easily obtained. Yet the few striae[1] observed, the form of the ground, the *roches moutonnées*, the position of the perched blocks, the ridges of drift within the area, and the drumlin mounds in the adjacent country serve as unmistakable signs of the direction of ice-motion.

2. *The Drumlin Belt around Donegal Bay.*

The drumlins of the country skirting Donegal Bay are developed with a sharpness of outline and clearness of arrangement nowhere equalled or approached in the whole of the region examined. They are, perhaps, most finely exhibited in the neighbourhood of Donegal town. The contoured maps of the country around and bordering on Donegal Bay—e.g., the Ordnance map of Donegal town (Sheet 23)—bring this out most strikingly. Generally these features are separate, only occasionally coalescing, overlapping, or mutually interfering.

Some of these mounds are doubtless fashioned in rock by direct sub-glacial erosion, possessing a large " solid " core and merely a thin coating of boulder-clay, thickening from the crest to the margin. More particularly is this true of those distributed on the inland side of the drumlin belt, where the " solid " hills begin. Some even prove to be entirely " solid " features—e.g., the basalt hill near Donegal town.

It is not proposed to discuss here the question of the form of the drumlins.

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[1] The striae, occurring north of Clogher Hill at the head of the Leaghany River, and marked on Mr. W. B. Wright's map (The Drumlin Topography of South Donegal, Pl. VIII), trend, I think, east, not west, as there suggested. Those recorded from two localities 4 miles west and south-west respectively of Killeter, were certainly produced by ice proceeding eastward in the opposite direction to that there represented.

This has been done by Mr. W. B. Wright in his paper on the drumlin country of Pettigo.[1] It may, however, be here remarked, in view of some divergence of opinion on the position of the blunt and higher end of the drumlin, that this was found in general to be situated towards the stoss side of the mound, the narrower, and more gently sloping end towards the lee.

This peculiar topography extends from Killybegs on the west, round the whole of the northern shores of Donegal Bay to Donegal town at the head of the bay, and inland generally to the foot of the hills bounding the coastal plain. It is equally well developed along the eastern shores of the bay, as far as and even beyond Ballyshannon and the River Erne, in the country east of Pettigo, and north of Castle Caldwell.

In certain areas the drumlins pass insensibly into the hill country behind, in which direction their drift cover becomes ever thinner at the expense of the rock core. This gradual transition from undoubted drumlin to equally pronounced hill country, characterized by rounded and moulded "solid" forms, is well seen in the area south of the Eglish valley, where the huge drumlin-like mounds, of much larger dimensions than usual, rise above the general surface of the country, their larger axes parallel with the general direction of the glaciation of the district. A similar transition takes place over the country to the north-east of Ederny, and to the south-east of Donegal town. In all these areas it is difficult or even impossible to draw a line separating the true drift drumlin from the moulded "solid" feature. This behaviour of the drumlins would appear to support the erosion theory of their origin.

In other areas there exists between the drumlin country and the highland a strip of irregular and very broken surface, as can be observed in the district extending between Barnesmore and the Clogher valley (lying east of Donegal town), and also along part of the eastern margin of the Glengesh Plateau. The transition forms occur therefore where the ground rises gradually into the hills, the discontinuity of form where the hills fall fairly steeply to the plain.

Between the ridges and mounds lie small lakes and ponds, while water-logged hollows and flats of peat or alluvial soil indicate the sites of former drift-dammed lakes. As examples of such inter-drumlin lakes may be cited Drumoske L., Drumhome L., and Birra L., all in the vicinity of Rossnowlagh, and Trumman L., to the north-east of Bridge Town; L. Ardnagossan and the lough at Tullynagran are of similar origin. These inter-drumlin lakes are also extremely numerous in the lowland situated to the east of Donegal Bay,

[1] The Drumlin Topography of South Donegal: Geol. Mag., N.S., Dec. v, vol. ix (1912), pp. 153-9.

between Donegal town, Ballyshannon, and Pettigo. That these are due to impounding of the drainage by drumlins, and not to solution of the soluble carboniferous limestone, is proved by their equal abundance on the relatively insoluble schist.

The drumlins have also regulated the course of the drainage, and caused the streams in general to flow parallel with the drumlin trend.[1]

The drumlin type of scenery is also characteristic of the fertile country encircling Lough Erne, the finest development being found along its eastern shores. Here the numerous inter-drumlin lakes include L. Bresk, White L., and Ballydoolagh L., while there are also present, as in the major drumlin country, large and small areas of turf, as near Mossfield Lower, marking the position of infilled lakes. The islets in Lough Erne, especially those at the Enniskillen end of the lake, are formed of one or more drumlins. These also form the promontories jutting into the lake, while in other cases they separate small lakelets from the main sheet of water.

These drumlins strikingly demonstrate the lines of ice-flow. They sweep round into Donegal Bay in wide swinging curves, their trend governed in part by the contours of the adjacent high ground, and running parallel with the general direction in which the drift has travelled. Thus their course, which towards the west of the belt north of Killybegs is approximately north-south, swings gradually round to east-west, in the neighbourhood of Ballyshannon. Near Donegal town, intermediate in position, the direction is likewise intermediate, north-east, south-west. An inspection of the map[2] will show this change in the direction of the drumlins, and their coincidence with the striae. These, on account of the thickness and widespread character of the drift, are by no means plentiful. A number were, however, observed by the officers of the Geological Survey and by myself.

The truncated ends of the drumlins along the coast furnish undoubtedly the finest opportunity for the study of the nature and composition of the drift. When these are supplemented by road and railway cuttings, sections in stream and river banks, the nature of the drift can be quite readily ascertained; but as this everywhere shows the same characters and composition, boulders and matrix alike being derived from the granite, metamorphic, and carboniferous rocks, individual mention will be made of but few exposures.

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[1] They have also greatly influenced the road-directions, e.g., the main road running north from Ballyshannon to Laghy through Ballintra. This road, like so many others in this drumlin belt, winds in a pronouncedly zig-zag manner along the valleys of accumulation between the mounds, while some of the older roads, especially those crossing the belt transversely to the stream of drumlins, bear a strong resemblance to a switch-back.

[2] All the drumlins here marked have been carefully reduced from my field maps.

The drumlins to the north of the line Ballyshannon-Belleek are largely composed of schist and not of carboniferous limestone, though the mounds rest immediately on the latter, and well within its boundary. This peculiar distribution was long ago noted by Maxwell Close, who recognized its significance of a westerly transportation. These gneissic or metamorphic boulders, derived from the triangular area of Pre-Cambrian rocks, decrease as traced seawards, the carboniferous limestone fragments increasing simultaneously, until finally, in the neighbourhood of Ballyshannon, the drifts are almost exclusively charged with boulders of the local carboniferous rocks. At Rossnowlagh, the drifts so well exposed in the upper and receding parts of the sea cliffs and in the railway section also consist chiefly of carboniferous rocks, together with boulders of schist, diorite, and well-rounded granite.

Striae furnish corroborative evidence of this east-west motion of the ice, though cross striations (E. by S., and E. N. E.), first noted by Maxwell Close, along the railway circa two miles east of Ballyshannon, may suggest that the direction was subject to slight variation at different times in correspondence with changes in the relative pressures of the component streams.

On the barren carboniferous limestone moorland, north-east of Ballyshannon, but few striated surfaces were observed. In the area north-west of Pettigo, striae and drumlins are fairly numerous, their orientation indicative of ice-motion to the south-west. Lakes abound, but of these few only are true rock-basins, most being held up by drift, usually in the form of drumlinoid mounds. The latter have impounded such lakes as Lough Amarla, and the loughs of Rath and Ballyalla. Other lakes again are entirely surrounded by turf, and seem to be merely small hollows in the turf moors, though probably also primarily due to irregular deposition of drift.

Lough Eske is most probably a 'Zungenbecken,' though its origin must be partly ascribed to solution of the underlying limestone. Even the floor of the great amphitheatre in which the lake rests may have been considerably deepened and lowered by glacial erosion, whose severity is borne out by the *moutonnée* surface. The drift where exposed is seen to be a very stony accumulation, consisting chiefly of carboniferous rocks, with some schist, quartz, and granite. To the east of Lough Eske the drift is a sandy, yellow, or brown clay, charged with boulders of these schist, granite, and carboniferous rocks, while the sandy nature of the matrix is to be attributed to the disintegration of the two rocks last named. The members of the carboniferous become increasingly argillaceous as they are traced southwards; this lithological change is reflected in a corresponding change in the character of the drift, which to the south of Lough Eske becomes much tougher in consistency, and darker in colour.

Boulders of the carboniferous rocks occur plentifully on the outcrop of these rocks, but were never found north of the line of junction with the schist. This distribution is additional confirmation of the north-south trend, indicated by the other erratics, by the striae, and the drumlins.

3. *The Glengesh Plateau.*

The large, roughly oval plateau of an average altitude of ca. 1000 ft. O.D., rising west of the line Ardara–Killybegs—the "Glengesh Plateau" of this paper—was most probably an independent centre of radiation and dispersion during the earlier phase of the glaciation. Even at the maximum stage, this centre would seem to have in some measure persisted, though the eastern edge was at times partly overridden by glaciers from the main Donegal ice-shed.

Under the central moorland, drift and "solid" are more or less effectually buried, though drift is well exposed in the stream sections in the higher parts of the Glen River and in its larger tributaries, e.g. the Owenteskiny River. It is therefore in general only round the periphery of the plateau, where the rocks emerge from beneath the quartzite *débris* and the turf cover, that the direction of the ice-flow by striae can be ascertained.

These and the *roches moutonnées* indicate that the principal source of the glacial streams lay to the east, and that the centre of radiation of the early phase lay in the hilly nucleus at the head of Glengesh, which is coincident with the greatest area of high elevation. Even during the later stages, when extraneous ice invaded the plateau, this continued to be the point of dispersion.

As might be expected from the relief of the region, the glaciers, except to the east, passed radially outwards from the highest tract, moving down the glens towards the coasts, though in places they swept across ridges and uplands in a direction somewhat oblique to the valleys.

On Croaghaveny in the north-east corner of the plateau, N.S. striae occur in several places, while all along the slopes of Glengesh Hill, striae going steadily N. 10° W. were observed on countless surfaces, proving that the direction of movement at this height on the plateau was diagonally across Glengesh. The hill summits along the edge of the plateau just south of Loughros Beg Bay are finely striated, the westerly component of the striations gradually increasing as we pass from Glengesh westward. Thus at Barkillew Hill, just west of Glengesh Hill, and at Croaghataggart, the striae bear N. 30° W., at Lough Anaffrin, N. 40 to 50° W., at Loughenaherk, N. 60° W., and along the shores of Kiltyfannad Lough, E.-W. and 10° N. of W.

Very little drift occurs in the northern valleys. It consists exclusively of quartzite and diorite.

The highly jointed and steeply dipping quartzites of Slievetoo have been ripped off by ice advancing from the south. The quartzite *débris* so removed was deposited to considerable depths in the valley which lies to the north, its unequal distribution resulting in the production of Lough Adoochro. The striae and rounded western slopes of this valley clearly demonstrate the oblique transgression of the depression by the ice.

Beefan and Garveros mountains were severely glaciated by ice passing westwards along the broad valleys of Glencolumbkill and the Murlin river, to the north of which they lie.

Striae going S. 20° W. occur on both sides of the valley of the Glen river, above Carrick. At Malin Beg and Malin More the drift attains a thickness exceeding that found elsewhere in the Glengesh Plateau, as is shown in several good stream sections. The direction of the ice-flow in this corner of the upland is clearly given by the drumlin mound at Malin More and by the striae at the quay at Ouhig, which bear W. 20° S.

The north-east shoulder of Slieve League doubtless split the ice flowing southwards, causing some to flow westwards towards Malin Beg and Malin More, and diverting some to Teelin Harbour, where, as J. F. Campbell long ago pointed out,[1] " the rounded, curved, glaciated rock surfaces " distinctly show the direction of ice-motion.

Ice passed seawards over Crockrawer (S.E. of Slieve League); its north-eastern slope is beautifully rounded, its sea-face sheer, while a number of erratic blocks lie strewn over the higher parts of the ridge. The distribution of the drift at and near Teelin, and south of Teelin Bay, indicates the southward trend of the ice, and confirms the striae which, all over this area and on both sides of the bay, bear steadily S. 20° W. They show no trace of a deflection of the glaciers flowing over Teelin, by any ice-mass pressing seaward along Donegal Bay. Ice passed along the broad valley of the Ballaghdoo river, and overrode the hill at Drumveagh, piling up the drift on its northern side. It then flowed southwestwards over the finely striated diorite and schist of Tawny Hill.

The fine U valley of Glenaddragh shows several large and small examples of truncated spurs, while its *moutonnée* sides, though only occasionally grooved or striated, clearly indicate the direction of ice-motion. The ridge between this valley and that of Ballaghdoo, on the west, is well rounded and smoothed, suggesting the coalescing along its length of the glaciers flowing in the adjacent valleys. The result of this great press of ice was to cause the glaciers to continue their course straight over the hills of Croaghmuckros and Croaghbeg (north of Gortalia), which stood opposite their mouths. These hills in

[1] Glaciation of Ireland, Quart. Jour. Geol. Soc., vol. xxix (1873), p. 205.

consequence present convex slopes to the north, and concave slopes to the south. This direction is confirmed by the striations at Clogher bearing S. 30° W. and by the great blocks of schist scattered hereabouts, and derived from the hills immediately to the north-east of this locality.

At Gortalia, the magnificent Carboniferous conglomerates reposing against the schist are covered with fine striations, which vary from E.-W. to W. 30° S. They were produced by ice passing westwards along Donegal Bay and pressing in on to the land. Here also occur large boulders of schist derived from the hills to the north-east.

On the summit of the cliff at Malin Beg, striae going N. 30° W. were observed by the Geological Survey. This direction, as the map represents, is at variance with the other striae directions recorded from this region. Since it is very improbable that this striated surface was produced by grounding bergs, it would seem that its formation must be referred to late glacial times when, the ice having retreated from the Glengesh Plateau, a great press of ice still moved westwards and seawards down Donegal Bay from the main ice-shed. At Malin Beg, being no longer restrained between the walls of the bounding hills, it would appear to have spread out fan-shaped. This suggestion of a fanning at the mouth of Donegal Bay by ice which further eastwards was hemmed in to the south of the Glengesh plateau would seem to find support in the occurrence of large boulders of Carboniferous conglomerate which were observed at Malin Beg, and which were derived probably from Muckros or Gortalia on the coast to the east.

The absence of shells in the drift at Malin Beg is probably due to the fact that the shelly floor deposits of the bay had already been cleared away by the earlier ice.

There is ample evidence to show that at some period during the glaciation, the chief ice-movement in Donegal Bay on the south, and in Loughros Bay on the north, was along the coast of the Glengesh Plateau, from east to west, i.e. right across the mouths of the major valleys, while the abundant striated surfaces high up on the edge of the plateau, hundreds of feet above the level of the sea beneath, prove the direction of ice-flow in this upper region to have been roughly at right angles to this course. The glaciers of the plateau appear therefore to have suffered no deflection at the very margin of the plateau by the main ice passing westward along the bays. This may mean that the ice streaming along the northern and southern foot of the plateau was less than the height of the edge of the plateau in thickness, so that the plateau-ice passed unobstructed on to the surface of the main sheet proceeding westward. This would give a thickness of the latter ice of approximately 1,000 feet, as the depth of the sea, especially to the north of the plateau, is negligible.

Only where the valleys open out to the sea, i.e., in the lower levels of the ice, is a deflection discernible. This is perhaps best illustrated by the low striated ridge which occurs near the mouth of Glengesh. Here the wheeling of the ice out of the valley is clearly traceable. The N. 10° W. bearing, which is the prevalent trend on the plateau just above, is turned into N. 40 and 50° W.—a deviation to be attributed to the pressure of the ice passing across the mouth of the glen from Ardara into the Loughros bays. Moreover, large boulders of a coarse dioritic rock, greatly resembling the rock *in situ* on Mogumna Hill to the east, lie scattered over the ridge just north of the Glengesh and Bracky hills, while a boulder of granite was also observed on the former hill.

The Glengesh Plateau had a very pronounced effect on the great glaciers proceeding westward from the main ice-shed of Donegal, causing the splitting of these streams on the eastern flanks and a deflection to the north and south. This cleavage is very well shown by the striae and the form of the ground, and is brought out on the map (Pl. IX). Only in the very centre of this wall was the pressure behind the impinging and extraneous ice so great that this was able to scale the face and surmount the edge of the plateau. This ascent of the ice from the low country to the east is magnificently revealed by the abundant striated surfaces on the hill-sides leading up to Crocknapeast and Balbane.

Over these summits the ice flowed in a westerly direction, pouring over the col which lies west of Roechrow and over that lying north of Croaghacullin, and sweeping down into Glenaddragh, passed out to sea near Muckros Head. It also ascended the southern slope of the spur, running out north-east from hill 1652, which is beautifully rounded (an occasional granite boulder is to be found on its slopes), and then plunged down into the huge corrie below; striae going N. 20° W. were observed in several places on the rounded diorite rim overlooking the corrie.

Glaciers streamed down Glengesh from Croaghnapeast, one of the highest points on the eastern edge of the plateau. At the mouth of this valley striated surfaces show directions of N. 20° W., also faint traces of a N.-E. flow —i.e., parallel with the axis of the valley. The latter were probably due to local glaciers occupying the valley in early glacial times, while the N. 20° W. striations are clearly memorials of the great ice masses that, more or less ignoring the configuration of the country, passed obliquely across the valley at the period of maximum glaciation. These later striae, which have almost obliterated the earlier, harmonize most thoroughly with the direction of the ice-movement in the adjacent areas and with the gradual swerving of the ice-sheet into the great plain of Ardara. It is possible, however, that an under-current of local ice flowed slowly N.-N.-E. along Glengesh, or that the valley was occupied by a mass of more or less stagnant ice, unable to emerge from its mouth because of the great pressure of the ice at this point. The former seems the more probable.

4. *The Derryveagh and Glendowan Mountains.*

The Derryveagh and Glendowan Mountains with those of the Errigal-Muckish range lying to the north form a nucleus of hills excelling in altitude and extent any other knot of mountains in Donegal. In early glacial times they doubtless gave rise to radiating glaciers.

During the maximum phase, as no escape was possible to the south because of the great pressure of ice from this direction, the excess of snowfall over the hills was compelled to seek relief by moving off to the north and north-west. The Derryveagh hills, therefore, behaved in almost all respects like the smaller Glengesh plateau just described; both acted as sub-centres, especially in the earlier stages, and though able, because of their bulk and capping of ice to deflect the powerful glaciers proceeding from the main Donegal ice-shed, causing a cleavage on their southern and eastern faces respectively, they were only partially successful in their attempts to ward off the invader.

That no ice streamed south-east from the Glendowan Mountains, the more easterly of the two granite ranges, is proved by the drifts of the bleak and desolate moorland drained by the Cummerk river and its tributaries. This critical area is composed of different members of the metamorphic rocks; and the drift, exposed in good sections in all the streams, is seen to consist only of schist, diorite, quartz, and quartzite; for though a careful search was made, no granite pebbles or boulders were discovered. Had glaciers flowed over this area from the granite hills, boulders of this rock would occur in great profusion.

The Derryveagh Mountains are covered with *moutonnée* surfaces, though these are sometimes hidden beneath a turf accumulation, while countless boulders of perched blocks of all shapes and sizes (up to 20 feet in length) everywhere dot the granite surface. Slieve Snaght, the highest summit of these granite hills, together with the adjacent mountains, was overriden from the south. This ice excavated several rock basins—e.g., L. Atirrive—and moulded the valleys.

The walls of the U valley of the Poisoned Glen are covered with countless *moutonnée* surfaces, frequently striated and grooved. Glaciers apparently poured into the glen from the Ballaghgeeha Gap at its head, and flowed towards Dunlewy. This plunging ice doubtless scooped out a hollow in the floor of this great glen; the moss flat in the bottom of the valley marks the site of the excavation.

Considerable drift, in part probably morainic, accumulated lower down the valley near Dunlewy, and is now being eroded and deposited as a delta at the head of Dunlewy Lough, giving this its characteristic straight and flat termination.

The pass at the head of Glenveagh leading to the valley of the River Barra is choked with drift charged almost exclusively with granite, though it contains also schist and basalt. This col in the rift forming the watershed between the Glen and Barra rivers would doubtless be considerably lower if this drift were cleared out, which, to judge from the present activity of the stream, is being rapidly accomplished.

A glacier passed down Glenveagh parallel with its length until it reached Glenveagh Bridge, when, being no longer confined between precipitous walls, it swerved more to the north and even occasionally to the west of north. Hence the gigantic *roches moutonnées* of Clack Mountain and Crockawama were overridden by ice flowing due north, while the same trend is indicated by the sea of magnificent *roches moutonnées* at the western end of the viaduct across Glenveagh, and by the few drumlins of the neighbouring area. The drift is composed chiefly of granite, though schist and diorite also occur.

The ice also proceeded northwards across Barnes Gap, as shown by the numerous striated surfaces and the *moutonnée* forms of the surrounding mountains.

Small boulders and pieces of schist, quartzite, and other metamorphic rocks were also observed on the southern slope and summit of Drumfin. As this area lies within the granite boundary, the occurrence of these boulders and fragments demonstrates ice-transport from the metamorphic country of the east and south-east. Near the road running along the foot of the eastern flank of Stragaddy Mountain, south of Barnes Gap, numerous small boulders of limestone, diorite, schist, and quartzite were encountered, in addition to granite, which forms the subjacent rock. Quartzite, schist, and diorite occur in the drift at Owencarrow Bridge and, as just mentioned, in the country west of this river. At Glenveagh Bridge the drift is chiefly charged with granite, together with coarse and foliated diorite (very common), boulders of basalt (the larger frequently showing spheroidal weathering), and a few pieces of schist. The same assemblage was found further up the glen at the debouchure of the valley running from Inshagh Lough, and in several places in small exposures along the road leading from Glenveagh to Garton Lough.

These and other occurrences, which have not been detailed, of schist and other metamorphic erratics in the granite country, do not necessarily imply the complete overriding of the granite hills by extraneous ice bearing these erratics. This is doubtless the explanation of those occurrences at Drumfin and Stragaddy on the borders of the granite, and also equally of the schist boulders in the Inshagh valley, more especially those in its eastern part. The same would also appear to be true of an occasional fragment of schist and diorite at Owencarrow Bridge, though the greater part of these, as all those found in the sections of Glenveagh Bridge, were indubitably transported from the band of metamorphic rocks which runs across the head of Glenveagh in the very heart of the granite country. This source is confirmed by their association in the drift with erratics of basalt which have been derived from the outcrops of the dykes which cross the glen towards its head.

5. *The Errigal-Muckish Ridge.*

Ice proceeding from the granite hills of Derryveagh to the south, passed in a northerly direction over the whole length of the quartzite ridge of Errigal and Muckish, with the varying amounts of west in its motion gradually increasing towards the south-west extremity of the range, though even in the north, i.e. towards the Muckish end, there appears to have been still a westerly component in the direction of ice-flow. The lower layers of this ice were constrained by the flanks of the hills, so that the ice-currents on the eastern slopes of Muckish were compelled to pass practically south-north, or even 10 or 20° E. of N. Where the constraining influence was no longer felt the ice immediately swerved round into the north-west, as seen, for example, on the finely striated surfaces on the col just north of Muckish, at an altitude of ca. 800 feet, O.D. Still further north, however, the ice-flow conformed with the prevalent movement over this northerly region, so that on Crockatee, to the north-east of Muckish, striae were observed going S.-N., and 20° W. of N.

This northerly ice-flow, oblique to the great depression extending from Dunlewy to Creeslough, is confirmed by the composition of the drift, which is singularly free from quartzitic material, the boulders being chiefly granite from the south, together with the schist, quartz, and metamorphic limestone of the district. The lines of flow from the granite hills to the lowlands around Falcarragh were guided by the deep portals in the quartzite ridge, e.g. the valleys containing Dunlewy and Alton Lough. Even the higher notches, such as those containing the rock basins of L. Aluirg, L. Feenane, and L. Nabrachbraddy, exerted some influence.

Granite boulders occur on the slopes of Errigal. They were most probably derived, as the trend-lines show, from the Poisoned Glen or the hills immediately to the north and east of this depression. As the summits of these hills are somewhat lower than the altitude of the highest granite boulders on Errigal, a difference of two or three hundred feet, a vertical uplift of this amount must have taken place in the comparatively short distance of circa three miles. It is, however, possible that the ice flowing from Slieve Snaght (2,240), which would normally pass well to the south of Errigal, was subject to certain variations in its direction of flow, due to a process of "nudging," causing some of the higher layers of the granite-laden ice from this mountain to pass on to Errigal. Though this would involve no uplift of the granite boulders, I am inclined to think their source lay at the head of the Poisoned Glen rather than on Slieve Snaght, and that some uplift actually took place.

The overriding of Errigal (2,466) implies a thickness of ice of at least 2,500 feet in this central area. With the waning of the ice, almost immediately after the passing of the maximum phase, the summit of the peak would project as a nunatak, the ice being probably piled up much higher on the east or "stoss" side than on the west or lee side.

6. *The Rosses and Bloody Foreland.*

Glaciers streaming from that section of the ice-shed situated to the north-west of the Barnesmore Hills flowed roughly westwards in the direction of Glenties and the plain of Ardara, as is proved by the striae and the occurrence of an occasional Barnesmore granite boulder. An ice current also bearing a few granite boulders passed obliquely across the depression in which lie the rock-basins of Lough Ea and Lough Maddy.[1]

West of the Barnesmore Hills, the lines of flow gradually swing from the east-west direction of the Stracashel valley to the south-west trend of the Caraween, Cloghmeen and Binbane ridge. This more southerly ice then proceeded south-westerly to Donegal Bay, while in a more westerly direction it came against the obstruction offered by Mulmosog Mountain, and being deflected by the latter through east-west to something north of west, united with the ice pouring out of the valleys near Glenties and swept in a direction bearing roughly N. 20° or 30° W. across the great irregular plain stretching to the north of Ardara. Large and numerous granite boulders derived from this area are scattered over all the metamorphic country to the south of Gweebarra Bay and over the low peninsula which runs westward from Ardara to Loughros Point. The whole of this peninsula shows unmistakable signs of severe glaciation from the east. On the diorite and schist, striae bearing W. 20° N. abound. Erratics of the local diorite are plentiful, though some of

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[1] Granites were observed among other places in the great accumulations of drift in the bottom of the Owen River, above Martin's Bridge.

the erratics would appear to have been derived from Mogumna and other hills rising south and south-east of Ardara.

Ice passed over the summit of Aghla Mountain (1,961) in a direction slightly north of west as shown by striae on the very summit of the mountain, while a few others possessing the same general direction have been met with on its flanks. A large glacier also flowed along the length of the depression in which lies Lough Muck, which seems in some measure to have guided the flow of the ice in this region.

Ice swept from the heights of Aghla Mountain, Scraigs, and Clogherdoo down the steep face which rises abruptly from the southern shores of Lough Finn, and passed obliquely across the depression and over Knockrawer and the neighbouring hills.

Continuing in this westerly direction, the ice overrode the summits of the hills rising to the west of the Shallogan valley, flowing ca. W. 20° N. towards the Gweebarra River. The drift is chiefly granitic, being the greater part of the material eroded from the granite hills lying to the south of the Gweebarra depression, though quartzites from the south are not lacking.

On Croaghleconnell, which lies to the west of the Gweebarra valley, a crossing of striae is extremely common, and these scratches can be resolved into two distinct sets, one bearing N.-W., the other 10° S. of W. They are most distinctly marked and occur on the same or on contiguous surfaces. Similar conflicting systems of striae occur on Meenabollagan (311), in this case trending N. 30° W. and N. 60° and 70° W. These clearly cannot be due to any constraining influence of the local configuration of the country, as they occur on the very summit as well as on the flanks of the hill, nor can they be ascribed to the small variations in direction of striae, inevitable beneath any ice-sheet composed of constituent streams of varying strength, as the two systems are too constant in their respective directions, are separated by too wide a gap, and intermediate values are absent.

These cross striations were noted by J. F. Campbell in his paper on the "Glaciation of Ireland."[1] He accounted for them by supposing the descent of the glacier down the Gweebarra valley, and on its complete retreat its succession on the ground by a smaller mountain-glacier, flowing from the north-west, and descending from the top of Slieve Snaght. There can, however, be little doubt that the ice producing this latter set of striae proceeded from the contrary direction, i.e. from the south-east.

In the Geological Survey Memoir on the north-west of Donegal, already referred to, the system going something south of west is ascribed to "the

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[1] Q.J.G.S., vol. xxix (1873), p. 208.

Scottish ice-flow" (page 108). J. F. Campbell and the Geological Survey alike regard the N.-W.-S.-E. set as the newer, with which dating of the striae I am in agreement; the fine distinctness and incisive character of the striae permit the determination of the relative age of the two sets without difficulty. It would seem, therefore, that in the earlier stages, glaciers flowed from the Derryveagh hills down the Gweebarra valley, producing the set of striations trending roughly parallel with the latter, and that the ice proceeding from the hills to the south and east under the impulse of the great Barnesmore Ice, was during the maximum stage so powerful as to cause the Derryveagh Ice to be deflected towards the north-west. When the main ice-mass began to wane the Derryveagh glaciers had either already retreated to the hills, or were unable to re-assert themselves and stream down the Gweebarra, because of the continued pressure of the ice from the south-east.

The Rosses form a distinct topographical unit, being composed of a well-jointed granite. The joints have determined the direction and parallelism of the countless narrow lakes, the straight stream courses, the trend of the coast, and the configuration of the off-lying islands.

The lake-bestrewn surface of the Rosses is composed of countless *moutonnée* granite bosses, indicating with singular regularity and constancy an ice passage over the region in a direction N. 20° or 30° W. The surface is dotted over with granite erratics of all sizes; the largest, the size of a cottage, is situated just near Crolly Station.

Along the inland margin of the plain, thousands of boulders have been precipitated in tumultuous confusion. They also characterize this fall-line in the southern areas, e.g. from Glenties to Letterilly and along the south-east side of the Gweebarra valley. They are to be ascribed in part to the quarrying of blocks along the margin of the plain where the steep face of the well-jointed granite greatly facilitated such operations by the ice, in part to morainic deposition in late-glacial times, when glaciers proceeded along the coastal plains.

The drift is very thin, but in its composition amply confirms the testimony of the striations and *roches moutonnées*, as to the direction of ice-flow. Thus quartzites and diorites are practically absent south of Bunbeg, where the drift is almost exclusively granitic. At Bunbeg, metamorphic erratics begin to put in an appearance and become increasingly numerous as we proceed northwards over the Rosses. This distribution is due to the fact that only here do we pass into the track of the erratics from the quartzite and metamorphic hills of Tievealehid and Crocknafarragh. This line, marking the western limit of these metamorphic erratics, is inserted on the small map (fig. 1). The Rosses country has therefore suffered considerable erosion and degradation, its surface having been doubtless lowered, not so much by abrasion as by the plucking of the granite blocks, which now lie profusely scattered over the surface, and doubtless over the adjacent floor of the Atlantic.

The thousands of lakes and lakelets have undoubtedly their origin in glacial erosion,[1] acting along master-joints of the granite; even the origin of those dotted over the surface of the moorland parts of the region is to be sought in this erosion, as drift is extremely thin.

The southern and eastern strips of Aran Island, which are composed of granite, exhibit the characteristic features of the Rosses, in particular the persistence and constancy of direction of the valleys, and the smoothed and glaciated rock surfaces. Huge granite boulders, derived from the granitic tracts of the island and of the mainland, lie scattered in countless numbers over the remaining quartzite part of the island. Some of these boulders are of very great size, even up to 35 feet in length, the largest perhaps occurring near Ballintra in the south-east of the island. This north-west transport of the erratics is confirmed by the direction given by the striae, the *roches moutonnées,* and the banking of drift against the south and south-east slopes of the hills. These have caused the lower layers of the ice to suffer some deflection, so that along the southern face of the hills the currents swept practically east-west, and on their eastern face slightly east of the general trend.

The numerous and large boulders of granite which are scattered over the quartzite hill of Tievealehid, prove most conclusively ice-transport down the depression of Dunlewy and Lough Nacung, and the overriding of the whole of the mountainous mass of Tievealehid and the adjacent hills by ice from the Glendowan Mountains.

The large islands of Inishbofin, Inishdooey, and Inishbeg lying off the coast were overridden by a northward-moving ice-sheet. In places favourable to the deposition of drift, this has accumulated to considerable depth, as much as 30 feet having been observed on these islands.

At the western end of Muckish, striae were observed on the lower slopes going N. 60° W. and even N. 30° W., indicating a swinging of the lower currents of the ice out of the Ray valley, where they were no longer hemmed in between Muckish and Crocknalaragagh. When the ice had fully escaped from the constraining influence of the hills and had swept out into the open plain it flowed almost due north, as is shown by the striae, bearing S.-N. and N. 10° W., and by the distribution of boulders of "porphyry" that occur only to the north of the outcrop.

[1] These joint lakes produced by glacial erosion are encountered in other granitic areas, e.g. L. Errig and L. Fad in the granite country between the Gweebarra and Shallogan valleys, Kindrum L., and the Glenmacannive L. (one-and-a-half miles N.-E. of Glenties), though the latter is in part held up by a slight accumulation of drift at its lower end.

In the part of Donegal described in this section, the ice sweeps out a complete quadrant, in the south passing almost due west, in the north practically due north.

7. *The Northern Peninsulas.*

The northern peninsulas were glaciated by ice which swept northwards; the Ards peninsula from S. 10° E., and Rosguill from S. 20° E.

The ice which crossed Barnes Gap and overflowed Crockmore, situated to the north of that valley, proceeded somewhat obliquely across Glen Lough; the glaciers from Salt Mountain and the area to the immediate west passing in a parallel direction over Bunbin and Cook's Heath Hill.

Salt Mountain and other hills of the Salt ridge show most clearly their glaciation from the south. Glaciers poured down from their heights in a direction slightly west of north, so that quartzite erratics derived from these sources lie scattered in great profusion over all the country to the north and west of the range.

The outcrop of the Fanad granite is beautifully moulded into well-rounded bosses, demonstrating a south and north ice-flow. No boulders of either the Rosguill or the Fanad granite were observed south of the southern margin of their outcrops.

The ice filled the loughs of Swilly and Mulroy Bay, conformed with their direction in its flow, as the map renders immediately apparent, and overrode the summits of the Fanad peninsula.

Probably in the earlier stages of the glaciation of the area, the ice was split on the great ridge of Knockalla. The presence of striae on the summit of the ridge conclusively proves, however, that the latter was finally swamped under the great ice-sheet.

The distribution of the boulders of the Donegal granite may be here briefly reviewed; the dispersal is illustrated in the small map (fig. 1), upon which are also inserted the lines of ice-flow over this part of Donegal.

Granite boulders occur in great profusion over the outcrop of the Donegal granite; these require no further description. They were observed in the metamorphic country to the south of Ardara, their occurrence here being due to slight "nudging." They are also plentifully distributed over the low peninsula terminating in Loughros Head, and over that which juts out to the south of Gweebarra Bay, while they occur over all the Crohy peninsula to the north of this bay. As already mentioned, they are found in the north-western part of Aran Island.

The roughly rectangular tract of country underlain by metamorphic and associated rocks and bounded on the west, south, and east by the granite of the Rosses and Derryveagh, is everywhere bestrewn with granite boulders of all sizes, plucked from the granite hills of the south. As already shown, they ascend the great Errigal, Muckish, and Crocknafarragh quartzite range, almost to its highest point, and must have passed not only through the larger and deeper gaps but also clean over the high level cols, where they occur in very great numbers.

They rest on the summit of the diorite ridges of Derryreel and Croaghlosky, and on the quartzite hill of Tievealehid. They are extraordinarily numerous along the coastal strip extending from Bloody Foreland to Falcarragh. Boulders of granite, coarse and finely crystalline, distinctly banded, and of all sizes (up to 8 feet in length) are strewn in great abundance along the hills to the south of Sessiagh Lough. They are common over all the Dunfanaghy area, and are scattered over the Horn peninsula in great numbers and range up to 7 feet in diameter. The larger boulders not infrequently exhibit the typical glacial form; the smaller ones, on the other hand, are usually well rounded. They are extremely abundant along the shore to the east of Horn Bridge and along the southern part of the peninsula, decreasing apparently in numbers, as traced northwards across the latter, becoming comparatively rare towards Horn Head and the northern coast.

The erratics of the Crocknakilla "felstone-porphyry" have a similar distribution, occurring at Faugher, Dunfanaghy, and Horn peninsula. No boulders of this rock were observed to the south of the outcrops.

Boulders of granite everywhere dot the surface of the Clonmass and Ards peninsulas (up to 9 feet in length). They are very abundant and large over all the country south of Carrigart and at Carrigart itself, while they are especially large and angular at Ballyness. They also occur in Rosguill, e.g. to the east of Rosapenna. In Mulroy Bay they are very few.

These granite erratics first begin to pass off the eastern margin of the granite in the neighbourhood of Garton Lough, where boulders up to 10 feet in diameter rest on the schist. Great numbers lie scattered over the surface at Losset Beg, and were traced in diminishing numbers from here northwards to Coldrum, where they occur sporadically. At Stragaddy the granite boulders are extremely numerous and of good size. They are also present in the vicinity of Lough Greenan, while an occasional boulder was noted near Kilmacrenan Station (4 feet in length). They also occur in places round the shores of Lough Keel and on the surface of the country near this lake.[1] Very few boulders were met with in the southern half of Mulroy Bay, though east of Gortnaclere and Springfield they again make their appearance in appreciable numbers, whence northwards and westwards they

[1] At "B" of "Ballyscanlor" of the one-inch O.S. map occurs a huge granite erratic, ca. 13 feet long, its other dimensions in proportion.

become increasingly numerous and large until they reach their greatest numbers near Carrigart as already mentioned.

In that part of Fanad lying to the south-west of Kindrum Lough, very few boulders from the main Donegal outcrop were observed, their detection and recognition being made the more difficult when they pass on to the outcrop of the northern granites, where indeed they are practically lost among the countless local granite erratics.

8. *The Valleys of the Finn and Foyle.*

The ice passed in general down the valleys of the Finn and Foyle. This is proved by the striae (vide map), by the transport of erratics, e.g. the Barnesmore granite, quartzites, and the diorites and limestones occurring north of the Finn valley, and by the low drumlinoid mounds.

The drumlin ridges in the "Pennyburn depression" west of Londonderry swing into the Foyle in wide parallel curves, in striking conformity with the line of the bounding hills on the north. Their arrangement indicates the wheeling of the ice round the southern shoulders of Scalp and Eskaheen Mountains. The numerous striated surfaces on the rocks to the north of the depression, bearing generally N. 50° to 70° E., show also the effect of the great Scalp Mountain range on the lower currents of ice. Though these markings and mounds were most probably produced during the maximum stage, they may be in part the product of late glacial times, when the ice retreating off Inishowen was so reduced in strength and thickness as to be unable to surmount this high range, and formed two powerful glaciers, the one streaming down the Swilly, the other filling the "Pennyburn depression" from side to side and skirting the southern edge of this range of mountains and subsequently flowing into Lough Foyle.

9. *Inishowen.*

The general direction of glaciation over Inishowen was northwards, the striae[1] bearing steadily south-north, though local deflections due to the relief were noted, as along the big depression of the Swilly where the striae indicate the winding of the glacier in agreement with the S-shaped curve of the fiord, while the huge valleys of Glentogher and the Mintiaghs guided the movement of the ice in these regions. The distribution of the surface erratics and of the drift material that thickly drapes the flanks of the hills, e.g. the diorites of the Mintiaghs and Buncrana and the quartzites of Slieve Snaght, the

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[1] Reference to many striations in Inishowen is made by Maxwell Close in his Notes on the General Glaciation of Ireland, Journ. Roy. Geol. Soc. Ireland, vol. i, p. 217, and by Carvill Lewis, *op. cit.*, pp. 110 to 116.

camptonites of Dunree, and the felspathic grits of Glentogher, indicates a eneral northerly transport.

10. *The Sperrin Mountains and the Foyle Estuary.*

The Sperrin Mountains are equally extensive and in their average altitude at least as high as the Barnesmore Hills; indeed, in actual altitude of the highest summits, the Sperrin Mountains slightly exceed the latter. The reason for their difference of behaviour, the one acting as a powerful centre of dispersion, the other overridden by extraneous ice, is probably, in the first place, due to their respective positions relative to the position of maximum precipitation, and, secondly, to the fact that the Sperrin Mountains lay between the eastward-moving Donegal Ice and the westward-moving Scottish Ice, which by piling up the glaciers and raising the ice-surface caused the stronger Donegal Ice to override the hills which lay in its immediate track. Nor is the contrast in the behaviour of the Sperrin Mountains as compared with the Sligo Hills less striking. So far as my researches allow me to speak, the latter hills seem to have been able completely to withstand and deflect the Donegal Ice masses, though the distance by which they are removed from the great Barnesmore centre is only some 16 miles, as against almost double that distance in the case of the Sperrin Mountains.

The Sperrin Mountains during the maximum glaciation were overridden by Donegal Ice. They are thickly swathed in drift that spreads northward to Lough Foyle, where at Eglinton it rests upon the Scottish boulder-clay. Here more or less rounded pieces of the older reddish and calcareous boulder-clay have been torn off and enclosed in the newer deposit, proving that the later glaciation from the south-west has to some extent churned up the older drift. In the bottom of the Roe Valley, there appears to be a mixture of drifts from eastern and southern sources respectively, the constituents of quartz, epidiorite, quartzite, and a few small granites, together with schist and carboniferous sandstone, with occasional pieces of chalk-flint, chalk, and basalt, the whole embedded in a clayey and sandy matrix. These materials are also found associated together at Calihame Bridge and along the lower (northern) flanks of Glenshane Mountain, and in the streams, east of Bolea, where the matrix of the drift is brick-red in colour, due to the disintegration of the Triassic rocks. A similar mixture of materials which at lower levels characterizes different drifts does not at higher levels necessarily imply a double glaciation, for in these higher regions metamorphic rocks, basalt, and chalk crop out over adjacent pieces of country. This close association of the outcrops of rocks, the boulders of which, with others, have elsewhere been used in the delimitation of the earlier and later glaciations, has rendered it well-nigh impossible to fix the limits of the earlier Scottish glaciation in such places as, for example, at the head of the Glenshane Pass and in the headwaters of the River Roe.

Most of the striae in the area east of the Foyle estuary are attributable to the later Donegal glaciation, e.g. those observed on the summit of Loughermore and the striated surfaces on Benevenagh, bearing roughly N.-N.-W. The prevalent direction is a little west of north, with an occasional tendency to swing more to the westward under the restraining influence of the relief, though this deviation may be in part due to the reaction of the western with the Scottish Ice, which was occupying the country to the east.[1] In the Roe Valley, boulders and pebbles of basalt predominate in the drifts near the great escarpment, decreasing gradually in size and numbers as the distance from the escarpment increases, and becoming rare, with a distinct preponderance of metamorphic rocks from the Sperrin Mountains and their foot-hills, in the drifts of the valleys west of the Roe. As already pointed out by J. R. Kilroe,[2] one of the most interesting pieces of evidence of the northward movement in this area is to be found in the valley of Largantea Burn, to the east of Benevenagh, where chalk fragments, doubtless gathered up from the outcrop north of Keady Mountain, are strewn along the stream course up to its head waters, though in decreasing quantities as traced away from the place of origin. Chalk-flints, less destructible and perhaps more easily recognisable, have been picked up on the highest ground thereabouts, while metamorphic grit was found at the summit of Benevenagh (1,260). Portlock (" Report," p. 638) writes in this connexion:—

> " On ascending the steep sides of Benevenagh, fragments of quartz and pebbles of mica-schist are found in the beds of the small streams, mixed with chalk and trap pebbles, and continue nearly to the summit of the mountain."

The striated surfaces on Benevenagh and these small patches of stony boulder-clay, traceable to within very short distances of the highest summits along this north-west edge of the Antrim plateau, prove, without doubt, that this elevated tract was buried to some depth below a northward-moving ice-sheet.

As already pointed out by Mr. W. B. Wright,[3] this northward movement

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[1] In agreement with these N.-N.-W. striae on Benevenagh is the occurrence of great numbers of large boulders (3 feet) of basalt, some amygdaloidal, and dolerite along the cliff road from Inishowen Head to Glenane Hill and over the low ground to the S. of the former.

[2] Belfast Nat. Field Club, 1913, p. 653.

[3] Quaternary Ice Age, p. 60.

over Inishowen, down the estuary of the Foyle, and along the edge of the basalt plateau, made its influence felt as far as Islay.

11. *The Barnesmore Granite Boulder Dispersal.*

The boulders of Barnesmore granite in the drifts of N.-W. Ireland are usually very well rounded, more rarely sub-angular, and only occasionally polished or striated. In size they vary within considerable limits; their average diameter is roughly one foot.

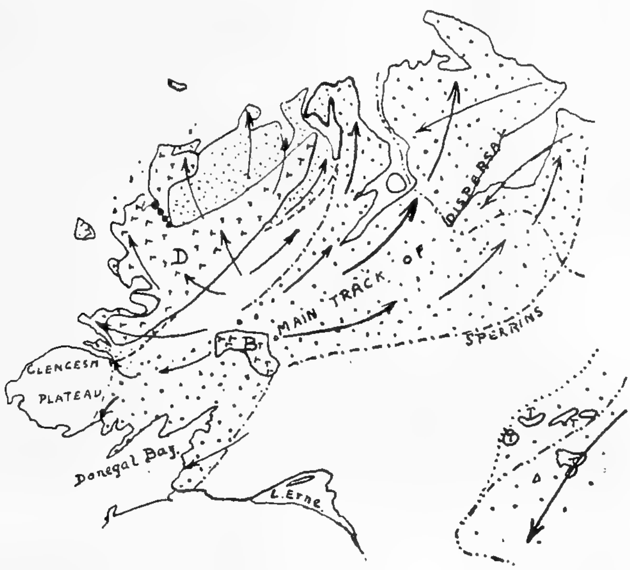

FIG. 1.

Map illustrating the distribution of granite boulders in the north-west of Ireland. *B* denotes the outcrop of the Barnesmore granite; *D*, that of the Donegal granite; *T*, that of the granites of Tyrone. The dotted areas represent the country covered by granite boulders. The dash line represents the limits of the Donegal granite boulder dispersal; the dot and dash line those of the Barnesmore dispersal; the dot line those of the Tyrone dispersal; dash and two-dot lines indicate the W. limit of the Scottish ice. Arrows indicate the direction of ice-flow. Scale—25 miles = 1 inch.

A striking proportion of them occur on the surface of the ground, a small percentage only in the drifts. This singular mode of occurrence attracted the attention of the earlier writers, who attributed it to the agency of "floating ice during the submergence of the country beneath the sea, when the stratified drift and eskers were formed, and after the time of the production of drumlins and rock-striations.[1]

It is intended in the following to describe briefly the approximate limits

[1] M. Close, Journ. Roy. Geol. Soc. Ireland, 1866, p. 229.

of the area of dispersal, and to define the track along which the boulders are more especially numerous. Their dispersal is indicated on the map (fig. 1) and on the general map (Pl. IX).

Within this tract it was found impossible to single out any special trains of granitic *débris*, as the granite is too homogeneous over its outcrop. Moreover, the finer-grained veins and off-shoots of granite and pegmatite are, as in the case of the Donegal granite, where they are more generally developed, too irregularly distributed to indicate special lines of flow, though boulders from these sources can be detected in the drifts.

All that can in consequence be definitely affirmed is that in the centre of the tract the boulders are generally larger and more numerous, becoming less so as we proceed to the margin, where they finally occur singly and at considerable intervals. Their sporadic occurrence towards the border and the fewness of good drift sections along this line have made it impossible to assign more than approximate boundaries to this boulder country. The exactness, moreover, with which the line can be drawn varies over different parts of its length according to the opportunities that natural and artificial sections offer for the examination of the drift. On the surface of the boulder fan and in exposures outside its margin, no boulder or pebble of the granite was detected, with the few exceptions to be mentioned presently.

As the Barnesmore granite mass lies astride the main ice-shed of Donegal, its erratics have travelled northward and southward from the axis, the train of boulders on the north extending from the granite outcrop to the seaward end of Lough Swilly and of Lough Foyle, on the south, as far as St. John's Point in Donegal Bay. No granite erratics from Barnesmore were detected on the surface of the bare limestone country east of Ballyshannon. To the west of a line through Barnesmore, Straness, Brown Hall (E. of Ballintra), and Ballyshannon, the granites are fairly plentiful, both in sections and on the surface, and become increasingly numerous as we proceed to the eastern shores of Donegal Bay and the line of the railway from Donegal Town to Barnesmore Gap.

Countless granites lie strewn along the beach from Donegal Town westwards, doubtless derived from the truncated drumlins. Boulders also occur very abundantly over all the peninsular tract, running to the east of Inver Bay and over the surface of the small peninsula ending in Ball's Hill, likewise over the country to the north of Inver and in the railway cuttings between this place and Donegal Town. They were observed in good numbers in the cliff sections round the St. John's Peninsula. They were noted as far as Heelin Port.

Proceeding westwards, these boulders cease to be plentiful beyond Kiln

Point, at the head of McSwyne's Bay; indeed, beyond here they are quite scarce. Only a very occasional boulder was detected in the peninsulas running south to the east and west of Killybegs Bay. The absence of granite boulders at Malin Beg in the drifts already alluded to proves that the main granite-bearing ice from Barnesmore passed far from the shore down the central part of Donegal Bay, and that the ice skirting this coast contained not even a straggler of this granite.

Large granite boulders were observed to an altitude of 1,200 feet along the eastern flanks of the metamorphic mountain of Caraween and on the adjacent hills. At Ivy Bridge, over the Owentocker River, several large granite erratics were noticed, while other large blocks of the rock occur in considerable numbers all down the valley below this point. Small boulders were detected at intervals as far as and along the eastern foot of the Glengesh Plateau, where towards its northern end they occur well up the slopes. As no granite of any description was encountered in the Glengesh drifts, the limit of the Barnesmore granite boulder country in this direction must be regarded as roughly coincident with the eastern foot of the plateau.

To the north-west of the Barnesmore Hills the limits of the boulder dispersal cannot be so accurately laid down. An occasional erratic from these hills (probably from Lavagh More, 2,211) has gained access to the valley of the Stracashel River, proving ice-motion down this valley from the east. In the upper part of the Owenroe River, e.g. at Martin's Bridge, the stream sections show well-rounded granites from this source, while occasional boulders were observed at intervals all the way down the valley as far as Crockbrack. Pieces of granite occur in the Finn valley moraine, at the western end of Lough Finn. Farther west, these boulders become inextricably mixed up with the erratics from the Donegal granite outcrop, so that no line of demarcation of the Barnesmore granite boulder country in this direction has been inserted on the accompanying maps.

In the following description of the dispersal, north of the axis, it is proposed to delineate the approximate limits of the fan on the west, south, and east, and to locate the main track.

Occasional granite boulders rest on the surface in the valley of the Reelan River. None were detected in the drift sections in the upper part of the Finn Valley until its confluence with the Reelan Rivers was reached, where in the railway section near Cloghanmore, a few small pebbles were observed. Though these were fairly common, not a single large boulder of granite was encountered. Here, therefore, we appear to be on the fringe of the fan of the granitic drift.

The boulders were encountered in great numbers in the valley of the Finn above Stranorlar. In a section, 12 feet high, in the Corlacky Burn, north-west of this place, only one small piece of granite was obtained,[1] while careful search among countless boulders in the walls of Lettershambo to the north of this occurrence failed to discover a single granite. A similar absence of granite fragments and boulders characterized the stream[2] section at Ardnabreena on the southern slopes of Cark Mountain, though a few were found in the better drift sections in the Sruffannaghallagh River, just below this locality. At the head of the overflow channel, just north-west of Cronaglack, a single boulder of granite was observed, though in the fine section near Stranabad Lower, some two miles south of this, none was detected. A careful search in the magnificent section at Altadush, in the upper reaches of the Swilly Valley, was no better rewarded.

One granite erratic was met with on the hillside about one mile east of New Mills, while a few were noted in the valley below the overflow channel, south of Craignasaggart (672). In the fine sections[3] exposed in the railway cuttings at the junction south-east of Letterkenny, very few were observed; the limit of the dispersal is therefore not far from this town. This is confirmed by the detection of a boulder near "The Thorn," about two miles E.-N.-E. of Letterkenny.

No granites were encountered over the country between Ellistria and Kilmacrenan, nor were they met with in the scanty drift exposures in the triangular area between this village, Letterkenny, and Swilly Bridge. This region would therefore appear to lie outside the granite boulder country. Its edge is near Tullyhall, where one or two small pieces were obtained.

An occasional boulder was seen to the south-east of Milford and a few along the eastern side of Mulroy Bay, e.g. at Kerrykeel. They also occur along the western shore of Lough Swilly and in the embayment to the north of Knockalla, e.g. W. of Portsalon, becoming increasingly plentiful as traced southwards towards Rathmelton.

These localities in the western region of dispersal, where boulders of granite were and were not detected, together with numerous others which have

[1] The section was composed of striated schist and quartzite, embedded in a matrix derived from the disintegration of the former. In the small sections beneath the turf round about trig. pt. 730 (on road), though schist and diorite with some quartzite were obtained, no granite was observed.

[2] The drift here consisted exclusively of schist, diorite, and quartzite. These rocks plus granite formed the constituents of the drift exposed in the Sruffannaghallagh River.

[3] These are nearly all grassed over, but one, some 30 feet high, shows boulders and fragments of schist and quartz, in addition to the occasional granite, quartzite, and diorite.

not been detailed, afford sufficient evidence upon which to construct a western limit. The line would appear to run along the northern side of the Reelan Valley, swinging round somewhat to the west so as to include Cronaglack, crossing the valley of the Swilly above Letterkenny, and keeping east of Ellistria, continuing to Milford and Mulroy Bay.

The following notes give the main line of distribution of the erratics. They are extremely abundant to the south of Stranorlar, lying scattered over the surface in their hundreds, occurring both in the drifts and on the surface, almost to the exclusion of boulders derived from the subjacent rocks. In the valley of the Deele River they occur in considerable numbers, and were observed along all the country from Stranorlar to Letterkenny, decreasing appreciably in numbers as traced to the latter.

The granites were seen in great profusion over all the country bordering the Finn Valley, from Stranorlar to Killygordon and Liscooly, occurring on both sides of the valley, though more abundantly on its northern side. They are very common indeed in the fine railway cutting at Drumboy, north-west of Lifford, fairly plentiful on the western flanks of Knockavoe, east of Strabane, and in the recess to the west of the Koram Mountains. They are also abundant about Ballymagorry and in the embayment extending north-east from Strabane to Artigarvan, also from Raphoe to Letterkenny. Carvill Lewis noted their presence at Pluck. They are plentifully strewn over Dooish, and occur at the Glentown quarries to the south-east of this hill, and over all the area of the large and broad depression in which lies Port Lough. They are also exceptionally abundant and large on the north and north-west flanks of Finwell Hill about Farland Point, and on the shores and southern slopes of Inch Island. An occasional boulder occurs on the western flanks of Greenan Hill, though in the thick drifts between the hills to the south of this, granites, both large and small, are numerous. They also lie scattered in considerable numbers over the floor of the "Pennyburn depression."

The main passage of the granite-laden ice was undoubtedly along the present Foyle Valley, as here the boulders are largest and most numerous, e.g. at St. Johnstown and Carrigans, and all over the country extending northwards to Londonderry. They are similarly abundant on the eastern side of the valley from Prospect via Prehen to Londonderry. Natural sections in the vicinity of this city are very few, but granite boulders (usually one foot long) occur in great numbers, and up to three feet in length in the walls of the fields and roads of the neighbourhood.

They are common in all the drifts of Inishowen, as far north as Malin Head and Inishowen Head, and were encountered in all the valleys of the peninsula. Great numbers occur at Carndonagh. They were even observed on the western flank of Raghtin More,[1] and at the foot of the Gap of Mamore, on the Swilly side of the quartzite range.

Granites are scattered over all the area north of the Sperrin Mountains, being observed on the hills[2] and in the valleys. They are abundant and large in the neighbourhood of Dunnamanagh, in the Glenmornan area, and at Moor Lough, while a few were encountered on High Moor (N.-W. of Slievebuck) at an altitude of 600 feet. They are also common at Claudy, and a few were seen at Feeny. They lie scattered over the Burntollet country, and between Waterside and the Faughan Valley. They are numerous along the southern shores of Lough Foyle, over the country between Londonderry and Eglinton, and on the hills to the south of here.

The main track of the Barnesmore granite boulders can now be readily traced. Picking it up west of Ballybofey and Stranorlar, it passes between Raphoe and Lifford, nearer the latter than the former, sweeps down the valley of the Foyle, crosses the city of Londonderry lying directly in its path, and continues down Lough Foyle, roughly coincident with its western shores.

The line limiting the fan of dispersal on the south and east can also be fairly accurately fixed. A few granites were observed at Meenglass, near the watershed between the Finn and Mourne Rivers, though at Repentance close by, one boulder only was detected, and this was after considerable search. Here, therefore, we appear to be near the bounding line. A few occur at Stirring, and one (4 feet in diameter) was observed at Trusk.[3] A boulder of granite (4 feet in diameter) was observed about one mile east of Meenasrone, on the north side of the Mourne Valley, while another was seen on its south side in the stream at Croagh. Boulders were met with at Carraffrin and to the north of this locality; none was observed to the south-east of this as far as Lismullyduff Mountain and Meenagolan.[4] The boulders occur along the hillside sloping northward to Clady on the Finn. A single boulder was seen at Lisky, just east of Victoria Bridge, and another near Elagh about three-quarters of a mile east of this. The most southerly of these boulders was

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[1] The boulder, 15 feet by 12 feet, occurring here at an altitude of ca. 150 feet, is derived from the adjacent mass of Dunaff, or rather from the granite bosses rising from the raised beach floor between Dunaff and this hillside. Boulders of this Dunaff granite have also strayed into the depression to the west of Clonmany, as was recognized by Carvill Lewis (*op. cit.*, p. 112, here inadvertently spelled Dundaff).

[2] E.g., Portlock (Report, p. 631) observes that at the N.W. of Slievekirk, the boulders of granite are "of very great size, and form a large proportion of the whole."

[3] Drift is piled up against the western slopes of Kinlitter Hill, while thousands of boulders are strewn along the shores of Trusk Lough. These are chiefly schist and coarse hornblendic rock with an occasional granite boulder.

[4] Possibly because of the fewness of opportunities, the area being practically destitute of drift, and the fields bordered by hedgerows.

noted at the head of the overflow channel falling to Douglas Bridge, while a second was seen to the north-east of Lisnafin Glebe (ca. three-quarters of a mile N.-E. of the first). A few others were encountered in the great amphitheatre N.-E. of Newtown Stewart, on the hillsides east of Sion Mills, and on the flanks of Meenashesk. They become increasingly plentiful as we proceed northward to Strabane, in which direction we are clearly passing towards the main track. In the fine section in the stream flowing north from Mullaghclogha (2,088), about one mile south of Craig and on the north side of the Sperrin watershed, one granite boulder was discovered at an altitude of roughly 800 feet, O.D. Another was seen south of Fairy Lodge,[1] and one near Crabarkey.[2] Occasional boulders were observed in the Roe valley below Dungiven, and an odd erratic was found near Largyreagh and Bolea, both near the foot of Keady Mountain, while sporadic boulders were observed at intervals along the Foyle estuary and the foot of the basalt escarpment to Magilligan, e.g. near the "Murder Hole" at an altitude of ca. 800 feet, O.D.

The southern limit therefore crosses the valley of the Mourne River obliquely and near its head, runs roughly coincident with the watershed between the Derg and Finn, cuts across the Foyle in the neighbourhood of Victoria Bridge, and skirting the northern slopes of the Koram and Sperrin Mountains, passes just south of Feeny and Dungiven and along the edge of the basalt escarpment to the mouth of Lough Foyle.

It is interesting to note that Portlock, remarking on the occurrence and distribution of the granite boulders, wrote:—[3]

> "In the more southern portions of Derry, they become very rare, or are reduced to fragments of small size in the gravel."

Within the limits briefly sketched above and represented on the accompanying maps (fig. 1 and Pl. IX) lies a fan-shaped area, over which the boulders are scattered. They increase very perceptibly in size[4] and number from the margins into the interior, and from Inishowen Head towards the source of the granite in the Barnesmore Hills.

The granites at Inishowen Head have been transported ca. 52 miles from the nearest possible point of the granite outcrop. Since they were tracked

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[1] Ca. two miles E.S.E. of Feeny. Portlock mentions "occasional granite" in the parish of Banagher. (Report, p. 747).

[2] Ca. two miles S. of Dungiven. This was the farthest south in the Roe valley.

[3] Report, p. 631.

[4] The largest erratic observed was the boulder named "Greystone," ca. half a mile N. of Drumdoit, and two miles S.W. of Clady; it is roughly 11 feet long, its other dimensions being in proportion. Another large boulder, measuring 12 × 9 × 8 feet, was observed at Cooladerry, just S. of Raphoe.

to the south of the hills to St. John's Point, they have been traced across country from sea to sea, a distance in a straight line of 77 miles. On the south of the axis the boulders are strewn over an area exceeding 300 sq. miles, on the north of the ice-shed over a fan exceeding 900 sq. miles ; these figures take no account of the odd boulders which have wandered into the territory of the Donegal granite erratics, nor of those which found their way into the drainage basin of the Fairy Water, or of the Strule above Victoria Bridge.

This great dispersal of the granite boulders on the north of the axis was due to the sweeping out of ever widening arcs as the ice proceeded outward from its centre in the Barnesmore Hills, the glaciers streaming towards the Swilly and Mulroy Bay on the west, and on the east down the valleys of the Finn and Foyle towards Magilligan. This factor was doubtless aided by a process of "nudging," due to variations in the relative pressures behind the component streams. By this lateral swinging of the ice-sheet, a tract of ground vacated by one stream would be usurped by an adjacent, for the time being, more powerful stream, which would transport any boulders already deposited in its path by the earlier occupant. The sporadic boulders occurring at considerable intervals on the margin of the great granite boulder country, e.g. those discovered near Victoria Bridge, were most probably, therefore, not transported directly by ice from the Barnesmore Hills, but by glaciers proceeding from the adjacent non-granitic part of the ice-shed. These straggling boulders, passed out in this way to the margin of the fan, some wandering out in the one direction into the country north of the Sperrin Mountains, and in the other into Mulroy Bay, have effectually blurred the real boundaries of the granite-laden ice streaming from the Barnesmore Hills.

This seems to be the only possible explanation of the occurrence of a boulder of this granite, just north of Dunteige, S. of Bessy Bell, and of a second granite boulder, near the National School of Ballynatubbrit (ca. four miles S.-E. of Newtown Stewart). Other granite boulders, referable to Barnesmore and encountered in this area outside the fan of dispersal as delineated above, include those found, among other places, at Rosnamuck Bridge, N. of Omagh, just E. of Deer's Leap, at Mossey's Hill, S. of Gortin (washed over from "Lake Cullion"), at Mountjoy, and at Ballynatubbrit.[1]

Traversing the granite boulder-country, especially in the main track of these erratics, one is impressed with their disproportion, both in respect to size and to numbers, as compared with the other ingredients of the drift,

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[1] None of these granites is included in the fan of dispersal as represented on the map (fig. 1).

with their extraordinary profusion, and with the amount of degradation of the granite hills they represent.

The great frequency of the Eskdale and Galloway granites in the Lancashire drifts would seem to have similarly impressed T. M. Reade, who made some very apposite remarks, which may here be quoted:—

> "It seems curious that such little patches of granite should have yielded such a harvest of blocks . . . Probably the reason why the granites, syenites, and other igneous rocks occur in larger proportion in the drift than would seem to be due to the area they cover *in situ*, is that they naturally break out in larger blocks, and moreover, they are generally found at a high level."[1]

The outcrop of the Barnesmore granite, covering an area of some 18 sq. miles, has given rise to boulders which dot an area of over 1,200 sq. miles. The reason suggested by T. M. Reade is without doubt applicable here. The granite is traversed by a regular system of joints which in certain parts of its outcrop impart to it an almost platy structure.

It must also be remembered in this connexion that the fan is only the smaller part of the area of dispersal of the granite erratics. Large numbers, though what proportion it is impossible to say, must have been carried out to sea. The occurrence of the submerged part of the fan makes it also impossible to estimate even roughly the thickness of granite removed from the Barnesmore Hills and the extent of the glacial degradation.

The distribution of these granite boulders, spreading out fan-shaped from Barnesmore, together with their increase in size and numbers as traced to these hills,[2] points unmistakably to the latter as their parent source. The question of their origin has, however, been the subject of some controversy, and rocks of various areas, near and remote, have been assigned as their point of departure.

The earliest of these identifications occurs in "Frost and Fire" (1865), where the boulders were regarded as having travelled from Aberdeen. This requires no combating to-day. F. E. Harte, in his eminently sane paper "On the Post-Tertiary Geology of the County of Donegal, etc.,"[3] very strongly advocates the local or Donegal origin of the granites, contending against the idea of

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[1] On the Drift Beds of the North-west of England and North Wales. Quart. Journ. Geol. Soc., vol. xxxix (1893), p. 120.

[2] Except in the strip immediately surrounding the Barnesmore granite margin both to north and south. This was noticed by the Geological Survey, who explained (Londonderry Memoir, p. 30) this anomalous behaviour of the erratics, by supposing that the granitic detritus, collected during the maximum phase of the glaciation, was transported as super- or en-glacial material to a considerable distance.

[3] Journ. Roy. Geol. Soc. Ireland, vol. ii (1871), pp. 30-67.

their importation from some north-eastern source. His suggestion, however, of their derivation from the main Donegal granite is clearly incompatible with their distribution as set out above and represented on the maps (fig. 1 and Pl. VII). The petrological and structural differences between the two rocks—the one, the Donegal granite, almost invariably exhibiting planes of foliation, the other lacking such features—are equally conclusively against this view.

It is interesting to note that Portlock, in his "Report" (p. 640), concluded that the large granite boulders of County Derry most probably came from Donegal.

J. R. Kilroe, in his paper presented to the Belfast Nat. Field Club in 1913, referring to the granite boulders "of striking resemblance to Barnesmore granite" found in the drifts of North Derry, says :—

> "I prefer to think that these erratics have come either from Scotland or from a submerged source to the north of Ireland" (p. 648).

Yet it is strange that these erratics only should have been so favoured during this Scottish glaciation. Moreover, granites are totally absent from the only indisputably undisturbed Scottish drifts, those of Eglinton and the neighbourhood. Furthermore, these granite boulders, often resting, as we have seen, on the surface, are the product of the last glaciation, from whichever direction the ice of that glaciation may have come, and their occurrence should in consequence be reconcilable with the phenomena of the retreat in the district, i.e. with the morainic accumulations and the marginal drainage. These, however, as will be demonstrated in the sequel, unmistakably show open and ice-free country to the north and north-east, and ice pressure from the south and south-west—a state of affairs patently irreconcilable with a simultaneous transport of erratics from the north-east.

Elsewhere, J. R. Kilroe, referring to the Scottish glaciation, remarks[1] :—

> "Confirmatory evidence for the westward movement is to be found in the absence of granitic blocks from the lower boulder-clay of Glen Swilly, and from the boulder-clay which rests on the granite at the north entrance of Barnesmore Gap."

It may be observed that granite boulders were encountered during the progress of this present investigation in the latter area, so that this objection

[1] Q. J. G. S. (1888), p. 831. In the Geol. Surv. Mem. of this district (Sheets 3, 4, etc., p. 107) the same error has arisen. It is there stated : "Along the headwaters of the Rivers Finn and Swilly" the boulder-clay contains "ice-scored boulders, blocks, and fragments of rock, which have unquestionably been derived from the country to the east and north-east." I have been quite unable to discover any evidence in justification of this statement.

can no longer be sustained, while their absence from Glen Swilly, it is submitted, is readily explained on the view of the mode of glaciation, as set forth in this communication.

An examination of the map (fig. 1), indicating the limits of the boulder dispersal from the Barnesmore and Donegal granite outcrops, shows that there is, south of Milford, no overlap of the Barnesmore and Donegal granite boulders, but that, on the contrary, there occurs a wedge-shaped strip of country, tapering northwards to Milford, which is completely destitute of granite erratics from either source, save perhaps for a rare and undetected straggler. Their absence, therefore, is not suggestive of Scottish glaciation, but must be ascribed to the passage of the granite-laden streams to the east and west of this strip and of Glen Swilly to which J. R. Kilroe more particularly referred, furnishing at the same time additional confirmation of the Donegal centre of radiation.

The Barnesmore origin of the erratics is supported by the lithology and petrology of the boulders and of the Barnesmore granite *in situ*. These rocks are alike, distinctly red in colour, though frequently pink, and exhibit a fairly medium texture; foliation, as already pointed out, is absent.

Professor H. J. Seymour, from an examination of rock sections of the boulders obtained during the course of the survey of the Londonderry district, and a comparison of these with sections of the Barnesmore granite, concluded that the rocks were petrologically identical.[1] This external resemblance and petrological identity, when supported by the distribution of the boulders, by the evidence furnished by the striae, the general glaciation, and by the conclusions drawn from the mode of retreat as proved by marginal phenomena, demonstrate conclusively the Barnesmore source of these countless granite boulders.[2]

Located in the country lying between the Swilly and Foyle and to the north of the Finn valley, are a number of dykes and sills of lamprophyre and "diorite,"[3] and other rock types. Their boulder trains furnish additional evidence of the lines of ice-flow. The conclusions based upon them confirm those drawn from the striae, and from the distribution of the granites of

[1] Londonderry Memoir, p. 30.

[2] The above description of the distribution of the erratics from the Donegal and Barnesmore granite outcrops respectively, clearly shows that the boulders of granite occurring in the country to the east of this, and referred by the indefatigable workers of the Belfast Nat. Field Club, with various degrees of probability, to these sources, must have been derived, apart from the granites of Tyrone, from parent masses outside the region under review.

[3] Petrographical descriptions of these are given in the Londonderry Memoir (p. 13), and in the Geol. Survey Memoir, Sheet 17 (pp. 33–38).

Barnesmore. Thus, no erratics from these sources were observed south of their parent outcrops, while on the north they have been traced into the Inishowen drifts.[1]

12. *South-Eastern Area.*

In all the southern and south-eastern parts of the country which was investigated, the ice-sheet moved, in general, from a direction somewhere in the west or north-west, towards the plains of Tyrone, Monaghan, and Fermanagh.

The glaciers which in the neighbourhood of Strabane streamed roughly N.-E. appear farther south to have had a more easterly component in their motion, as is shown by the few erratics which are traceable to their parent sources.[2] The striated surface, going N.20°E., east of Moyle House,[3] probably indicates a local deflection due to the relief. Bessy Bell was glaciated from the S.-W. or S.S.-W.

The ice-masses, pent up against the slopes of the Sperrin Mountains, found relief by a great thrust to the east and south-east, in the direction of Cookstown and Dungannon, as is suggested by the few drumlins, the form of the ground, and by an occasional scratched surface. A mighty glacier swept along the broad "Omagh-Draperstown corridor," as is shown by a number of striae.[4] This ice transported north-eastward the boulders of the Tyrone granites, occurring in great numbers to the north-east of their outcrops and

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[1] A few only of the observations made during this investigation can here be mentioned. The rock of Coram (ca. 2 miles due E. of Stranorlar) was found as a boulder at Roosky. Boulders of the rock occurring N. of Liscooly and at Farland were found in the drift at half a mile S.-E. of Convoy, near the main road east of Black Repentance, at Knocklee and at Roosky. The hornblende lamprophyres from these and other localities just N. of the Finn valley were observed at Dooish, Glentown, Berry Hill, Eden, Caw House, Prospect, Stradreagh, Toulett Upper, Londonderry (e.g., Lone Moor Road), as far E. as Sheskin River and Gortnessy, and as far N. as Cabry River, Bogstown River, Aught River, Clunelly, Bredagh Glen, and Owenkillew River.

The hornblende lamprophyre from Inch Top occurs as erratics in the Crana River (e.g., above Mullinderry Bridge and at Cock Hill). The Tooban Junction lamprophyre has contributed to the drifts of the Inishowen slopes N.-W. of Muff. The hornblende lamprophyre occurring E. of Cullion was traced in the drifts by Knock and Gortica to Gortnessy and Sheskin River. Pebbles of pinkish felsite found in the Bogstown and adjacent rivers may have been derived from the rock near Kilfrum. I have been unable to refer to their parent sources a considerable number of erratics of lamprophyre and of felspar porphyry. It was found impossible to match, with any degree of confidence, the great numbers of pebbles of epidiorite, both porphyritic and non-porphyritic, which were obtained from the drifts of the strips of country bordering the Foyle both N. and S. of Londonderry.

[2] E.g., the porphyritic rock from just N.-E. of Newtown Stewart, which was observed as erratics at Woodstock.

[3] Just E. of Newtown Stewart on the right bank of the River Strule.

[4] See Mem. Geol. Survey, Sheet 34, p. 23; also map accompanying this paper (Pl. IX).

as far as Draperstown on the margin of the area under review. The granites and other rocks of Slieve Gallion have also been carried in the same direction, and are encountered all along the Bann, as far north as Coleraine.

No boulders of these Slieve Gallion rocks were observed south of their outcrop. This furnishes strong confirmatory evidence of the view maintained in an earlier section of this paper, and based chiefly on the sections south-west of Draperstown, that Scottish ice never had access to this region nor to the "Omagh-Draperstown corridor."

The Tyrone granites and aphanites have been encountered as far east as the western shores of Lough Neagh, and were observed by Dr. A. R. Dwerryhouse even much farther east, at Soldierstown, beyond the S.-E. corner of Lough Neagh.

The Fintona Plain was glaciated along its length from the south-west, or west-south-west, towards Omagh and Mullaghcarn. The Fintona Hills, forming its southern margin, were completely overridden by ice from the west and the north-west.[1]

The mass of Slieve Beagh, which lies directly on the line of the "Central Axis" of E. Hull (*ante*, p. 176), was glaciated up its very summit by extraneous ice; it never nourished local glaciers, nor was it at any period a radiation point or "knot" on an axis of dispersion.

The limits of dispersal of the Tyrone granites[2] and associated igneous rocks are indicated on the small map (fig. 1), on which are also inserted the position of the outcrops.

These rocks possess such general affinities, that it was found difficult, indeed frequently impossible, to determine the parent source of any particular boulder. This uncertainty of determination is rendered all the greater because, as Professor G. A. J. Cole has pointed out in his paper descriptive of the granites and associated rocks,[3] "a good many areas of the granite may still be hidden under bogland." The rocks of whole areas are, moreover, "seamed with granite and microgranite." Their general characteristics are, however, so extremely clear, that there is seldom much difficulty in assigning surface erratics or boulders in the drifts to this group of acid rocks. The distribution of these granite erratics is fully confirmed by that of the aphanites or the basic rocks with which they are so intimately associated.

The granite erratics have been observed over all the country of the

[1] E.g., striae going S.-E., observed near the summit of Brougher Mountain, one of the highest parts of the whole range.

[2] Their petrology has been briefly referred to in an earlier section (p. 182).

[3] On Metamorphic Rocks in Eastern Tyrone and Southern Donegal.—Trans. Roy. Irish Acad., vol. xxxi (1900), p. 431.

"Omagh-Draperstown corridor," with the exception of its very western end. Their northern margin coincides roughly with the northern edge of the depression.[1] They extend to Draperstown and beyond. They also occur plentifully in the morainic ridges of the country to the north and east of Pomeroy, while several were seen at Drumduff Bridge, and considerable numbers around Clare Rock. They were observed at Crockandun and over all the country to the south of this, also to the south of Beragh, and as far west as Seskinore. They were seen at Birney's Hill (N. of Augher), at an altitude of ca. 500 feet. Numerous granites occur in the great Donaghmore moraine.

They occur very sporadically along the western margin of the fan where they are very widely scattered. The line on the map (fig. 1) has been drawn to include these stragglers. They were found, among other places, ca. half mile S.-E. of Eskragh, at Foremass (ca. half mile S.S.-E. of Six-Mile-Cross), at Bernisk Glen, south of Bara Glen Bridge, north of Tirnaskea (ca. one and a half miles N. of Ballygawley), at Five-Mile-Town (with aphanite), in moraines east of this place, and at Smotan Bridge (on the E. slopes of Slieve Beagh).

Within these approximate limits, boulders of these rocks were encountered, occurring sporadically towards the margin, and in considerable numbers towards the interior of the fan. It will be noted that some occur actually to the west and south-west of the outcrops. These occurrences are to be attributed to the earlier Scottish glaciation. The distribution of these erratics is, in consequence, the result of the two ice-flows, the earlier from the north-east and east, the later from the west and north-west. These conflicting movements have resulted in a less simple distribution than that which characterises the Barnesmore and Donegal granites.

The main track of dispersal would appear to run roughly west-east in the direction of Cookstown and Moneymore, though great numbers dot the country to the north of this strip. As already pointed out, they have been seen as far east as Soldierstown.

At an earlier page it was stated that J. R. Kilroe had postulated a glaciation from the north, intermediate between the earlier (Scottish) and the later (Donegal) glaciations. Part of the evidence upon which this intermediate glaciation has been based was at that place discussed (p. 191); the remaining evidence may now be examined. To quote his own words[2]:—

> "In this [Bann] valley, however, a certain association of granitic schistose, and epidiorite rocks, as erratics, occurs in such notable

[1] A boulder was, however, observed in the moraine above Stradovan Bridge (N.E. of Mountfield), in the lower part of the Mullaghcarn mass (altitude ca. 700 feet).

[2] *Op. cit.*, p. 651.

prominence that one is forced to seek a cause for their presence. Such an association can scarcely have originated in the south, a source of this character being wanting there; there is, however, a distinct multiplication of granite erratics, noticeably as one proceeds southward by Garvagh and Kilrea, pointing to Slieve Gallion as the source. . . . Of an extensive movement from Donegal and Londonderry over the basalt plateau and other intervening high grounds there seems no evidence whatever, and no reasonable grounds for conjecture. We are, therefore, shut up to the north or north-east, where the sea conceals the prolongation of the Archaean Gneiss area."

Like the erratics of granite, whose southern source Mr. Kilroe recognised, these basic and metamorphic boulders are clearly referable to the Slieve Gallion and Co. Tyrone area, for petrologically these rocks are identical, while, as Dr. A. R. Dwerryhouse has shown, the Bann was glaciated by ice proceeding northward.

The shell-bearing deposits of the Roe valley, on the one hand, and the granites, schists, and epidiorites of the Bann, on the other, together constituting J. R. Kilroe's evidence of a southward-moving ice-mass, may be, therefore, more satisfactorily regarded as products of the earlier and later ice-sheets respectively, their occurrence fully harmonising with and confirming the movements of the ice-sheets over this region as set out in Dr. A. R. Dwerryhouse's paper and in this communication.

At an earlier page it was shown that Lough Derg lay on the line of the great ice-shed of Donegal. It is difficult in the field to trace the continuation of this ice-shed to the south of this lake; the hills are beautifully rounded, but the rocks have seldom retained any ice-scratches or other indubitable evidence of the direction of ice-flow.

In the earlier stages of the glaciation, the ice-shed doubtless ceased somewhere in the neighbourhood of Lough Derg. Gradually a great mass of ice would appear to have accumulated over the site of Lough Erne. The great bastion of carboniferous rocks rising from its southern shores would seem to have played a very important part in barring the progress of the ice in this direction, causing it to pile up and finally to split on the northern face, swerving to the west into Donegal Bay and eastwards over Enniskillen into the Central Plain. In this way there was gradually formed an axis of dispersion over Lough Erne, linking up the main ice-shed of Donegal with that centred in the Sligo Hills. This ice probably imparted a more easterly motion to that moving over Tyrone, while the northerly movement of the ice down the Bann and over the Sperrin Mountains may be also in part ascribed to its influence.

The distribution of the drift proves that the large glacier occupying the Erne valley flowed southwards and eastwards. Thus Maxwell Close noted "two good-sized lumps of micaceous schist" in the drift near Enniskillen, and continues: "These must have travelled fifteen miles at least from the north-west." Though the source of these boulders is probably the metamorphic region north-west of Lough Erne, their possible derivation from the O. R. S. conglomerates may not be excluded. Indeed, very few boulders unmistakably referable to the igneous and metamorphic complex extending from Ballyshannon to Lough Erne were encountered in the Erne valley, the great bulk, almost all, of this material being transported westward and out to Donegal Bay. The ice-shed lay, in general, somewhere to the east of the triangular Archaean tract.

The topography of the country, moreover, south of Slieve Beagh and in the Enniskillen valley suggests the passage of glacial streams from Lough Erne southwards, at least in the late-glacial phase; the drumlins indicate the passage of ice along the valley, and a swinging of the ice at Newtown Butler round the south-west slopes of Slieve Beagh. This would appear to be part of a great fanning of ice executed about Ballyhaise and Cavan, as the drainage lines, features, and drift in all this area are clearly indicative of ice flowing from the north-west. Indeed, the chief relief of this Enniskillen ice was manifestly found in the direction of Cavan.

The south-east trend of the ice is seen as far as the south-east confines of the region described in this paper, and over that area situated to the south of it, the ice passing over Keady, Castleblayney, and Carrickmacross, and out into Dundalk Bay. This is proved by the striae recorded by the Geological Survey, and by the form of the ground, as seen during a hurried traverse of the country. The same direction was taken by the ice in the adjacent region dealt with in A. R. Dwerryhouse's paper. A perusal of the Geological Survey maps and memoirs suggests that the southerly motion of the ice over at least the northern part of the Central Plain was due in some measure to the impetus imparted by the ice-sheet of N.-W. Ireland.

In fine, from this great ice-shed, extending from the Glendowan Mountains in the north-west to the south of Lough Erne and Sligo in the south, huge glaciers passed radially outwards, on the south-west over Donegal Bay, on the west and north over the Rosses and Northern peninsulas, on the north-east over Inishowen and the Sperrin Mountains, on the east down the valley of the Bann and over Cookstown, Dungannon, and the plain of Tyrone, and on the south along the valley of the Erne, over the Clogher valley and Slieve Beagh, to the Central Plain.

VII.—RETREAT OF THE DONEGAL ICE.

With the passing of the maximum stage of glaciation, changes occurred in general in the reverse order to those which may be supposed to have marked the waxing of the ice-sheet. The facts are patently displayed and show that at its margin the ice began steadily to shrink backward, and simultaneously to diminish in thickness. Lower and lower ridges and hills successively appeared above it, and the continuous sheet gradually gave place to a number of large and detached lobes and valley glaciers. During this later phase the effects produced by the ice at its maximum extension were considerably modified. This modification was due to deposition rather than to erosion.

Though it is impossible in all areas to trace a connected history of the glacial events during this valley glacier phase, yet in most regions this can be done with striking precision. Even in the other areas, where evidence is less plentiful, there are clear indications of the late-glacial changes.

The determination of the mode of the retreat during the different stages is based upon the evidence supplied by moraines and lake phenomena with their temporary drainage channels. The principles governing their formation were described in Professor P. F. Kendall's paper on "A System of Glacier-Lakes in the Cleveland Hills."[1]

Of the true character of the great majority of these overflow valleys, now either quite dry or occupied by insignificant streams, no doubt can be entertained; their appearance, location, and non-accordance with the pre-glacial or present drainage most clearly demonstrate their mode of origin. Other valleys may be due to similar marginal streams, but where differential ice erosion has so strongly influenced the detailed topography as in the Donegal Highlands, and where beds of different powers of resistance alternate so rapidly, it would be hazardous in the extreme to select from these any which were used as temporary glacial drainage channels. These have been omitted from the following description.

Owing to the dissected character of the country, direct overflows are plentiful, though the marginal type of channel is the more common. The pre-existing drainage lines were also frequently followed, and in consequence considerably deepened and enlarged.

Except in the Sperrin Mountains, there are but few occurrences of accumulations suggestive of a beach or deltaic origin.

Where a thick turf cover conceals the outcrop of rocks of unequal hardness, it is frequently tempting to interpret these surface irregularities as due to original inequalities in the deposition of the drift. This difficulty

[1] Quart. Journ. Geol. Soc., vol. lviii (1902), p. 471.

is further complicated by "desk-structure."[1] In several localities in Donegal, ridges occur which strongly resemble in external form true morainic accumulations, but which, on examination, prove to be bosses or ridges of some hard rock, with just the merest cover of drift.

In the peripheral areas, however, a distinct change takes place. Here the morainic accumulations are extremely well developed; the contrast between the great morainic development of the plains and valleys of Fermanagh and Tyrone, and the occasional and isolated occurrence of a morainic mound in the valley of Donegal is indeed most striking. This difference may be attributed in part, though not entirely, to the respective rates of waning of the ice-sheet. In the earlier stages of the recession, now represented by the moraines of the peripheral belt, the retreat was comparatively slow, with frequent pauses; in the later stages, when the glaciers had shrunk back into the hills, it was rapid and practically continuous. This deduction is in agreement with that drawn from the corries. The moraines occur frequently as a series of confusedly arranged wavy mounds, and where breached by river erosion, are frequently seen to consist of sand and gravel with included blocks and boulders.

In the absence of moraines in the central highland region, it is somewhat difficult to separate the glacier stage from the preceding ice-sheet phase. This separation is rendered all the more difficult by the coincidence, in general, of the directions of the ice-motion during the two stages, which is a consequence of the radial dispersion of the glaciers along the major valleys. In these cases, though only small streams are involved, the marginal drainage phenomena have proved invaluable.

In the description of the retreat it is proposed to discuss the areas and the glaciers in the following order:—

1. Sperrin Mountains.
2. Tyrone glacier.
3. Slieve Beagh and Clogher Valley.
4. Fintona Hills.
5. Fintona and Erne glaciers.
6. Foyle and Swilly glaciers.
7. Mulroy, Sheephaven, and Glenna glaciers.
8. Rosses and Dunlewy glaciers.
9. Glengesh Plateau.
10. Great Finn glacier.
11. Barnesmore Hills.

[1] E.g., the ridges running east-west as foot-hills along the northern slope of Muckish. These are really due to the gentle dip of the quartzites to the south, though the rocks are to some extent masked by drift.

1. *The Retreat from the Sperrin Mountains.*

In the Sperrin Mountains a suite of channels was observed, which bears witness to the former presence of swollen torrents, linking chains of lakes, which, resting between the hill-slopes and the temporary support of the ice-barriers, were the result of special conditions imposed upon the land drainage of this hilly country.

During the retreat of the ice from the Sperrin Mountains, their highest parts were the first to be uncovered. The drainage of these ice-free surfaces was unable to escape normally, as the main valleys and the lower parts of the tributaries were full of ice. In consequence lakes were formed in the unoccupied heads of the main depressions, the accumulated waters held up by the ice-barrier running in finger-like projections up the tributary valleys.

These temporary lakes were drained by channels cut across intervening cols and spurs; lower and lower cols were opened, and lower and lower channels brought into use as the retreat progressed.

There is abundant evidence in these hills to permit of the marking of the position of the ice front throughout the region during the various stages of the retreat, though the location of the overflow channels would seem to have been determined as much or even more by the general configuration of the country where left exposed by the ice-retreat as by the detailed nature of the retreat itself. A few of the more important of these stages are represented on the map (Pl. VIII).

These channels occasionally indicate a small local advance of the ice-margin, though no general advance along the whole line would seem to have taken place.

Magnificent deltaic terraces were formed in these extra-glacial lakes, and were best developed where tributary streams, pouring out of higher lakes and transporting excessive quantities of sand and gravel, entered lower lakes. To a much less extent they fringe the lakes round their landward margin. The material of which these huge deltas are composed is well water-worn, varying in coarseness from fine sand to boulders a few feet in length.

The higher or older terraces were largely destroyed during the building up of the lower and newer ones, the lowest being, in consequence, best preserved, the highest least recognisable and most effaced. Hence, the highest terraces of all appear now as a mere collection of detached remnants, while few occur on the same grand scale as the comparatively low terraces found in the vicinity of Claudy.

Weeks spent among these terraces impress one with the great extent and vast amount of terracic material; and this area perhaps more than any other raises the question of the source of so much gravel and sand. The rapid waste of drift in the higher parts of the valleys and on the steeper slopes of the ice-free hills, the excavation of the large glacial drainage channels, and the sheets of sub- and en-glacial material swept from the ice itself seem, however, quite adequate to account for their prodigious development.

In the "Londonderry Memoir" (p. 78), "the terraced structure of the sides of the Faughan valley," e.g., in the neighbourhood of the "Oaks," and at Burntollet Bridge, is ascribed to erosion by "streams flowing in late-glacial and post-glacial times." The terraces are, however, unmistakably accumulation features; the coincidence in height of their upper surface with the intake of glacial overflow valleys draining marginal lakes, which covered the areas in which they occur, their characteristic location at the debouchure of large glacial streams draining higher extra-glacial lakes, their magnificent delta structure, and the water-worn nature of the fine sand and gravel of which they are composed, prove most conclusively their accumulative and not erosive origin.

(a)—*First Stage.*

In early glacial times the Sperrin Mountains formed, as has been shown, the centre of an independent ice-radiation. In later times, as the marginal drainage phenomena most strikingly prove, the ice completely covering these hills gradually diminished in thickness until the backbone of the range was exposed. From this main watershed the ice slowly retreated, falling away simultaneously to north and south, and uncovering some of the deep recesses on either side. In the earliest of these retreat phases lakes were continuous over the cols of the main watershed. This is most clearly seen in the case of the col to the east of Sawel Mountain (2,240). The well-marked notch, cutting across the spur to the south-east of Barnes Top (1,506), with an intake just below 1,250 feet, O.D., could not have been formed unless the col, some 150 feet lower, were covered with water held up by ice in the south.

This lake—"Lake Cloghornagh"—over 150 feet deep on the col, at the initiation of the valley, was held up to north and south by barriers of ice, which had already shrunk from the main watershed, and whose melt waters could only escape by the channel to the south of Barnes Top.

The recessed character of the hills to the south of the main Sperrin watershed brought about, as the ice-front still further retreated, the formation of a series of marginal lakes, each of which had its own separate overflow channel cutting across the main watershed into the temporary lakes held up in the corresponding recesses in the northern flanks. These overflows, as finally evacuated, are of great size and doubtless originated in one or two cases [1] as the relatively small channels produced by the waters draining directly off the ice-front as the ice parted to the north and south of the watershed. All these direct channels fall north, and indicate that the ice withdrew more rapidly on that side than on the south of the watershed. Hence, in the case of the "Lake Cloghornagh," its level was so lowered by the opening of lower cols across the northern tributary spurs that the smaller lake, held up in the recess of the Oughtnamwella and Glenirn burns, drained northwards across the col. This "Cloghornagh" overflow (C.C.)[2] is deep, and carved out of schist. The intake is about 1,090 feet, O.D.[3]

In these independent lakes, held up in the recesses south of the main watershed, the waters stood at different levels, the height of each lake being determined by the altitude of the col at the head of the valley across which the outlet was cut. Hence, the highest lake was that which drained by the channel across the ridge S.-E. of Mullaghaneany (2,070), the intake of which was roughly 1,350 feet, O.D. The "Tamnagh" channel (T.) starts on the col to the N.-W. of Dart Mountain (2,040) and intakes at 1,420 feet, O.D. The intake of the channel across the col E. of Mullaghclogher (1,896) is roughly 1,350 feet, O.D. One of the most easterly of this series of lakes was impounded in the upper part of the large valley of the Glengomna Water, and discharged its waters by a fine valley falling east (intake just below 1,250 feet, O.D.) into "Lake Altalacky." No trace of connecting streams across the intervening subsidiary watersheds was observed. The sands and gravels observed in all these recesses up to about 1,200 feet, O.D., are doubtless the lacustrine and moraine deposits of these lakes. These direct overflows were not thrown out of action until the ice-front had shrunk southwards and well away from the main watershed, and the great valley of the Glenelly had become ice-free. As the ice swung off the hills, the lakes from east to west became in turn confluent with the waters of "Lake Glenelly."

Held up in the recess to the north-west of Draperstown was a lake—"Lake Altalacky"—some 700 feet deep in its deepest part near the ice-foot, and of over six square miles surface area. The outlet at the head of this great recess might be expected to bear some relationship to the size of the lake whose surplus waters it discharged. This overflow is the Altnaheglish valley (A.O.), the finest of these direct channels. Its intake is just above 1,000 feet, O.D. The valley is quite good on the col, and carved out of schist; it falls

[1] E.g., that between Dart Mountain (2,040) and Learmount Mountain (1,615).

[2] The letters in brackets correspond to similar letters on the accompanying maps, and are inserted as aids to identification.

[3] The lake was continuous across the col at the head of the Aughtnamwella Burn.

steeply for some miles as a cross-contour valley.[1] This lake and channel remained in action for a long time, as a considerable retreat of the ice from the hillslopes bounding the lake would uncover no other outlet for the escape of the impounded waters. Only when the ice-barrier had completely withdrawn from the mouth of the recess did this lake cease to exist. The long persistence of this channel is in marked contrast with the more or less rapid changes of marginal drainage which were effected on the north during the same time. The Altnaheglish overflow continued in operation until the whole valley, to a point well below its confluence with the Glenedra, had become ice-free, and the Altnasheskin valley (A.S.) no longer carried off the waters of "Lake Glenedra." The stratified sand and gravel, frequently current-bedded, exposed in the deep sections in the streams now draining this great depression[2] N.-W. of Draperstown, doubtless represent the lacustrine deposits formed on the floor of "Lake Altalacky."

Hence this high and prominent watershed of the Sperrin Mountains, one of the most important watersheds of North Ireland, was cut across by a series of seven overflow channels, carrying off the surplus waters from extra-glacial lakes held up in the recesses to the south of it.

The "Tamnagh" (T.) and "Cloghornagh" (C.C.) channels discharged into a large lake, "Lake Dreen," supported by ice resting on the flanks of Learmount (1,615) and Mullaghash (1,581). The surplus waters escaped by a broad valley, south of the latter hill, intaking just below 1,000 feet, O.D., and discharged into the large "Lake Glenedra," which extended finger-like up the Fingeen, Glenedra and Altnaheglish valleys. These were blocked across their mouths by an ice-lobe thrust into the recess between Teeavan Hill (1,085) and Mullaghash (1,581). The lacustrine deposits, situated near the confluence of the Altnaheglish and Glenedra rivers, and derived chiefly from material swept out of the ice, were largely dissected and re-distributed by the glacially-directed stream courses when later the lake level was lowered. Water-worn sands and gravels are exposed in the fine sections all along the sides of the Glenedra valley.[3] "Lake Glenedra" received the waters of "Lake Altalacky," and formed an exit by the large dry glen (A.S.) east of Teeavan Hill.[4] It poured its waters and carried its detrital matter into the huge lake, "Lake Benady," held up in the Benady Glen. The height of this lake at this stage was roughly 800 feet, O.D., rather below it than above it, as shown by the magnificent terrace[5]

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[1] The site of the proposed reservoir for Londonderry City lies in its lower part.

[2] E.g., in the banks of the Dunlogan River, near Moneyneany.

[3] Those occurring near Glenedra Bridge, at an altitude somewhat exceeding 1,000 feet, possibly represent morainic accumulations.

[4] The Altnasheskin valley of the six-inch O.S. maps.

[5] The Murnee Hills of the six-inch O.S. map.

at the outfall of the Altnasheskin overflow (A.S.). Sections, some 60 feet or more in height, in the sides of the White Burn, show great quantities of sand, in places finely current-bedded; their arrangement clearly indicates stream deposition from the south. The material is composed chiefly of well-worn disc-shaped pebbles of schist, derived from the sides of the Altnasheskin glen.

The huge lake, extending far up the valley of the Benady Glen, received a stream of no great size, flowing northwards over the Glenshane Pass. The recess to the south of the latter is extremely small, and the overflow correspondingly diminutive. The channel (G.P.) intakes roughly about 975 feet, O.D., but fails to indent the 800-foot contour.

Where did the waters of this great "Lake Benady" escape? In the great basalt escarpment, Benbradagh (1,535), Donald's Hill (1,318), Keady Hill (1,101), and Benevenagh (1,260) are from south to north the most conspicuous features. The altitudes of the intervening cols are 785, 740, and 740 feet, O.D., respectively taken in the same direction. On the col, some four miles south-east of Benevenagh, in the most northerly recess of all, is a small overflow, the "Murder Hole" of the one-inch O.S. map. This valley intakes at roughly 750 feet, O.D., and falls gently east. It is cut in basalt to a depth of some 30 feet. Not only is the intake of this valley some 40 or 50 feet lower than the level of "Lake Benady," as given so accurately by the Murnee Hill terrace, but in comparison with the Altnasheskin glen (A.S.), only one of the feeders of this large lake, the "Murder Hole" is quite insignificant and totally inadequate to carry off all the drainage from the ice-free parts of the Sperrin Mountains and the flood waters from the melting ice-front, all of which, as the map (Pl. VIII) clearly shows, must have been discharged by the outlet of "Lake Benady." With the single exception of this small overflow, the cols just mentioned show no trace of drainage across them, from west to east. It would seem that the lake waters were discharged over the ice or, more probably, by a channel or shelf along the face of Benbradagh, but now completely effaced by the later slips. This channel probably drained into a lake held up against the escarpment of the basalt plateau; its outlet, now no longer recognisable, was cut along the face of Benevenagh.

This lake received the surplus waters of lakes impounded on the dip slope of the plateau by ice standing in the Bann valley. These streams, discharging from east to west, produced the two pots, the "Legananam Pot" and the "Legavannam Pot," both in the recess to the north of Benbradagh.[1]

The extremely fine sand, exposed in the banks of the Benady river above

[1] They cut the 600 and 700 contours.

Dungiven,[1] represents the lacustrine deposits formed in "Lake Benady." Possibly belonging to this stage, though doubtfully I think, are the warps and highly calcareous clays containing a few small pebbles, and buff or reddish in colour, exposed in the good sections, 20 feet high, in the brick-field at or near Mullane, north-east of Limavady.[2] More probably of this stage are the beautifully current-bedded sands observed just east of Castle Bridge, near the main road from Limavady to Dungiven, also the pebbly stratified deposit at Walk Mills (three miles S.-E. of Limavady), though these are in part morainic.

Indicating the position of the ice-front at one stage of the retreat is a ridge of sand and gravel which commences at an altitude of 850 feet, O.D., on the flanks of Keady Hill and crosses the valley of the Curly River, finally disappearing as a series of scattered morainic hillocks near the Largantea Burn. This ridge was attributed by J. R. Kilroe[3] to an en-glacial river, which, as a temporary aqueduct, flowed some 150 feet above the present Curly bed. A stage in the retreat, in part probably later than this, is represented by the morainic country running from the debouchure of the Owenrigh River in a north-easterly direction to Dungiven, and continuing with interruptions as an irregular strip of country along the foot of Donald's Hill, past Ardmore, to the south-east of Limavady, where the constituent sands and gravels are well exposed.

Hence, there would appear to have been a progressive shrinking of the ice to the east and west from the line of the basalt escarpment, and to the south and north from the Sperrin Mountains. Slightly lower levels characterize the lakes on the western and northern sides, so that all the direct overflows across this great watershed, from the western end of the Sperrin Mountains to Benevenagh on the north, with the single exception of the "Murder Hole," the most northerly of the series, fall either west or north. The position of the ice margin at this stage, with the corresponding impounded lakes, is represented on the map (Stage 1, Pl. VIII).

(b)—*Second Stage.*

In the succeeding stage (Stage 2, Pl. VIII) the most striking feature is the vast extent of the deep lake held up in the valley of the Glenelly River. Prior to the opening of the Inver Burn channel, this lake had a length of

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[1] E.g., S. of Boviel, at "v" of "River Roe" of one-inch O.S. map, in the left bank of the river. Here the section, some 70 feet high, consists almost entirely of sand, with an occasional layer of pebbles.

[2] These with more probability are the deposits of "Lake Foyle," formed at a later stage of the glacial period.

[3] Belfast Nat. Field Club, p. 656.

roughly 12 miles, and a depth of over 500 feet; its surface covered nearly 15 square miles. The surplus waters of this "Lake Glenelly" were discharged by the valley of the Glengomna Water (G.W.) into the Moyola River, its detritus probably contributing in no small way to the building up of the delta of this river separating Lough Beg from the main water of Lough Neagh. That this outlet was free indicates a great retreat of the ice southwards along the Bann valley, a retreat vastly greater in amount than the corresponding shrinkage to the north of the Sperrin watershed. The glacier flowing down the Bann obtained its fresh accretions by a very circuitous route, via the "Omagh-Draperstown corridor," and would doubtless retreat earlier than the more readily and directly-fed glaciers flowing along the northern face of the Sperrin Mountains.

The intake of the Glengomna overflow is about 850 feet, O.D.[1] Glenelly, west of the outlet, is choked with stratified sands and gravels thrown down into the lake. They are exposed in the fine stream sections at Crocknakin and just below Granagh. Much of this material, as of that which swathes the sides of this huge valley, was doubtless swept out of the ice and into the lake as the ice-front receded westwards. The moundy ridge running along the valley side, just east of the Glenlark overflow (G.O.), at an altitude of 1,000 feet O.D.,[2] represents an earlier phase in the retreat when the ice was thrust into Glenelly from the east, and the drainage was over the main Sperrin watershed, while the smaller mounds, south-west of Crocknakin, near the intake, and down the valley of the Glengomna Water, indicate later halts. The pre-glacial rock-floor of the Glenelly and its tributaries is, in consequence of the extraordinary thickness of the lacustrine deposits, very seldom seen.[3]

With the westward retreat down Glenelly, the ice gradually and simultaneously withdrew from the hill-range to the south of the valley impounding the waters of the Glenlark River. These drained northwards by an overflow (G.O.) at the head of the glen (intake about 1,050 feet, O.D.) into "Lake Glenelly," ceasing at the altitude of its Glengomna outlet. The sands and gravels occurring in the upper part of Glenlark represent the lake deposits formed at this period. A lake was similarly held up in the upper part of the Coneyglen, N.-W. of Mullaghturk, and drained by the Altaturk Glen (A.G.) into the Moyola River. The summits of the Craignamaddy range running west from Barnes Gap (B.G.) were in all probability ice-free at this stage, the moundy

[1] The Glengomna Water now enters the main valley of the Glenelly over a corrom.

[2] The position of these mounds is indicated very well on the one-inch O.S. map. Reference is made to them in the Geol. Survey Memoir, Sheet 26, p. 21.

[3] In one case only, that of the Garvagh Burn, does the tributary enter by a rock gorge. Here the stream has obviously failed to find its old course, and had to carve out a new one through the schist.

surface on the southern flanks of the range probably marking the edge of the ice. Consequent upon its withdrawal, the most westerly of the great recesses in the northern side of the Sperrin Mountains, north and north-west of Mullaghclogha (2,088), became ice-free. The large lake in the recess drained over the col to the south of Mullaghanimma, and into the lake (L.G.) held up at the head of the Glenrandal valley. A later and more important stage is represented by the deep, straight channel falling northwards along the face of the hill. A doubtful overflow valley occurs below this.

"Lake Glenrandal" (L.G.), drained firstly by the deep and narrow Doalt Glen (D.), intaking at 960 feet, later by the Carnanreagh channel, which intakes at about 750 feet, O.D. Both are cut in rock.

These two streams have contributed to the sands which occur as moundy features over the floor of "Lake Dreen," e.g. N.-W. of Dreen itself, though the bulk of the material was probably washed out of the ice. The detritus brought down by the Cloghornagh Channel (C.C.) from the south side of the Sperrin watershed has formed a terrace in this lake south of Dreen.

The surplus waters of "Lake Dreen" flowed through the Glenmoyle valley (G.M.), near Glenmoyle Lodge. It is cut in rock, and intakes at about 800 feet, O.D. Morainic ridges on the lower N.-E. slopes of Learmount (S.-W. of Dreen) probably mark the position of the ice-front at this stage.

With the withdrawal of the ice from Meeny Hill, and the opening of the Doalt Glen channel (D.), the drainage of "Lake Dreen" escaped by the lower and larger valley of the Ballydonegan River (B.D.). This glen runs along the western foot of Mullaghash (1,581), and has its intake at roughly 550 feet. A moraine, probably corresponding with this stage, runs north-west of Dreen roughly east-west, while the fine series of mounds extending south of Feeny from just east of Umrycam to Fincarn mark, without doubt, the position of the ice-edge along this part of its course. The deep dry Banagher valley (B.), intaking at about 540 feet, O.D., is carved out of "solid." The greater part of the deltaic and lacustrine sand and stratified gravel occurring to the south of Fincarn, and above the intake of the Banagher valley, represents the sediments deposited in the lake by the large streams entering it from the Finglen and adjacent valleys. The Ballydonegan valley (B.D.) only began to operate as the overflow of "Lake Dreen" after the Banagher valley was thrown out of action.

By the retreat of the ice from Teeavan Hill (1,085) to its position west of the Banagher valley, the large lake extending up the Altnaheglish River ceased to exist, as the normal drainage down the Owenrigh was now open. The "Lake Fincarn," to the west, prior to its drainage by the Banagher valley, discharged its surplus waters by the "solid" glen of the Cushcupal Water, and later by the small channel west of this, cut into the terracic and morainic deposits of "Lake Genedra."

During the stage represented by these channels, the ice swung clear of the basalt escarpment; the normal drainage from the latter and from the ice-free portion of the Sperrin Mountains, together with the melt waters from the ice-front, was now able to escape northward by the River Roe.

Hence, as the map (Stage 2, Pl. VIII)[1] represents, the drainage flowing northward and southward from the main watershed of the Sperrin Mountains was, at this stage of the ice-retreat, completely distinct, the surplus waters of the one series of lakes flowing by the Banagher channel into the River Roe, those of the extensive "Lake Glenelly" and its tributary, "Lake Glenlark," into the Moyola River. At no subsequent period of the retreat did this complete separation of these drainages obtain, as they were linked up by the large connecting-through valley of the Inver Burn.

About the time represented by this chain of lakes, the higher parts, probably above the 1,250 contour of Mullaghcarn, began to project as a nunatak above the ice-surface; the line of junction between the ice-free summit and the ice covering the lower flanks of the hill probably sloped somewhat to the north-east, as the maximum pressure was from the south-west.

(c)—*Third Stage.*

The highest lake in the series, formed during the next phase (Stage 3, Pl. VIII), was situated in the angular recess west of Mullaghcarn. The position at one stage of the ice-front, which impounded the waters of this "Lake Cullion," is marked by a belt of irregular mounds and hummocky ridges, extending from Cullion Bridge to Turcur. The escape of the waters of this deep (about 350 feet) lake into the vast "Lake Gortin" was by the Altaravan Glen (A.), in the very angle of the recess. This valley intakes at 848 feet, O.D., and falls to 800 feet, O.D. The irregular, moundy terrace,[2] which at this height runs so conspicuously along this part of the hillside, is its delta. This feature has been profoundly modified by the later glacial streams, much of the lower terrace having been derived from its destruction.[3]

The western wall of ice, which impounded "Lake Gortin," swung from the northern flanks of the Ballynatubbrit Mountain, across the big Gortin

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[1] This line represents a somewhat later stage in the south than in the north, when the Altnaheglish and Cloghornagh overflows had been thrown out of action by a further retreat of the ice.

[2] These huge mounds, as seen from Slievebeg, the hill to the N. of the valley, are seen to approximate to one level and to be terracic in form, with flat top and steep face.

[3] The small lakes and tarns on this hillside, e.g., Black Lough and Oak Lough, are impounded by this deltaic material.

depression to the western shoulder of Craignamaddy. This lake was drained by the gigantic trench of "Barnes Gap" (B.G.). It intakes at about 760 feet, O.D., and falls to 600 feet, O.D., which is the level of the Inver channel. At its entrance into "Lake Glenelly" a fine flat-topped terrace was built up.

The southern ice-support of "Lake Gortin," which extended up the valleys of the Owenreagh and Owenkillew rivers, swung from the north-east shoulder of Mullaghcarn, across the Owenreagh valley[1] on to the southern slopes of Crocknamoghil, over the eastern end of the hill of Crockanboy, across the Owenkillew valley and on to the slopes of Crockyneill and Mullaghturk.

The greater part of Mullaghcarn would at this stage project above the ice which fitted closely on its southern and eastern flanks, as no trace of marginal drainage was observed at the height of 900 or 1,000 feet, which in this area must have been approximately the altitude of the line of contact of ice and hill.

Hence, "Lake Gortin" was largely held up by the ice-face on west and south-east. Its greatest depth exceeded 500 feet, while its water-surface was approximately 20 square miles.

The water-worn sands and gravels exposed in the sides of the Glenawtsk Burn and in the bottom of the Owenreagh River are its lake deposits. Similar lacustrine sands and gravels occur plentifully in the valley of the Owenkillew, and are extremely well exposed in the sides of the Glenlark valley up to, roughly, 750 feet, O.D.[2]

There can be very little doubt that, as a comparison of the positions of the ice-fronts at the second and third stages represented in the map (Pl. VIII) will readily show, the retreat of the ice from the earlier to the later position was effected by the splitting of the ice-sheet into two portions, the line of division occurring between Barnes Gap and Mullaghcarn. The lake occupying the area between the ice-fronts gradually increased in extent, as the ice withdrew westwards to Gortin and beyond, and southwards to the "Omagh-Draperstown corridor." This splitting of the ice-sheet is manifestly to be ascribed to the shelter afforded by the increasing size of the Mullaghcarn nunatak.

A slight recession of the ice westward, along Glenelly, beyond the second stage represented in the map (Pl. VIII), uncovered Eden Hill (977) and the col at the head of the large tributary of the Eden River. This threw the

[1] The large ridges running towards the river from the valley sides, just south of Rusky, probably mark its position at this stage.

[2] The mounds in the higher part of this glen, and on its southern side (indicated by the three outliers of the 1,000-foot contour of the one-inch O.S. map), represent the deposits of an earlier moraine.

Glengomna outlet out of action and initiated the carving out of the magnificent Butterlope Glen (B.L). This glen falls rapidly from its intake at 780 feet, O.D., to about 630 feet, O.D. Here it now falls over a step into the wide valley of the Inver Burn, but was doubtless originally continuous with a tortuous channel, the "Balix" overflow, which runs with but little fall along the side of the Inver valley, and whose intake is about 600 feet, O.D., i.e. some 30 feet below the exit of the Butterlope Glen. These two channels were the product of the marginal streams deflected into the rock by the ice which stood in the depression of the Inver Burn. A still further withdrawal to the west threw out of action the Butterlope and Balix Glens and opened the Inver valley, which then carried off the waters of the lake to the south. This line of drainage, initiated by the retreat from the hills to the north of Plumb Bridge, persisted for a considerable period and excavated a channel, second in importance to none in the Sperrin Mountains, and in size inferior only to the Burngibbagh valley to be described later. It intakes at about 580 feet, O.D. The winding of this glacial river has separated the Balix and Butterlope valleys, which, as stated above, were originally continuous.

"Lake Glenelly," the waters of which escaped by this "Inver Channel," was at this stage held up by ice, which rested on the southern shoulders of Crockaclady and swung across to Slievebeg, just west of Plumb Bridge, the ice-front standing not very distant from the slopes of Sturrakeen to the north of this village. This proximity is confirmed by the deep Glengoppogagh (Gg.) which is cut into the "solid" rock on the south-west flanks of this hill. It intakes at about 750 feet, O.D., and was obviously produced as the ice retreated off this shoulder as an intermediate step from the Butterlope Glen to the Inver Channel. The period of the occupation of Glenoppogagh was very brief, as only a slight recession of the ice-front would throw it out of action. The surplus waters of "Lake Gortin" were discharged by the Barnes Gap overflow into "Lake Glenelly" when the height of the latter was determined by the Inver channel. The 600-foot terrace formed at the entrance into the lake clearly proves this. During the Butterlope Glen stage of "Lake Glenelly" this lake, the level of which stood at about 780 feet, O.D., must have been some 13 miles long and not less than 400 feet deep, with finger-like ramifications up all the tributary valleys.

The Inver overflow continued in operation for a very considerable period, as gauged by the great size of the valley, the huge terraces produced in the lake into which it poured its waters, and by the fact that not until a further retreat of the ice-front some six or seven miles to the westward had taken place, was a lower and alternative means of escape possible.

The drainage of the deep and large valley to the west of Crockaclady Hill was simultaneously impounded, forming a lake independent of "Lake

Glenelly." Its outlet was over the col at its head (just over 700 feet) and into the valley of the Dunnyboe Burn.

The waters of this lake and of "Lake Glenelly" flowed northward through their respective overflow channels into the lake held up in the valley extending southwards from the village of Dunnamanagh, forming great deltaic terraces where they entered the lake.[1] The altitude of these higher terraces corresponds closely with the intake of the highest overflow channel to the south-east of Lough Ash (L.A.). This extremely large valley intakes at about 580 feet, O.D., is entirely excavated in rock, and falls east. Smaller channels coming into this "Lough Ash" overflow from the west probably represent the erosion by the flood waters pouring along the valley in which lies Lough Ash itself and from the ice-front standing near the entrance to the valley.[2]

The two small and shallow valleys, south of Ballynacross, possibly represent slightly earlier phases in the retreat from the Mullaghanimma hills.

A small lake, held up in the valley south of Liscloon, drained southwards by a channel (L.O.) into the "Lough Ash" overflow, the combined waters flowing along the upper part of the Glenrandal River into "Lake Claudy." A slightly earlier stage is represented by the two valleys falling east to the south of Slieveboy. The more southerly valley is slightly lower at the intake than its neighbour, and as post-glacial erosion of either valley is clearly negligible, a slight re-advance of the ice-margin with renewed cutting of the southern valley would seem to have taken place. This advance probably did not exceed one-quarter of a mile.

A lake of considerable size was dammed up by the ice, which stood across the valley of the Faughan, just west of Claudy, and swung from the northern slopes of Eglish Hill on to the western shoulder of Boultybracken. The ice-front stood about the site of Oak Lodge, for the mounds and ridges of this place, described in the "Londonderry Memoir," p. 78, as "typical eskers with steep bedding and sinuous outlines," probably represent the material thrown down by the ice standing in the lake waters. This lake possessed three chief branches: the first extending south-east up the valley of the Faughan as far as Learmount and Park, the second east towards Feeny, the third along the

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[1] E.g., above Aghabrack, and at Bunbunniff in the valley of the Inver Burn, and at Altishahane and near the confluence of the Dunnyboe Burn and Inver Burn. These terraces are flat-topped and their composition and structure are revealed in numerous stream sections. In these the material is seen to consist of water-worn pebbles and current-bedded sands in great quantities.

[2] The deltaic and morainic mounds impounding the waters of Lough Ash mark its position. Sections in these mounds show strongly current-bedded and water-worn sands and gravels, consisting chiefly of flat discs of schist, with much sand derived from the disintegration of quartzose schists.

Fore Glen towards the north-east. All the streams coming into the lake from the south threw down their detritus to form the huge shingle and sand terraces which lie at, roughly, 400 feet above sea-level, and fringe the southern shores.[1] They have in places a slightly billowy surface, occasional lakes marking the more pronounced hollows, e.g. Tullintrain Lough.

Like the present Lough Derg, this extra-glacial lake had two outlets, both in operation simultaneously. They drained into the River Roe. The one extends as a deep and extremely broad valley (F.O.) from "The Glen" to the south of the village of Feeny. The intake is about 430 feet, O.D. At Altcattan Bridge, just south of Feeny, the overflow proper begins, where the valley has cut deeply into the "solid." The present small stream is out of all proportion to the huge valley in which it flows.

The second outlet is the Ballymoney overflow (B.O.), at the head of the Fore Glen, the intake of which is likewise about 430 feet, O.D. Like the Feeny overflow, it is wide and flat in its upper portion, which also was a transition from lake to outflowing river.

At an early stage in the excavation of these gorges, when the level of the lake was somewhat higher, the waters of the two branches, in the Fore Glen and in the Feeny area, then probably cut off from each other by ice standing to the east of Claudy, were doubtless confluent along the broad flat valley[2] (altitude about 450 feet, O.D.) west of Mullaghmeash Hill. A lake in the large valley of the Burntollet, which at a later stage was confluent with "Lake Claudy," was at this period independent of it, the ice standing across the valley somewhere on the line of the present Ness Waterfall, or slightly east of this locality. The well-developed gravel mounds of Barr Cregg most probably mark its position at some stage. The discontinuous morainic ridge near

[1] This terrace extends as a strip fringing the valley to the west of Straid Hill (1,002). It occurs about Straidarran Ho., and continues as an ever broadening band from south of Ballyrory to Teenaght and Tullintrain, measuring along this stretch almost one-half mile wide. It covers all the country between this and Comber Ho. and Scardagh and as far south along the valley of the Glenrandal River as the bridge (320). On the left bank of this stream it covers a considerable area, extending from the Rectory as far as Comber Church. The good sections hereabout were described by Portlock (Report, p. 636). On page 639, referring to these sands, he remarks that in them "is seen a quiet and long-continued action, probably assisted by the damming up of the channels by ice"—a truly remarkable statement for that time (1843). This clear description of Portlock's requires no supplementary remarks, other than the statement, that wherever exposed, the material invariably shows the same characteristics and arrangement. Good sections were also observed at Binn, south-east of Claudy, where the terrace features of flat-top and steep-face are magnificently shown. Traces of this terrace occur as a narrow shelf along the north side of the lake. The best view of these magnificent terracic features in the Faughan and the finest of the Sperrin Mountains, including the 400 and the lower terraces, is perhaps to be obtained near Claudy, looking south.

[2] This valley is brought out by the 500-foot contour in Pl. IX.

Loughermore Bridge doubtless represents an earlier position of the ice-margin. The lake held up in the upper part of the Burntollet valley was drained by a channel north of the hill of Glenconway. But little cutting had taken place before a retreat of the ice-front freed the lower col to the south-west of this hill, and the overflow, intaking at about 660 feet, O.D., and falling south into the Fore Glen, was formed.[1]

The ice, in its retreat from the Roe valley and behind the hills of Glenconway and Loughermore, halted for some time at Holly Hill, to the west of Dungiven. Here it deposited as a marginal accumulation the belt of irregular mounds of stratified sands and gravels forming conspicuous features in the landscape.[2]

A later pause in the retreat is represented by the morainic mounds and the series of short, parallel ridges at Moys[3] running towards the Roe. The gravel mounds at Sistrakee Top, in alignment with these and some three miles W.-S.-W. of Moys, probably form part of the same great morainic accumulation. They were traced at least one mile farther west, to the south of Legacurry. A still later halt is represented by the hummocky country running from Catmill, S.-E. of Faughanvale Bridge, to the S. of Walworth Wood and from near Tamlaght Bridge to the Mullagh.[4]

The position of the ice-front at this stage is indicated on the accompanying map (Stage 3, Pl. VIII). The more striking features of the marginal phenomena at this period are the great lakes of Gortin, Glenelly, and Claudy, and the large transverse valley of the "Inver Channel," which carried the waters of the lakes on the south side of the Sperrin Mountains into the series of lakes on the north side.

(d)—*Fourth Stage.*

A retreat of the ice-edge off the western shoulder of Slievebeg threw "Lake Gortin" into confluence with "Lake Glenelly"; the "Barnes Gap" outlet thereby became inoperative. The confluent lake now drained by the "Inver Burn" channel. Its level was determined by the intake of the latter, just below 600 feet, O.D. In conformity with this lowering of "Lake Gortin," the stream discharging into it the surplus waters of "Lake Cullion" no longer ceased to cut to just below the 800-foot level, i.e. the height of the Barnes

[1] The curious delta-like form at the entrance of this valley into the Fore Glen, and brought out by the 500-foot contour, is in part a corrom.

[2] Reference is made to these gravel hills in the Geological Survey Memoir, Sheet 18, p. 23.

[3] Mr. J. R. Kilroe described these features (Belfast Nat. Field Club, *op. cit.*, p. 656).

[4] The name of the short ridge on the west side of Roe Park demesne, Limavady.

Gap intake and the highest terrace south of Gortin, but adjusted itself to the new level of the lake. This further downcutting has resulted in the formation of the deep winding valley which is cut in the "solid" and falls very steeply to the new lake level. The huge deltaic terrace of current-bedded sands south of Gortin, exposed in the sides of Gortin Gap, and possessing a flat upper surface roughly coincident with the 600-foot contour, belongs to this stage. A distinct ledge along the front of the 800-foot terrace marks the inner edge of the lower feature.

The waters of "Lake Cullion" were lowered by the opening of a lower col; this outlet is the deep "Glengink overflow" (G.), which intakes at about 720 feet, O.D. This stream also formed a flat-topped terrace in the lake to the north, at an altitude of about 600 feet, O.D., e.g. at Woodbrook. The hummocky strip of country running from Aghalane, south of Ballynatubbrit, to Esker Bridge and Kingarrow, marks the position of the ice-margin in the Cullion recess at this stage. The stratified sands and gravels revealed in the sections in the Cappagh Burn are, without doubt, partly lacustrine, partly morainic in origin.

A short halt in the recession of the ice from the Cullion embayment is represented by the "Killymore" overflow, E. of Mary Gray. Its intake is about 660 feet, O.D. Deltaic deposits are poorly developed at its exit at about 600 feet, O.D.

The position of the edge of the ice on the south and the south-east slopes of Mullaghcarn is given by two channels. The first of these is a very small valley, intaking at an altitude of 800 feet, O.D., and draining a small lake held up in the valley of the Glencurry Burn. It falls south for a very short distance, and probably drained along the edge of the ice into the second valley situated N. of Mountfield. This intakes at about 780 feet, O.D., and drained into "Lake Gortin." The ice-front further to the N.-E. possibly coincided with the morainic strip of country running to Cashel Bridge and with the morainic mounds sweeping along the hillside between Crockanboy and Slievemenagh and across the "Omagh-Draperstown corridor."

The western limit of "Lake Gortin-Glenelly" was at one stage marked by the gigantic morainic ridge of sand and gravel stretching right across the Glenelly at Dergbrough, below Plumb Bridge. As traced southwards, this feature dies down and over a stretch seems to disappear, but re-appears on the lower flanks of the hills and in the valley of the Owenkillew River, near Spring Hill. Still farther south it is continued on the lower flanks of the hills bounding this great amphitheatre on its southern side. At Levercaw there occurs a hummocky belt of country, partly deltaic and partly morainic, which runs generally parallel with the side of the range at an altitude of about 500 feet, O.D. The deposits near the exit of the Glengink overflow had a similar composite origin, for the ice-front at this phase stood just clear of its mouth and almost on the western edge of its delta.

The Dergbrough moraine and the ice towering above it served as the western end of this combined lake, which extended up the Glenelly some 12 miles, and had a depth on the site of Plumb Bridge of about 300 feet. With this lake that in the deep Glashygolgan valley (west of Crockaclady), was at this stage confluent.

The relief of this country, as will be gathered from the maps, is such as to secure a stable position of discharge during a considerable oscillation and retreat of the ice-front, ensuring persistent cutting along the line of the Inver Burn. Altaravan Glen (A.) and Glengink (G.) were successively in operation while the Inver channel was in action, as is proved by the heights of their deltas. A small retreat in the Cullion recess would in turn free the Glengink and Killymore cols, while in the recess to the north, a very extended withdrawal, to be measured in miles, would not affect the drainage along the Inver channel.

On the floor of the embayment, W. of Plumb Bridge, was laid down a series of moraines. Their invariable convexity to the east is proof of a thrust in that direction. They are in places[1] especially conspicuous, and are seen to consist of schist pebbles with much sand, clearly deposited at the foot of the receding ice-front. One exceptionally well-defined position of the ice-edge is given by the morainic mounds running along the northern slopes of the hill east of Moyle Ho., to the south of Killymore Bridge, and by the hummocky and billowy strip of country sweeping along the floor of the amphitheatre from north of this last locality to Agnaglarig. These moraines indicate the thrusting of a large lobe into this huge amphitheatre, resting on the walls on either side of its wide entrance. Between these morainic mounds and ridges the whole floor of the great recess is deeply filled with lacustrine sands and gravels. These are finely displayed in the banks of the Glenelly River,[2] and represent the floor deposits of "Lake Gortin-Glenelly."

A small lake, "Lake Douglas," was held up in the upper part of the valley of the Douglas Burn, east of Victoria Bridge. Its waters escaped by a small channel, intaking at about 630 feet, O.D., and falling south. A shelf falling slightly north occurs at Meenawaddy. Its height is about 530 feet, O.D. A later stage is represented by the valley west of Meenawaddy, which intakes at about 470 feet, O.D.

[1] E.g., at Shannony Bridge, Carnargan and Fullagherin Bridge.

[2] E.g., at North and South Lislea. The finest of all these magnificent sections is in the banks of this river at the first "e" of Glenelly River" (one-inch O.S. map). Here the section, some 60 feet high, is composed almost entirely of beautifully stratified sands and well-worn gravel and shingle.

The stream, forming the highest of these features, flowed into "Lake Gortin-Glenelly," overflowing by the Inver Channel. The others were manifestly too low to escape by this channel, and pouring north, served as the escape of the waters of this large lake by the Foyle valley along the western side of the Sperrins. "Lake Gortin-Glenelly," just prior to the abandonment of the Inver Channel and the initiation of the lower Meenawaddy channels, was of great size; its surface area was some 33 sq. miles, its greatest length about 13 miles, its greatest depth over 300 feet.

The ice, which swung across the western end of the huge amphitheatre, from Mary Gray to the hill east of Meenawaddy and the western flanks of Meenashesk, formed a diminutive lake at Conthem Hill; the shallow channel (C.H.), intaking at about 800 feet, OD., was its outlet. This channel entered a larger lake impounded in the recess to the S.E. of Strabane, which was drained northwards by the Foul Glen (F.G., E. of Knockavoe). This glen intakes at 725 feet, O.D.

A large lake was held up in the valley of the Glenmornan River, N.E. of Strabane. At an early stage these waters were confluent with those of the larger "Lake Dunnamanagh."[1] With the recession of the ice, this lake divided into two, the one in the Dunnamanagh valley, the other in the Glenmornan valley.[2] This lake was drained by the channel, falling gently north, and intaking N. of Gorticum Irish. The great terraces in the Glenmornan valley, the altitude of which is about 400 feet, O.D., or slightly higher, were formed at this stage, very largely by material swept out of the ice. An earlier position of the ice-front is indicated by the small, yet extremely good, "in and out" channel falling north, carved out of the hillside just E. of the Gorticum overflow.

Later retreat uncovered the col north of Windy Hill, and initiated the magnificent valley (W.H.) carved along this line. It intakes at 381 feet, O.D., and falls east.[3]

This stream formed a very fine deltaic terrace, where, at Crockanore, it entered "Lake Dunnamanagh." By subsequent down-cutting in late-glacial times most of this high terrace was removed.

[1] An earlier stage is represented by the deep glen excavated in "solid," running northward along the eastern side of the Dunnyboe valley. It was formed when the ice still stood in the latter, and is clearly an exact analogue of the "Balix channel" on the side of the Inver valley.

[2] The deep glen, cut in "solid," falling *west* into the Glentornan valley from its head clearly carried a large stream, draining from the Dunnyboe Glen. Its waters would seem to have escaped on to or into the ice.

[3] The shallow valley, about three-quarters of a mile S. of this, falling east into the Gorticum overflow, probably acted as a gutter carrying off the waters flowing directly from the ice-face.

A comparatively short withdrawal to the west of Windy Hill caused the excavation of the small glen at Ballylaw falling north. It intakes at 243 feet, O.D.[1]

A later phase is represented by the Stonypath channel, along which runs the Donegal railway (about halfway between Strabane and Donemana Station). The height of the intake is about 180 feet, O.D. The irregular country to the west, about Lisdoo, may mark the moraine of this time. During the period of operation of the "Stonypath overflow," a lobe of ice must have been thrust well into the embayment of the Glenmornan valley to cause the eastward deflection of the overflow valley at its intake and the deposition of the Holly Hill ridge of sands and gravels, representing the moraine of this halt.

The Glenmornan valley is choked full of current-bedded lacustrine sands and gravels which form perfectly flat terraces, e.g. the extensive terrace at Keenaghan.[2]

By the recession of the ice-front to the approximate site of the village of Dunnamanagh, the waters of "Lake Dunnamanagh" were lowered; the "Lough Ash overflow" (L.A.) was thrown out of action and the cutting of the "Drain channel" initiated. This broad valley, intaking roughly one mile S. of Dunnamanagh at about 450 feet, O.D., discharged into a lake[3] held up in the Liscloon valley, flowing then via the Liscloon overflow (L.O.) and the Glenrandal valley into "Lake Claudy," as described above. A further retreat, though comparatively slight, caused the excavation of the magnificent "Black Park Channel," just E. of Dunnamanagh, which intakes at about 370 feet, O.D., and falls north. The detritus transported by this stream doubtless contributed to the terraces which occur immediately to the north of its debouchure into the depression of the Burndennet, including the beautiful terrace (altitude about 320 feet, O.D.) on which Dunnamanagh Church now stands. This channel carried the waters of the lake held up in the valley to the south of Dunnamanagh into a similar lake, "Lake Burndennet," to the north of that place, the two lakes later becoming continuous on a slight westward retreat of the ice-front.

The surplus waters of "Lake Dunnamanagh" were carried off at three distinct stages by separate outlets, the "Lough Ash channel" (L.A.) intaking just below 600 feet, O.D., the "Drain channel" intaking at about 450 feet, O.D.,

[1] Measurements of altitudes were made by a small pocket aneroid and are in consequence only approximate. In many cases, as here, spot levels supply the exact height.

[2] They are also well developed, among other places, at Gorticum Irish, Gorticum Scotch and Grove Hill.

[3] A corrom marks the outfall of this valley at Liscloon.

and the "Black Park channel" intaking at about 370 feet, O.D. Terraces corresponding to these three overflows are clearly developed in the valley to the south of Dunnamanagh, and were produced as the deltas of the large "Inver Channel" overflow.[1]

The waters pouring by the large valley extending south from Dunnamanagh into the large "Lake Burndennet" to the north of that village, deposited their detrital matter as huge terracic accumulations[2] at and around this place. The moundy accumulations of sand and gravel N. of Dunnamanagh[3] are manifestly the material irregularly dumped down on the floor of this lake. In later stages the lake was almost choked up by the infilling of detrital sand and gravel.[4]

The overflow of the lake by Bond's Glen (B.O.) is of great magnitude, and falls N.-E. into the Faughan Valley, W. of Claudy. The extent of the down-cutting would appear to be about 70 or 80 feet, the channel having been initiated at about 400 feet, O.D. The terraces in the lake above fall, in consequence, through this height from 400 feet to 320 feet, successively newer terraces forming at lower and lower levels in correspondence with the lowering of the outlet. The terrace at Crockanore, formed as a delta of the "Windy Hill" (W.H.) overflow, corresponds to this Bond's Glen outlet of "Lake Burndennet." A recession of the ice-front of more than four miles was necessary before the marginal drainage was presented with fresh means of escape by the huge Burngibbagh valley.

"Lake Claudy" drained, as shown above, by two outlets, the "Feeny" (F.O.) and "Ballymoney" (B.O.) overflows. Not until the ice had retreated

[1] The location of the highest terrace has already been detailed. The "450" terrace is very well developed among other places at Lisnaragh, at Claggan and around Hugheys Lough, which lies in a hollow in the terrace. The lowest terrace occurs N.-W. of Lisnaragh. Elsewhere it was largely destroyed during the later phases of the glacial drainage; indeed all these terracic deposits were later considerably modified by the opening of the still lower channels, and the consequent rapid erosion of the earlier deposits.

[2] Streams "showing in places beds of stratified sand and gravel, sometimes 150 feet thick" (Mem. Geol. Survey, Sheet 17, p. 30). This terrace, about 320 feet, O.D., in altitude, is perfectly well developed about Dunnamanagh, extending along the sides of the valley for almost one mile S. of this place. It occurs N.-W. of the village and extends as a broad strip, almost half a mile wide, from here to Bunowen and Leitrim Hill. The latter, completely surrounded by deltaic material, is composed of "solid," and doubtless formed an island in the lake.

[3] These are especially well seen east of Fawney; Duck Lough lies in a hollow between the mounds. The irregular character of the surface is indicated by the 300-foot contour of the one-inch O.S. map. These lake deposits also cover an extensive area to the north of Fawney, at an altitude of something above 300 feet, O.D.

[4] The large pit in this terracic material at Downholme, near Dunnamanagh, shows well-worn shingle, chiefly schist and of good size, clearly indicating the strength of the current.

off the hill just north of the Oaks, and uncovered the col at Gortnessey, were these overflows thrown out of action. Prior to this lowering of the lake the water surface covered some 22 sq. miles.[1]

The depth and size of the "Gortnessey Channel" (G.C.) are doubtless partly[2] to be ascribed to the erosion exercised by the large stream, which, as a glance at the map (Pl. VIII) will show, carried off at one period almost the whole of the drainage of the Sperrin Mountains.

The Castle River valley probably conveyed the drainage, as the ice, at a slightly earlier stage, fell away from the hillsides to the east of this. The Sheskin River also served for a short time as a glacial overflow.

The "Gortnessey Channel" (G.C.) drained a lake—"Lake Faughan," the successor of "Lake Claudy"—extending up the Faughan as far as Teenaght, where the 300-foot terrace begins; indeed all this upper part of the lake would appear to have been completely infilled by sediments brought down by the greatly swollen Faughan. The water-worn sands and gravels, which are heaped up in the form of mounds, and fan out to north and north-west, represent materials swept into the lake from the ice-face. The finest parts of the 300-foot terrace, however, are those occurring near the entrance of Bond's Glen into the Faughan valley.[3] They were clearly the deltas of the large stream pouring out of the higher "Lake Burndennet."

The position of the ice-front at this stage, as it curved across the Faughan valley from the Gortica Hill, is clearly marked by the morainic ridge near this place, described, though not recognized as a moraine, in the "Londonderry Memoir" (p. 58), and by the very fine mounds developed at The Cross.[4] Hereabouts they cover an area of considerably over one square mile, and consist of immense deposits (sections show over fifty feet of the material) of sand and gravel. They were regarded by J. R. Kilroe[5] as the result of the "prolonged discharge" of "glacier waters when the Faughan valley above this point was still occupied by ice." There can, however, be no doubt, from the sequence of

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[1] The sands and gravels of Toneduff and the terraces in the depression N. of Dunnamanagh, e.g. W. of Gortnasky and N. of Lower Town, at about 420 feet, probably indicate the extension of this lake over the ground now occupied by Bond's Glen into the area of "Lake Burndennet," and that the latter overflow was initiated as soon as the waters in the Faughan Valley were lowered and permitted of drainage across the connecting neck.

[2] They are possibly in part the effect of rejuvenation.

[3] They occur, for example, just N.-W. and S.-W. of Toneduff Bridge, extending as a distinctly recognizable terrace for almost a mile below this bridge and along the west bank of the Faughan. The best view of these terraces is obtained from the main road (Londonderry to Claudy) just W. of Claudy.

[4] A map of these mounds is given in the Londonderry Memoir (fig. 8, p. 59).

[5] *Ibid.*, p. 59.

events brought out in the examination of this and the adjacent areas, that they represent the materials swept into the quiet waters of a lake out of the ice which stood, not *above* but *below* this point.

An indistinct morainic ridge running along the eastern side of the Gortnessey valley was formed at a slightly earlier stage. Formed about this time, and as the ice withdrew from the south-west flanks of Slieve Buck, are the poor channels observed to the east of The Cross, falling north into the Gortnessey valley.

The Fincarn Glen[1] carried off for a short period the surplus waters of "Lake Faughan," and was abandoned when the westward retreat of the ice-face freed the main valley of the Faughan at Drumahoe. The small gravel mounds south of this last locality and on the south side of the Faughan and Burngibbagh valleys are moraines of this stage.

The position of the ice-margin during this, the fourth phase of the retreat from the Sperrin Mountains, is represented on the map (Stage 4, Pl. VIII). As in the previous stage, the drainage from almost all these hills, both south and north of the watershed, and the melt waters proceeding from some forty miles of ice-face, were carried by a series of marginal channels and a chain of lakes along the western flanks of these mountains northwards to the Foyle estuary. The most important feature of this period was the "Inver Channel." During all the phases of the retreat, represented on the north by the complex drainage-system briefly outlined above, this great transverse valley continued to convey the waters of the south side of the range to the north side. It persisted right through to the Burngibbagh stage, and even after that channel had ceased to operate.

(e)—*Fifth Stage.*

The next phase of the retreat saw the recession of the ice off the hills east of the Foyle and the opening of the normal drainage of this river. The position of the ice-front at a late stage in the existence of "Lake Burndennet" is given by the relatively small overflow channels occurring at higher levels north of this lake. The first of these occurs just east and below the summit of Killymallaght Hill. It intakes below 800 feet, O.D., and was fed only by the waters pouring directly off the ice itself. The stream flowed into a lakelet held up in the embayment north of the hill, its surplus waters excavating the "Curryfree overflow"[2] on the western flank of the hill of that name. Its intake is about 670 feet, O.D., the channel falling north.

[1] A photograph of this channel forms the frontispiece of the Londonderry Memoir (1908).

[2] Reference to this overflow is made in the Londonderry Memoir, p. 82.

These two overflows clearly denote a temporary halt during the retreat off the hills to the north of the Burndennet valley, and while the lake impounded in that valley still drained by Bond's Glen into "Lake Faughan." A short retreat to the westward threw these small high-level channels and also the main outlet out of action, and opened the escape by the large Burngibbagh valley.

The latter runs for nearly six miles parallel with and to the east of the River Foyle from well south of Cullion to Drumahoe in the Faughan valley.[1] The highest part of the valley lies about three-quarters of a mile north of Cullion railway station at an altitude of about 130 feet, O.D. Here the valley is as well marked and developed, its sides as steep and its floor as broad as in the lower stretch. With the exception of one or two small valleys farther west, the Burngibbagh channel furnishes the last evidence of constrained drainage to the east of the River Foyle in this area.

At the time of this overflow, the Foyle valley to the west was still occupied by ice, which continued to produce a lake in the valley of the Burndennet; this is the last phase of "Lake Burndennet," the successor of "Lake Dunnamanagh." The irregular and moundy country in this wide depression at Dunamana Station marks the floor deposits of this lake. The sands and gravels were derived in part from the streams pouring into the lake from the south, i.e., the large Inver overflow river entering at Dunnamanagh and the smaller streams flowing through the Stonypath[2] and Ballylaw channels, in part from the sheets of material swept out of the ice standing to the west. The bulk of the detritus carried into the lake from the south of Dunnamanagh forms the flat terraces of sand and gravel which occur N.-W. of this village and about Mountcastle.

The size of this lake, of its deltaic terraces, and of the streams pouring into it across the Sperrin Mountains via the "Inver Channel," and round them from "Lake Glenmornan" by the "Stonypath" and "Ballylaw" channels, taken in conjunction with the great dimensions of the Burngibbagh valley, the outlet of the lake, furnish some measure of the volume of the waters which drained along this valley. With the exception of that comparatively small part draining normally by the River Roe, it carried off the whole of the drainage of the Sperrins and the melt waters of a great length (over 40 miles) of ice-front.[3]

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[1] In its upper part it is traversed by the Donegal railway.

[2] This overflow, though by no means small, is quite diminutive when compared with the huge Burngibbagh valley, and proves clearly the great volume of the river which entered "Lake Burndennet," south of Dunnamanagh itself, and which escaped by the Burngibbagh outlet.

[3] Professor H. J. Seymour suggests, in the Londonderry Memoir (p. 7), that "The

At an early stage this river did not escape by the lower part of the valley of the Faughan, but by the valley running northwards, east of Kilnappy Hill. A slight retreat, however, opened the normal drainage valley of the Faughan.

The deposits of sand and gravel which occur near Gortmessan Church were formed fluvio-glacially as the ice retreated from the hill-flanks some two miles west of Dunamana Station. The mounds near Tamnabraddy and W. of Clampernow, north of this, are most probably morainic, and of slightly earlier date.[1]

The ice retreating off the western flanks of the Sperrin Mountains opened up the normal drainage lines successively from north to south. Hence, while the Foyle, north of Strabane, was ice-free, a lake was held up in the recess S.-E. of this town. As the ice retreated off Knockavoe, the hill to the west of Foul Glen (F.G.), it formed two very small channels: the one, east of Calheme, intaking at about 600 feet, O.D., the other, about one mile south of Ballee. These carried the drainage northwards along the ice-margin into "Lake Glenmornan." The largest of these channels, however, is the Strabane Glen, just E. of the town of Strabane. It intakes at about 310 feet, O.D.

The ice in its withdrawal from the hill-slopes east of Sion Mills formed along the hillside a sandy moraine. Corresponding with this position of the ice-margin is the valley east of Edymore, falling northwards. A later and even more clearly defined stage is marked by the deep "Sion Mills overflow," which intakes at about 170 feet. The hummocky strip of morainic country extending from The Loop, via Drumnahoe, Lisnafin, almost to Glenknock Cottage (about four miles in length), marks the position of the ice to the south of this channel.

The winding valley, W. of Bogside, was initiated as the recession of the ice carried the ice-front west of Sion Mills. The mounds of local material at Three Mile Hill[2] and extending southward to Knockboro are the morainic

[Burngibbagh] valley may possibly have been formed by the Burndennet stream, the course of which was probably deflected near Dunnamanagh station into the Foyle by the large deposits of glacial gravels formed there." The present Burndennet stream is totally inadequate to produce the large valley of the Burngibbagh, or the extraordinary large accumulation of sand and gravel below the outlet of the Burngibbagh, to which reference will be made later. On the contrary, the Burndennet stream without doubt flowed westwards to the Foyle valley, so soon as the constraining influence exerted by the ice was removed.

[1] The small channels running parallel with the hillside, just E. of the Foyle valley, e.g., the one about half a mile E. of Gortmessan Church, and the other just above Londonderry coming into the main road to Claudy, probably indicate marginal drainage along the hill-flank and independent of the great drainage lines further E. The valley running N. to Meenaghhill may represent a slightly later stage.

[2] Situated two miles S. of Sion Mills on the right bank of the Mourne River.

representatives of this phase. The large valley, which enters the Mourne River near Douglas Bridge and intakes at about 270 or 280 feet, O.D., discharged into the Mourne and Foyle drainage the overflow waters of the now greatly shrunken remnant of "Lake Gortin-Grenelly"; on the abandonment of this valley the lake ceased to exist. The morainic country stretching from south of Douglas Bridge on the north to the right bank of the Mourne River, just north of Newtownstewart in the south, marks the position of the ice-edge at this period.

The retreat of the ice from the Sperrin Mountains has now been briefly outlined. The mode of recession shows most unmistakably the progressive melting of the ice from the main watershed and the gradual increase of the ice-free surface as the glaciers receded down the mountain flanks. Throughout almost the whole period of the retreat, the drainage, held up in a series of large and small extra-glacial lakes, was discharged northwards, proving incontestably the pressure of great ice masses from the south and west.

2.—*The Tyrone Glacier.*

Even after the ice had partially uncovered the Sperrin Mountains, great glaciers still continued to pour along the "Omagh-Draperstown Corridor" to Draperstown and beyond, and over the country east of this, sloping towards the Lough Neagh basin. At the maximum phase of the glaciation, the highest summits of the pyroxenic and metamorphic range of Beleevnamore, extending S.-W. from Slieve Gallion, were buried beneath the ice-sheet. As the thickness of the ice diminished, these summits began to project above the ice-surface, until finally the ice masses east and west of the range were connected only by tongues thrust through its larger gaps.

Through these, the ice proceeding eastwards along the great corridor to the north squeezed large glaciers, which formed in retreat a series of crescentic morainic ridges. At one stage they were united to the east of the range, but split up into individual separate glacier tongues with the recession of the ice. The arrangement of these ridges, their crescentic form, the convexity directed to the east and south-east, indubitably prove the retreat towards the west or north-west, i.e. towards the "Omagh-Draperstown corridor."

The finest of these gaps and associated moraines is probably the northernmost, situated between the western flanks of Slieve Gallion and Fir Mountain. Here the curving of the lobar recessional moraines across the valley is extremely well shown, the drainage from the melting ice-front being carried off by the Lissan water towards Draperstown. The waters pouring laterally from the ice, when its edge stood on the line of the magnificent moraine just south of Lough Fea, excavated a valley some 50–60 feet deep, now quite dry, and cut through the earlier-formed moraines and the "solid." In this and the neighbouring gaps, the rapid descent of the moraines along the sides of the hills to the floor of the valley suggests the equally rapid fall of the ice-surface at the snout of the glacier. Of the several lakes held up by the moraines, the largest is Lough Fea itself.

Similar morainic arrangement characterizes all the other breaks in this metamorphic range. Even the smaller gaps, e.g. that between Beleevnamore Mountain and Evishbrack Mountain, had small glaciers thrust into them. It is manifestly impossible to give details of all these morainic ridges; the map indicates sufficiently clearly their position and mode of arrangement.[1] These moraines are frequently asymmetrical about the axes of the gaps, the asymmetry pointing to a push from the west, oblique to the axes. This is perhaps most easily recognisable in the group of moraines S.-W. of Beleevnamore Mountain.

The retreat can be readily followed from Draperstown south-westward. Though the drift is piled up more or less smoothly against the sides of Mullaghturk, farther north along this side of the corridor, definite morainic features become conspicuous. The finest of these are the prominent mounds and ridges, over a mile in length, observed on the eastern slopes of Slieveavaddy, at an altitude of about 800 feet, O.D. Ridges of even greater size, in part of morainic origin, occur near Draperstown. The eastward diversion of the streams by drift deposition, to which reference will be made later (p. 267), is well shown on the eastern flanks of the hills, W. of the Moyola valley.

The most magnificent moraines, however, are those skirting the southern edge of the corridor, located frequently well up on the hillside, and swinging across the breaks in the range, e.g. the pronounced hummocky Crockundun Hills (N.-E. of L. Fea), Wolf Hill (W. of Fir Mountain) and the ridges at Dunnamore and west of Evishanoran Mountain. These are the gigantic lateral moraines of this Tyrone glacier, formed after the lobes thrust through the gaps had completely shrunk back to the parent glacier out of which they had sprung. Other morainic mounds and ridges, less conspicuously displayed, traverse the wide floor of the depression. The ice-foot along which they were formed stood in ponded water. The moraines sweeping across the gaps to the south-east effectually closed these against escape of drainage from the "Corridor." In consequence, the comparatively shallow lake, held up by the barrier of the receding ice on the south-west, and fed by melt waters, drained by a channel excavated in part in "solid," between

[1] Reference to a few of these mounds and ridges and to some of those occurring in the adjacent areas and dealt with below is made in the Geol. Survey Memoirs, Sheet 26 (pp. 21, 22) and Sheet 34 (p. 21).

Mullaghshuraven and Altihasky, and so into the Moyola River. This lake and its outlet continued to exist until the direction of the normal drainage via the Owenkillew River was opened. It was therefore in existence during part of the second and third stages of retreat from the Sperrin Mountains.

The morainic features were encountered at intervals along the floor of the depression towards the south-west, occurring either as fine billowy belts, or projecting as isolated mounds and ridges above the flat turf bog. East of Mulderg, they again assume considerable proportions, e.g. the large moraine, irregular and hummocky, forming the ridge appropriately named "The Murrins." Other large ridges of the same character cross the wide expanse of turf country between the lower slopes of Mullaghcarn and Castle Rock, e.g. Bauck Hill. Similar ones cover the tract south of Mountfield, extending as far east as Milltown and Loughmacrory; this large lake is held up by moraines. They are ridged up on the hillsides of the small recess above Mountfield. The country from Mountfield to Drumnakilly is covered with scores of these ridges, here extremely finely displayed. Very interesting and significant is the mode of behaviour of the ice, as shown by the moraines. In the great majority of cases, when an obstruction stood in its path, though such barriers were only small hills rising but 100 or 200 feet above the general surface of the country, the ice was held up in front of the obstacle, but swept along on either side. This is illustrated by the following hills:—Laght Hill, Crockancor, Scalp, Slievemenagh, Mulnafye and the low ridge running west from Mullaslin Gap; the lobes thrust through the gaps in the Beleevnamore range, as sketched above, are merely instances on a far larger scale. These moraines have seriously interfered with the drainage. Numerous lakes and lakelets are impounded in intermorainic depressions; indeed, all the lakes of this extensive area are true morainic lakes.[1] The origin of the large and small undrained areas of bog,[2] abounding in this region, is doubtless to be sought in the similar impounding of the drainage by the moraines. The thick turf lying between the larger moraines has most probably in places completely buried the lesser and intermediately situated mounds and ridges, while only the summits of others, somewhat higher, project as small eminences above its surface.

Numerous sections show the nature and the mode of arrangement of the materials of these ridges and mounds; these need not be detailed here.[3]

[1] The largest are L. Carn, L. Fingrean, L. Mallon, Black L. and the pretty Loughmacrory.

[2] One of the largest is that of Cloghfin, several square miles in extent; a few morainic mounds project as islands above the turf surface, their position marked by a few houses and cultivated fields.

[3] One of the best is at Mullaslin Gap.

Everywhere they consist of sand and gravel and water-worn material. This clear evidence of water action doubtless led the earlier workers astray, for all these features were consistently regarded and described as eskers.[1]

More recently,[2] Professor J. W. Gregory has alluded to these gravel accumulations of County Tyrone. He clearly recognized their marginal formation. He writes:—

> "In Tyrone, in the hills to the north and north-west of Pomeroy, is a third group of eskers, formed as glacieluvial marginal deposits around glaciers flowing from the hills" (p. 148).

His conclusions as to the direction of ice-movement, as evidenced by these features, are, however, totally at variance with the results here submitted, which are based upon a careful examination of the drifts, striae, marginal drainage phenomena, &c. Speaking of the moraine along the northern foot of the Evishanoran Mountain (886), he says (p. 134):—

> "It has obviously been formed as a marginal formation due to a glacier flowing northward and north-westward from Evishanoran Hills."

He continues (p. 134):—

> "The esker near Dunnamore was probably similarly due to ice from Slievemore (842 feet)."

The following argument seems to clinch the evidence already set forth. The emergence of the main watershed of the Sperrins as an irregular nunatak, and the shrinkage of the ice down the flanks of the hills, as set out above, can only mean that the snow-line hereabout at that time was somewhere in the neighbourhood of 2,000 feet or more. To suppose that glaciers issued from hills only some six miles to the south and some 1,400 feet lower, as is suggested by Professor J. W. Gregory, would lead to hopeless contradiction of levels of snow-lines in this area.

Water streaming from the ice has, without doubt, been the chief agent in the moulding of the morainic material into its present form. Some of these ridges and mounds, e.g., those running along the lower slopes of the Beleevnamore Range, were formed as true moraines along the edge of the ice above the level of standing water; others were equally clearly produced by ice standing in ponded waters. Professor Gregory draws a distinction between

[1] Even Professor G. A. J. Cole, in the introductory sketch to his paper on the Igneous Rocks of the Country West of Cookstown, refers to these moraines as the "classical eskers"; and again, in his paper on the Metamorphic Rocks of this area, already quoted (*op. cit.*, p. 446), speaks of "The gigantic eskers and gravel mounds."

[2] The Irish Eskers, Phil. Trans. Roy. Soc., Lond., ser. B, vol. 210 (1920), p. 133.

the "eskers" of Tyrone and those of the Central Plain of Ireland. He says:—

> "But the Tyrone eskers are different in character from those of the Central Plain; they are very irregular in level; for example, the esker which crosses the Cookstown-Omagh road, near Barony Bridge, rises rapidly up the hillside, and has the aspect of a terminal moraine formed by a glacier that came down from the Pomeroy Hills. Its material, however, is sandy, and its included stones are all washed and water-worn; it is a glacieluvial deposit" (p. 142).

Though it is not proposed here to enter into the question of the mode of origin of the "eskers" of the Central Plain, it may be stated that I am in full agreement with Professor Gregory in regarding the majority of these ridges as marginal formational features, i.e. as moraines formed in water, having taught this view in my University lectures for a number of years. I submit, however, that the mounds and ridges of the moorlands of Tyrone, where formed in ponded waters, differ in no respect, other than in size, from those of the Central Plain. The materials of the ridges of both regions were alike dumped down in lake waters, the waters of Tyrone, however, standing at a higher level than those covering the former region.

In the cramped valleys and high-level plains of Tyrone true moraines, formed above lake level, naturally predominate, and only over the relatively small part of their course where they traverse the floor of the depressions are the conditions of formation identical. The Dergbrough and other large moraines in the Sperrin Mountains are, over those stretches where the ice stood in water, indistinguishable either in appearance or in structure from the marginal "eskers" of the Central Plain.

In Tyrone, and in all the region examined, these waters were indubitably those of fresh-water lakes, and not of the sea. Apart from the post-glacial raised beach, no trace of submergence in N.-W. Ireland was anywhere discovered during the course of this investigation. On the contrary, in late-glacial times, as the Burngibbagh valley unmistakably proves—several other cases from the north of Ireland could be readily cited—the level of the sea was below the 100-foot contour line.

An extremely fine morainic country occurs to the north of Pomeroy. These moraines, sometimes very irregular and hummocky, sometimes smoother in outline, were formed by an ice-push from the west, as shown by their convexity towards the opposite direction, and by the granite and pyroxenic erratics which they contain. These ridges, moreover, sweep in a series of curves, springing out of each other tangentially, the inner curve invariably on the western side of the outer.

One of the most magnificent of these morainic features extends from Six Mile Cross to Pomeroy, the latter village being built upon it. It is of considerable width and is gashed by the river running down from Crooked Bridge. Carvill Lewis was over this ground, and with his usual perspicacity recognized its morainic character. He writes:—[1]

> "Huge drift hills, the largest I have ever seen, lie between Pomeroy and Carrickmore, piled up some 400 feet high. They are stratified and unstratified drift. Fine exposures. Enormous accumulation. They are part of a great moraine (?) 300 feet high, and are covered with large boulders. It seems to be a terminal moraine. Several lakes are in the moraine."

In a foot-note is added:—

> "This is probably a moraine made at the melting of two glaciers, one an Irish, and the other a Scotch one; one going north, the other south, perhaps (1886)."

Though correctly discerning their morainic origin, he was at fault in ascribing them to the action of two ice-sheets; a correct interpretation could, however, only be obtained from a careful examination of the adjacent regions.

To the south of this billowy belt and along its foot extends a large valley—the "Pomeroy overflow"—greatly exceeding in depth 100 feet, and followed for some miles by the line of the G.N.R.I. It is now occupied by a small stream totally inadequate in size to excavate the valley. Where its sides are of drift, the valley is extremely wide and deep, exposing the moraines in many beautiful sections,[2] becoming constricted, however, where it breaches the "solid." As judged by its location and size, it is evidently the channel which carried off not only the drainage from the hill-slopes to the west but also the great flood-waters pouring off the melting ice-front standing on the line of the moraine to the east. Its width and depth are commensurate with the height and breadth of the morainic accumulation, both indicating by their dimensions a prolonged halt on this line. Many other moraines in the vicinity are gigantic and enclose lakes. Of one of these accumulations Carvill Lewis wrote:—[3]

> "Immense kames are about Lough Cam, the largest I have seen. Lough Cam is enclosed in a series of ridges."

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[1] *Op. cit.*, p. 115. Portlock refers to this moraine as "the masses of detritus near Pomeroy." (Report, p. 639.)

[2] These are well seen from the Great Northern Railway. At Pomeroy itself, the drift is seen to consist of slates (L. Palaeozoic), large and small boulders of pyroxenic rock and granite. No flints rewarded a careful search. This composition is clearly indicative of ice transport from the west.

[3] *Ibid.*, p. 115.

The drainage from the ice-front, the several retreat positions of which are marked by these numerous morainic ridges, was effected by many channels now used by insignificant streams, in all cases much too small to have excavated their valleys. These have been omitted from the map, as their insertion would only lead to confusion. They are, however, recognized in the field with great facility, their remarkable freshness rendering possible the restoration of the glacial happenings, the manner of accumulation, and the system of drainage with an ease and degree of certainty rarely equalled.

3. *Slieve Beagh and the Clogher Valley.*

Some of the earliest moraines, formed in the withdrawal from the region of Dundalk and the country north of the Central Plain, are represented by the series of irregular ridges observed in the neighbourhood of Castleblayney and in various places south of Keady. Similar recessional features with closely associated outwash fans underlie the demesnes of Glaslough, Caledon, Tynan, Abbey and Killylea. These morainic ridges trend roughly N.-E.-S.-W., almost at right angles to the direction of the drumlins and of the striae of the district.[1] These features were regarded by T. Hallissy[2] as drumlins, of which in this area he distinguished two sets, the one trending N.-E.-S.-W., the other bearing S.-S.-E.[3] Of the true drumlin character of the latter, there can be no doubt; their form is characteristic and their direction coincident with that of the striae. With reference to the former set Mr. T. Hallissy remarks :—

> "It becomes a problem of some difficulty to account for the orientation of those drumlins which point north-east and south-west."

As already pointed out (p. 194), he hesitatingly ascribed them to the earlier Scottish glaciation from the north-east; their preservation during the supposed late glaciation from the "Central Axis" he explained as follows :—

> "As the latter set of drumlins N.-E.-S.-W. are situated on part of the axis of precipitation from which the Irish ice-sheet was fed, the mounds might easily have been protected from subsequent disturbance by an overlying stratum of snow or ice, which remained in a condition of static equilibrium. It is easy to imagine how this basal layer of the central ice did not take part in the general radial ice-movement, while that overlying it flowed outwards, impelled by the shearing stresses set up by gravitation" (p. 16).

[1] A list of striae is given in the Geol. Survey Mem., Sheet 58 (2nd. Edit.), 1914, p. 18; see also map accompanying this paper (Pl. IX).

[2] *Ibid.*, p. 15.

[3] These two sets are represented on the map, fig 1, of the Monaghan Memoir. The drumlins photographed in Pl. II (facing p. 16) of this Memoir belong to the set going S.-S.-E

As has already been shown, and as the retreat phenomena most clearly prove, the "Central Axis" never had an existence over this part of its supposed course. In view of this fact, and of the over-riding of this area by a powerful ice-sheet from the north and north-west, it would be a matter of the greatest difficulty to explain the preservation intact of a series of mounds formed at an earlier period and almost transverse in direction to the later ice-movement.

The position of a later halt is marked by the almost parallel strip of morainic country, extending from near Emyvale, passing north of Tedavnet to Scotstown and to the south-west of this place. Considerable quantities of gravel are exposed in several places along this line. From this position the

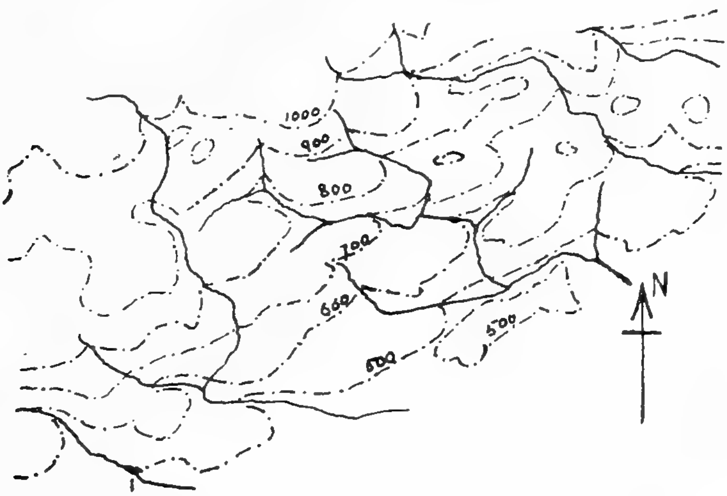

FIG. 2.

Map showing the eastward diversion of the streams, and the aberrant deflection of the contours along the S. slopes of Slieve Beagh (Co. Monaghan), by ice proceeding eastward. Scale—1 inch = 1 mile.

ice retreated westward and north-westward, flowing in two large streams along the southern and eastern flanks respectively of the Slieve Beagh mass, the higher parts of which, by the thinning of the ice-sheet, now projected above the ice-surface. The huge lobe to the east of this hill, thrust between Slieve Beagh and Ballygawley, withdrew northwards along the lower eastern slopes of the former, straightening on to the Augher-Clogher line, and thereby forming the eastern end of the Clogher valley glacier. The morainic ridge at Smotan Bridge, on the eastern slopes of Slieve Beagh, marks one of the pauses in this retreat.

That the last movement of the ice in the area immediately south of Slieve Beagh was eastward is clearly indicated by the diversion of the streams and the aberrant deflection of the contours in this direction, as shown on the one-inch contoured map of this hill, and by the small map above (fig. 2, p. 267).

Similar features were observed in a great number of areas during the progress of this investigation, and have proved of great service in the determination of the direction of ice-flow, when other means have failed or been indecisive. They suggest the possession by ice of great power to mould any drift deposits over which it passes, and thereby render very improbable the preservation of drift features, such as the supposed drumlins just referred to, which are inconsistent in direction with its movement.

The surface of the country stretching east of Slieve Beagh is characterized by extreme irregularity, due partly to moraines, partly to drumlins.[1] The latter features trend roughly south. Numerous lakes, lakelets and marshes lie between the mounds and ridges, while the River Blackwater winds in and out among them. Commencing a few miles south-west of Castlecaulfield and extending via Donaghmore to Cookstown, there occurs a huge morainic belt, in places three and more miles wide, which was formed as a great recessional moraine of the Donegal ice-sheet. This must still have been of considerable thickness, as the belt nowhere shows a lobate arrangement corresponding with its large constituent glaciers issuing from the west. The moraine is perhaps best seen at Donaghmore and to the N.-N.-E. of this village, where it forms a wide strip of country studded with kettle holes and exhibiting the characteristic billowy surface. Its vegetation, moreover, is equally decisive as to its character, the zerophytic grasses of these sand and gravel tracts contrasting most forcibly with the surrounding growth.[2] This moraine spreads south-eastward to Dungannon, which, like Cookstown, is largely built upon its surface. The Castlecaulfield and Aughnacloy country is likewise clearly morainic, the drainage hereabouts being peculiarly T-shaped, chiefly due to the crossing of the drumlin and morainic directions.

This great morainic belt represents an earlier period of halt than the Pomeroy and Tyrone moraines, and was formed prior to the break-up of the ice-sheet into the lobes of the glaciers feeding it. It does not, however, represent the terminal moraine of the Donegal ice formed at the maximum extension, for the latter was continuous with the Scottish sheet, and proceeded much further eastward. The evidence for this is furnished by the features and by the composition of the drift in the country to the east and south-east. Furthermore, it seems necessary on *a priori* grounds to suppose

[1] The one-inch contoured map of the O.S. gives some idea of the complexity and intricacy of these features.

[2] On this gravel belt, as on other large moraines, are situated the great demesnes of the area, e.g., Parkanaur, Donaghmore Ho., Desertcrest Ho., Loughry Ho. and Killymoon Castle.

that ice which was sufficiently powerful to press over the summit of Slieve Gallion and down the valley of the Bann in the one direction, and over the Fintona and Slieve Beagh hills in the other, must have thrust greatly to the south, over the comparatively low country extending to the south-east of Pomeroy and over the plains of Tyrone.

The ice, retreating northward from the Slieve Beagh Hills, lingered longer in the larger valleys than on their intermediate watersheds. Thus, the series of moraines, spanning the large Donaghmore Glen, indicates its occupation by a lobe of ice at a time when the bounding hills were ice-free. These morainic features mark the successive phases in the withdrawal of the glacier along the depression to the wide plain to the north. The lake so impounded drained by the large valley which, beginning at about 790 feet, O.D., falls S.-E. towards Rosslea.

The ice protruded in similar fashion into the large depression of Glennoo. Its behaviour here is likewise demonstrated by the morainic mounds and ridges sweeping down into the valley from the sides. Until escape by channels along the north-western flank of Slieve Beagh was rendered possible by a still further retreat, the lake held up by this lobe of ice discharged its waters by the large valley at the head of the recess. This channel, intaking at over 700 feet, O.D., falls rapidly to the S.-S.-E.

In retreating off Slieve Beagh itself, a small extra-morainic lake was held up in the valley on its north-west flank. The surplus waters, during an early phase, were carried off by a small valley, intaking at about 900 feet, O.D. This outlet had been in operation for only a short period when it was superseded by a great and deep, steep-sided gash running along the western face of the mountain.[1] It commences at about 650 feet, O.D. The large valley to the west of this, also excavated in rock, likewise acted for some time as a marginal channel, though it served also as the natural drainage outlet for the ice-free area surrounding the higher part of the valley. The large glen west of this again (E. of hill 608), though acting as a marginal channel carrying off the waters from the ice-face which rose from its western side, served chiefly as the outlet for the surplus waters of the extensive lake held up in the valley of the Glennoo. The intake is about 590 feet, O.D. "Lake Glennoo" was later drained by the "Crocknagrally channel" (between hills 608 and 684), which intakes at about 550 feet, O.D. This channel continued to discharge the waters of the impounded lake, while the ice wheeled northwards to assume the position indicated by the morainic ridges running roughly E.-W. from hill 684. By the freeing of the lower northern slopes of Black

[1] This great trench is readily recognizable at Fivemiletown, some four miles away.

Mullan, effected during this withdrawal, the lakes in Glennoo and Donaghmore Glen became confluent. The "Crocknagrally" outlet ceased to operate when the "Aghavoory channel" (W. of hill 651) was initiated. This valley intakes at about 450 feet, O.D. At this stage the ice swung just clear of the outfall of the channel, and on to the hillside south of Brookeborough. Its position is marked over much of this course by morainic accumulations. Some water escaped over the slightly higher col to the south of hill 651, but this ceased to act as overflow when the "Aghavoory channel" was opened.

On the northern face of Slieve Beagh occurs the finest of these channels. It is a huge glen, beginning at Brown Hill at an altitude of about 500 feet, O.D. It carried some of the drainage of the lakes just described, and would seem to have been in operation during part of the period represented by the Crocknagally and the earlier overflows running along the western flanks of the hills.

A somewhat earlier stage is represented by the small channel which falls east at Carlough. This probably poured its waters into a lake draining by the large valley east of Greaghnagee, likewise falling east. A moraine marking the position of the ice-margin during the formation of these drainage channels runs roughly E.-N.-E. from the western end of Greaghnagee.

A well-marked valley, intaking just south of Culla More (844), took the drainage of a lake held up in the valley of the Fury Water.

All these retreat phenomena of the Slieve Beagh Hills conclusively prove that during the final stages of the glaciation of this area the ice pressure was from the west and north-west, and that ice-free country lay to the east.

The wide depression of the Clogher valley is choked with morainic material, which has produced countless lakes and influenced the direction of the streams. The ice clearly withdrew across the Clogher valley, W. of Augher, in a westerly direction towards the Fintona Hills. This mode of retreat is proved by the trend of the huge morainic belts running parallel with the axis of the valley, both in the valley itself and on the flanks of the hills to the south, and by the very fine marginal phenomena of the northern flanks of Slieve Beagh.

Having retreated from the recesses on the northern slopes of the Slieve Beagh hills, the ice shrank back with its edge extending in a wide curve sweeping along the valley. These belts of morainic country can be readily picked out from the hills south of the valley, while among the hillocks themselves their morainic character is no less striking.

The very extensive ballast pits at Ballyraddan Hall, just out of

Fivemiletown, reveal the nature of the deposits; they are composed of water-worn pebbles,[1] sand and gravel.

A further recession of the ice at the extremities of this line caused the formation of the moraine, running from the southern flanks of the Fintona hills about Ballyness Mountain, under Fivemiletown and Colebrooke Park,[2] to the neighbourhood of Lisbellaw.[3] The whole of Colebrooke Park, and of the park of Blessingbourne at Fivemiletown, is underlain by spreads of morainic and outwash gravel. A later moraine is represented by the irregular country stretching north-east and south-west from Creeve Hill.[4]

A still later pause is indicated by the broad and undulating moraine which runs parallel with and along the foot of the hills from north of Tempo to the vicinity of Lisbellaw, and which culminates in Glundees Hill.

These billowy morainic belts, of considerable width, are frequently composite; they contain subsidiary morainic walls, readily distinguishable in the broader surface. Many instances of such composite moraines were noted.

These indicate, as Mr. W. B. Wright has shown in the case of the Killarney moraines,[5] a major and minor periodicity. I have not attempted during this investigation to determine the periodicity.

Continued shrinkage of the ice from the position, marked by the large "Glundees moraine," caused a division into separate glaciers, thrust eastward through the gaps in the "Brougher Mountain Range." The series of lobar moraines formed during this withdrawal greatly resemble in their internal structure and mutual arrangement those observed in the hill country to the west of Cookstown. The great morainic belts to the east of this, along the foot of the range and beyond, furnish a parallel with those of the country east of the Beleevnamore Range of Tyrone.

The Fermanagh moraines are by no means so patent nor so picturesque as those of Tyrone, though greatly excelling these in number and in strikingness of arrangement. The map brings out clearly the behaviour, mutual arrangement and adaptation to the relief of these lobar moraines of the "Brougher Mountain Range."

Of the breaks in this range, the chief are the Glen and Esk valleys. The finest series of lobar moraines are to be found in the Esk recess. The

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1 The chief constituents include quartz, quartzite, carboniferous limestone, sandstone, shale, conglomerate, an occasional porphyry and epidiorite.

2 Between these places it is known as the Long Range.

3 Lisbellaw itself stands on rock.

4 This hill is entirely "solid."

5 Minor Periodicity in Glacial Retreat, Proc. Roy. Irish Acad., vol. xxxv, sect. B (1920), p. 93.

influence on the ice of the Ballyreagh Hill and of hill 702 is also clearly brought out by the moraines.

This effect of hill-barrier and gap is no longer recognisable in the broad belts of morainic country marking the position of the ice-front along the plain. The lobar ridges die down in places where streams, issuing from the ice, have swept away any morainic materials. These gaps are also doubtless in part due to the destruction of the morainic ridges by water escaping from lakes held up by the ice-front against such earlier formed moraines. A few low, irregularly-shaped, and winding, connecting ridges are suggestive of eskers. The waters, streaming from the receding ice-lobes in the Glen and Esk recesses, escaped across gaps in the earlier moraines into the valleys which run down through the breaks in the "Brougher Mountain Range" into the valley of the Tempo River. The valley of the Glen River carried off the surplus waters from the part of the ice-front immediately to the west of this. Escape by the valleys north and north-west of Greaghrawer was completely barred by the earlier moraines hereabout. On the elevated plain, west of the "Brougher Mountain Range," these morainic ridges have seriously interfered with the drainage; lakes and turf-flats mark the areas deficient in drainage.

Similar lines of morainic mounds and ridges, pivoting on the hills at either end, swing across the recess south of Trillick. The different bands are separated by small turf-flats. The arrangement of the ridges indicates a thrusting into the embayment from the west and a withdrawal in the same direction. With further retreat the ice-front was more or less straightened out, the ice finally resting against the hillside and depositing one large and continuous moraine.

4. *The Fintona Hills.*

Well-developed moraines run obliquely across the mouth of the embayment north-east of the Trillick recess. The ice, represented by these features, held up a lake which discharged by a direct channel into the upper part of the Tempo valley. This outlet, the intake of which is about 700 feet, O.D., forms on the col a broad, flat-floored notch, cut in rock.

A similar series of moraines runs across the large embayment south-east of Fintona, exhibiting a pronounced convexity towards the south.[1] Their composition is revealed in several places, e.g. just south of Fintona, where the sands and gravels, showing rude but distinct stratification, are indicative of the swift and changeful currents near the edge of the ice. These moraines,

[1] The best of these occurs on the western side of the valley and to the north of Mountstewart.

transferred to the map (Pl. IX), indicate sufficiently well the position of the ice-margin at successive stages of the retreat, and how, during the northerly recession of the ice-front, this became less and less curved, till, to the south of Fintona itself, the moraines become virtually straight. Here again, however, the ice-front and moraines are, in general, in close dependence on the relief.

Throughout the whole of the withdrawal a temporary lake was held up in this embayment, and discharged by the large valley at the head of the recess. The intake is at 489 feet, O.D. Another well-developed channel begins north of Crockard, and falls east, having been produced by the drainage from a lake in the small embayment to the west.

Roughly similar again is the arrangement of the moraines in the large recess extending south-east from Seskinore. A series of morainic ridges spans the valley. The finest swings across the valley from the eastern flanks of the Crocknatummoge hills over Raveagh and Eskragh to the south of the Fall Brae. This is the same moraine which is best developed in the "Fintona recess," and of which mention has just been made. This serves as a useful datum-line for the correlation of the other morainic features.

The ice, which formed these moraines, likewise impounded a lake—"Lake Seskinore"—in this large embayment; its surplus drainage escaped by an overflow valley (S.), largely preglacial in origin, yet, perhaps, unsurpassed in the whole region dealt with in this paper.[1] It enters the Clogher valley to the north of Clogher, is practically streamless, and some 400 yards in width; its flat floor falls very steadily and gradually southwards from its intake at about 350 feet, O.D. Its size greatly exceeds that of the valley to the west, to which reference has just been made. The difference is clearly not to be ascribed merely to the extent of the lakes which were drained by the two valleys. The "Seskinore channel" was the means of escape of the waters which poured from all the higher lakes held up in the recesses in the hills to the east of this as far as Carrickmore, some twelve miles distant.

A series of lakes was impounded in the valleys south of Carrickmore. A fine dry valley (A.) was observed at the head of the Altmore River, which carried off the waters of a lake held up about Altmore Lodge; the great accumulations of well water-worn sands and gravels at its head doubtless represent a moraine formed about this time. The small overflow channel (I), falling east, located just south of Inishative, was formed by the ponding of the Altanagh River.

Bara Glen (B.G.), a cross contour valley, intakes at about 750 feet, O.D., and

[1] Reference is made to this valley in Geological Survey Memoir, Sheet 46, p. 6.

ceases to fall when its floor reaches the 660-foot level, or the height of the intake of Bernisk Glen (B.). This glen is gashed to a depth of some 80 to 100 feet in O.R.S. conglomerate, and falls right to the floor of the Owenbrack River. The approximate grading of the two valleys suggests a free outfall and the location of the ice-front at this stage at least as far north as Beragh and Six Mile Cross.[1] Before the ice had swung clear of the hill at Foremass, the waters of Bernisk Glen poured into "Lake Owenbrack" and escaped into the "Seskinore channel" by the valley (F.) along the side of that hill.

A small valley—"the Cloghfin channel" (C.)—cuts chiefly in drift and intakes at 750 feet. It took the drainage from a small lake held up to the north of this. It falls south to just below the 700-foot contour, or the level of the lake in the Owenbrack valley.

Huge moraines, deposited high up the hill-slopes, stretch from east of the Fall Brae to Black Bridge in the Fallaghearn valley. Though they were largely destroyed during a later phase of the retreat, as their materials contributed in great measure to the floor-deposits of "Lake Fallaghcarn," enough still remains to make them most striking features in the local scenery. An earlier formed moraine, almost equally large, runs to the south of these for about two miles in an east-west direction. The ice-front, when coincident in position with this moraine, ponded back the drainage of the hills to form a large lake which discharged by the direct overflow of Todd's Leap (T.). At this stage, another and somewhat larger lake existed to the south of White Bridge, cut off from its neighbour by the shoulder of the intervening hill. This lake likewise drained into the Clogher valley by a direct channel south-east of Lough Abraddan. The slight retreat of the ice had for its effect the merging of the two lakes into one sheet, the surplus waters of which continued to drain by the lower Abraddan channel (A.C.). This overflow falls south, and intakes at over 600 feet. O.D. Lake-terraces corresponding with this outlet occur below Black Bridge.

The next shrinkage was more considerable, roughly three miles, and by uncovering the watershed between this valley and that of the Owenbrack to the east caused the formation of an extensive lake continuous over the watershed about the site of Dunmoyle. Its outflow was by the "Abraddan channel," though some water possibly escaped over the pass leading to Harper's Bridge,[2] while its floor deposits, consisting chiefly of fine sand, are

[1] This is doubtless part explanation of the great width of the valley of the Owenbrack River below the outfall of the Bernisk Glen.

[2] The floor of this pass is now obscured by a great expanse of thick turf. The depression doubtless served as an overflow at an early stage before the waters in the Fallaghcarn and Owenbrack valleys were continuous, and when a small lake existed at the head of the latter.

exposed in many sections near the Lurganboy Bridge.[1] This lake, prior to its extinction, was practically choked up with deltaic and lacustrine materials, largely derived from the ice itself.

The ice-margin, during part of this period, is represented by the moraine curving from beyond Aghnagar to the "Tower" and Bernisk Glen. The latter was not yet in operation, as the drainage from "Lake Bara" was at this time carried by the relatively small "Cloghfin overflow."

During the recession to the position above Beragh and Six Mile Cross, the ice rested for a brief period against the hill of Foremass. The waters from "Lake Owenbrack," reinforced probably at this time by the Bernisk Glen stream, swept along a wide channel (F.), which falls south-west along the side of this hill. Its intake is about 550 feet, O.D.

A lake was held up about Garvagh, in the higher reaches of the Routing Burn. Its outlet was over the wide pass across the watershed towards Sess Kilgreen and Ballygawley. The melting ice, standing in the lake waters, deposited great quantities of fine sand, which occur as mounds at the head of the valley and are well exposed in the sides of the Routing Burn. A series of crescentic morainic ridges, curving across the valley, marks successive pauses in the ice-retreat, while throughout the recession, the channel at the head of the valley continued to discharge the surplus waters of the increasing "Lake Garvagh."

It has been shown above that during the withdrawal of the ice from the Fintona Hills, a lobe of ice persisted in every embayment, even where such recess was of comparatively small dimensions. This adjustment of the ice to the smaller details of the relief suggests a relatively thin sheet.

After the direct overflows into the Clogher valley had been thrown out of action and marginal channels initiated, the whole of the waters, draining from the extra-glacial lakes held up in these recesses, escaped by the "Seskinore channel" (S.).

At the east end of the Fintona Hills the drainage was carried off by the large "Pomeroy overflow" into the Lough Neagh drainage system.

5. *The Fintona and Erne Glaciers.*

The ice, which shrank off the Fintona and Omagh hills, streamed eastward along the Fintona Plain as a glacier some eight miles in width. That the easterly direction of thrust, which prevailed during the maximum phase, persisted during the later stages, is demonstrated by the form and arrange-

[1] Similar lake deposits are also revealed in many river sections above and about the cross-roads (495).

ment of the morainic ridges,[1] by the marginal drainage phenomena, and by the eastward diversions of the streams along the hill flanks. This latter feature is clearly recognisable in the streams draining the southern flank of Pollnalaght.

A series of roughly parallel morainic belts, skirting either side of the plain, marks the lateral moraines of this great Fintona Glacier. They are especially well developed along its southern edge, e.g. south of Fintona and of Seskinore, and on the northern side along the south-east flank of Pollnalaght. Trillick lies in a hollow between two such moraines. Farther east, very fine moraines occur at Beragh and south of Six Mile Cross,[2] where they form pronouncedly undulatory belts of country.

The drainage from the ice, which deposited these lateral moraines, escaped on the south by the "Seskinore channel," and on the north by its equivalent, the Dooish valley. Springing out of these lateral ridges are the terminal moraines.[3] Of these, the finest leaves the lateral at Seskinore curving away to the north as a very broad, billowy strip of country;[4] others are clearly developed north of Fintona. They all exhibit a convexity to the east. These morainic arcs are separated by turf and river flats and numbers of lakes. Though for the most part fairly regular in their development, they not infrequently coalesce over short lengths, only to diverge again at some little distance.

The lateral moraines are crowded together into comparatively narrow strips which margin the plain; the spaces between the separate drift ridges gradually widen as they pass into frontal moraines along the median line of the plain.

Great gravel spreads occur where the frontal moraines spring out of the lateral; upon such lie the grounds of Seskinore House and Ecclesville, near Fintona.

The melt waters from the ice-front, at the different stages of the retreat, were largely carried off by the valleys, formed successively between the retreating ice-face and the last-formed moraine, and which are now

[1] Though very regular in form, as drawn on the map, small irregularities are by no means uncommon, but are not reproducible on this scale.

[2] These features, described as terraces, are sketched in the Mem. Geol. Survey, Sheet 34, pp. 21, 22.

[3] The position of some of these is brought out by the contours, and by small peripheral streams running in the valleys between the morainic ridges, e.g. S.-W. of Omagh, E. of Bundoran Junction, N. of Fintona, and N.-E. of Dromore. The Quiggany Water, which flows N. from Fintona, follows the course of the moraines; the Owenreagh, on the contrary, cuts across several. In other cases, and these the majority, contours fail to bring out the features.

[4] The ridges around Dromore are chiefly "solid" features.

represented by the longitudinal valleys between the successive ridges.[1] Lakes were occasionally produced, their waters rising until they found escape by cutting across the barrier of the previously formed moraine, even through places where the latter chanced to be superimposed upon a low "solid" eminence.[2]

This Fintona glacier shrank westwards by successive stages; the last moraines, marking its front, curve out of the lateral ridges to the east and south-east of Bundoran Junction, and die out on the elevated rocky ground extending northwards from Irvinestown.[3]

From the above description it will be seen that the mode of recession from this plain differed from that in the Clogher valley. Here the ice withdrew obliquely across the valley, while there it retreated as a huge glacier from east to west, parallel with the trend of the depression. This difference is manifestly to be ascribed to the difference in the direction of thrust: this being in the one case oblique to the axis of the valley, in the other, coincident with it.

The ice retreated northward along the depression of Upper Lough Erne. This is shown by the effect on the drainage, i.e. the constant southerly diversion of the courses of the existing streams, e.g. along the S.-E. slopes of Slieve Rushen. Some of these valleys lie between morainic ridges, and doubtless served as channels carrying off the marginal drainage of the ice, but, as in the case of the southern slopes of Slieve Beagh, the waters were chiefly those issuing from the melting ice-front and not from impounded lakes.

The hill-slopes north-west of Clones show the same easterly trend of the streams and aberration of the contours as observed on Slieve Beagh. These features point, as in the latter area, to a great thrust of ice from the west in the closing stages of the retreat. This would seem to prove the wheeling of the ice out of the Erne valley about Newtown Butler into the comparatively flat country to the south of the Slieve Beagh hills,[4] the ice, as suggested by

[1] These valleys are in consequence only in part due to accumulation. They are much too large for the present streams, even when sufficient allowance is made for the incoherent nature of the materials which form the ridges.

[2] A very good example of such is seen in the pretty valley falling N.-E., and situated about one and a half miles S.-W. of Omagh, and through which runs the main road from this town to Dromore. This valley is about 30 feet deep, flat-floored, and contains only a very small stream. It is carved in "solid."

[3] A small valley at Croneen Barr, to the S.-E. of Lack, probably drained a small lake at one of these stages.

The moraines near Bundoran Junction trend roughly W.-N.-W.–E.-S.-E.; the road and railway between Irvinestown and Bundoran Junction run roughly between two of them.

[4] Yet most of the mounds and ridges trending S.-W.–N.-E. in the Clones-Monaghan depression are, as already pointed out (p. 266), morainic in origin; some, as Mr. Hallissy

the striae,[1] appearing even to have climbed the hill-slopes and overridden the hills around the Donaghmore Glen.

Two distinct sets of mounds and ridges of drift cover the floor of the Upper Lough Erne depression. The one set runs roughly parallel with the axis of the valley and appears to be true drumlins. These are crossed roughly at right angles by a second set which is to be ascribed to the retreat.[2] Their combination has resulted in the peculiar outline of the waters of Upper Lough Erne.[3]

As shown by the moraines along the eastern side of the valley, e.g. those east of Lisnaskea and Maguire's Bridge, the Erne Glacier persisted after the ice had retreated from the Slieve Beagh hills.

6. *The Foyle and Swilly Glaciers.*

In Inishowen, moraines and marginal drainage phenomena are singularly poorly represented.

The ever-diminishing thickness of ice caused the emergence of the highest peaks and ridges, e.g. Raghtin More, Slieve Snaght and the range which rises from the western shores of Lough Foyle. These nunataks, with continued melting of the ice, broke up the once continuous ice-sheet into several separate glaciers, the largest being those occupying Loughs Swilly and Foyle and the Mintiagh and Glentogher valleys.

The successive positions of the eastern edge of the Foyle glacier, as it shrank off the foot-hills of the Sperrin Mountains, have already been described. The position of its varying western margin is fixed by a few "dry" valleys and an occasional morainic mound on the hill-slopes falling to the western shore of Lough Foyle. One of these well-developed marginal channels was observed at The Colonies, about two miles S.-W. of Moville. It falls north, and intakes at about 430 feet, O.D. A second, in aligned sequence with this, and approximately one mile in length, was encountered near Ballyrattan.

Corresponding to slightly later phases of the retreat of the Foyle Glacier are the small channels to be found near Clare Mount (three miles S.-W. of Moville), while the somewhat doubtful overflow channels to be observed

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has suggested, may be true drumlins, formed, however, by ice proceeding from the S.-W., and not from the N.-E., as that writer affirmed. The position of the pointed end of these features, remarked upon by Mr. Hallissy, and regarded by him as exceptional, would thus conform to the ordinary rule.

[1] For the striae localities, see the one-inch Geological Survey maps of this area (Sheets 45, 46, 57, 58), and the map (Pl. IX) accompanying this paper.

[2] The angular *débris*, noted by Maxwell Close in some of these ridges (*op. cit.*, p. 218), is doubtless of morainic origin.

[3] A similar aspect would be presented were the drumlin and morainic country of Aughnacloy and Tynan to be partially submerged.

along the stretch between Moville and Inishowen Head may mark earlier stages.[1]

The morainic mounds about half a mile S.-E. of Magheralahan and those just south of Moville were thrown down along the western edge of the Foyle Glacier.

Still later phases of the retreat are represented by the valleys of accumulation and denudation west and south-west of Muff.[2] Here the streams and ridges exhibit a striking parallelism, due to the swinging of the ice out of the "Pennyburn depression" into the Foyle estuary. To the north of Muff the northward deflection of the streams is readily recognisable. Though these valleys are largely due to ridging of the drift, one or two were undoubtedly scoured out by marginal drainage.[3]

It is difficult to correlate the marginal phenomena on the west and east sides of the Foyle estuary. It may be said, however, that the "Ballyrattan" and "The Colonies" channels were most probably in action at some period during the existence of "Lake Claudy" and the operation of the "Feeny" and "Ballymoney" overflows, and were probably somewhat later than the third stage of the Sperrins retreat.

The ice, which retreated off the eastern shoulders of Slieve Snaght and the western slopes of the range bounding Inishowen on the east, formed a large Glentogher glacier;[4] this gradually shrank southwards, to form, finally, merely a small lobe protruded from the edge of the larger Foyle Glacier.

The extensive deposit which stretches from Carndonagh northward to Doon Bridge[5] represents the deltaic fan thrown down by the great river

[1] Like all the glacial marginal channels of this strip, these are parallel with the grain of the country. It is in consequence a matter of some difficulty, if glaciated surfaces be absent, to distinguish between those depressions produced by differential ice erosion and those subsequently modified by marginal drainage. The valleys just described are undoubted "dry" valleys; of the marginal origin of the rest I am very doubtful. Equally uncertain are the two steps, the one occurring at 280 feet, O.D., the other just below, in the steep face of Binion, on the western side of the peninsula; these are more probably structural features.

[2] The morainic character of the deposits is noticeable in the sands and gravels of the Galliagh Burn and in the vicinity of the Old Race Course, where the material, as exposed in the sections (25 feet high), is seen to be the product of the Donegal glaciation, and to include much Barnesmore granite.

[3] E.g., the valley east of Thompson's Town Bridge and that at Soppog, at the head of the stream flowing to Muff. Of the valley east of Ballyarnet I am less certain.

[4] Though the exceedingly deep and steep-sided gorge of the River Straid is doubtless, in the main, a rejuvenation feature, it possibly carried off the drainage of a lake held up by the ice-front which swung across from the hill of Crocknakilladerry to the hills running from the N.-E. slopes of Slieve Snaght.

[5] This great deposit of water-worn material is revealed in several places, e.g. at Doon Bridge, and wherever the sea has eaten into it; also in the large excavation used as

which coursed down the Glentogher valley from the snout of the Glentogher glacier, and which at a later stage flowed from the extra-glacial lake[1] held up by the Foyle Glacier in the embayment at the head of the glen. It probably also includes the remains of the boulder-clay which, well washed and sifted, was swept off the hill-slopes and from the sides and floor of the valley.

Occasional "dry" valleys mark the progress of the withdrawal of the ice from the Malin Peninsula. The largest of these is the deep and broad glen which falls steeply eastward into Glentooskert. It discharged the overflow waters of a very large lake impounded in the valley of the Keenagh River. A couple of small valleys on the sides of the hill to the north of Malin Town, falling east, are probably due to marginal drainage. Some water also probably escaped eastward into the Portaleen valley. These channels and others, as to the origin of which there can be less certainty, agree in denoting a recession of the ice westward and southward from this peninsula.

The ice, which receded from the western flanks of Coolcross and Slieve Snaght and the eastern shoulders of Bulbin, formed a large Mintiagh glacier. This, at one stage of the retreat, held up a small lake to the south of the King of the Mintiaghs, which drained northward by a small channel. By retreating southward, the Mintiagh Glacier was merged into the larger Swilly Glacier, and a lake impounded in the broad valley of the Owenbeg River. The surplus waters of this lake were discharged by a large direct overflow, which intakes just north of Mintiagh's Lough, and falls northward into the valley of the Clonmany River. The lake surface stood at about 320 feet, O.D., and attained its maximum extension just prior to its extinction, and when the edge of this part of the Swilly Glacier swung from Liafin Hill, passed Ballymagan Hill to Mouldy Hill and Gollan Hill. An earlier position of the ice-front is marked by the morainic ridge at Fallask, along the north-west foot of Crocknamaddy. For a brief period, prior to the disappearance of "Lake Mintiagh," its overflow waters found escape by the valley near Keeloges Bridge.

"Lake Mintiagh" received the waters carried by a channel from a higher lake held up in the recess W. of Scalp Mountain.

Of slightly earlier date was the lake which was impounded in the valley

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ballast pit by the L. & L. S. Railway, just W. of the Carndonagh Railway Station, and in the very good sections in the R. Donagh, near this place. It is seen to consist of diorite, schist, quartz, coarse and fine metamorphic grits, burnt and unburnt chalk-flints, chalk, spheroidal basalts (very deeply weathered) and granite. (Barnesmore.) All the pebbles are well rounded or sub-angular and clearly water-worn.

[1] The height of the lake surface was about 530 feet, O.D.

of the Owenerk, and which drained by the valley falling northward along the western foot of Bulbin.[1]

Of the manner of the withdrawal of the ice from east Fanad, and of the successive positions of the western margin of the Swilly Glacier during the retreat, no sign was detected north of Rathmullan. On the hill-slopes west of this village, however, unmistakable indications of the recession of the ice were obtained.

A lake was formed in the broad depression of the Glenalla River, which discharged by a large glen, intaking just above 400 feet, O.D. (it contains Gort Lough). A slightly earlier position of the ice-front is given by the valley, about half a mile north of this lake; a later, by the "in and out" channel, above the 300-foot level, and about half a mile N.-W. of Ray Wood.

No further trace of the Swilly Glacier was noted between this locality and Manorcunningham. Intaking some three miles east of this village, and just above 200 feet, O.D., is a magnificent overflow valley,[2] some three or four miles in length, which discharged the surplus waters of an extensive lake, held up by an ice-barrier curving from the hill just north of Manorcunningham to the hills south-west of Pluck. The moundy sands and gravels, which cover all the floor of the wide depression south-east of Manorcunningham, e.g. at Ballyboe and Monclink,[3] represent deposits swept into the lake from the melting ice. A moraine corresponding to this position of the ice was observed along the southern slopes of the hills about Oakmore; a later one runs as an irregular ridge from east of Letterkenny towards the river. The valley south-east of Crocknear (two miles S. of Letterkenny), which falls north, appears to have been modified by marginal drainage.[4] Above Letterkenny, all trace of the glacier was lost.

The signs of retreat being so meagre, it is impossible to correlate the positions of the east and west margin of the Swilly Glacier, or to trace in more detail its mode of retreat.

7. *The Mulroy, Sheephaven and Glenna Glaciers.*

The ice which shrank off the northern peninsulas formed a number of separate glaciers of which but occasional glimpses are obtained. The

[1] Some waters may have escaped by the Gap of Mamore at an earlier stage when the lower outlet was still uncovered.

[2] It is traversed by the Londonderry and Lough Swilly Railway between Manor and Newtown Cunningham.

[3] See Geol. Surv. Mem., Sheet 17, p. 28.

[4] A later marginal channel is possibly represented by the poor valley occurring on the western slope of this hill, above the 200-foot level.

marginal drainage was carried by the different channels for very short periods only, and has rarely recognisably modified the extremely irregular surface. Yet the shrinkage of the eastern margin of the Mulroy Glacier can in places be followed with considerable ease. Thus a lake was held up in the recess east of Carrowkeel, and drained by a series of channels in parallel sequence. They are all in "solid," and fall north or north-east. The highest and earliest of these intakes about 400 feet, O.D.; the second is the poor channel east of Murren Hill; the third, the lowest and best formed of all, intakes just below 200 feet, and N.-E. of Upper Town.

The only undoubted channel between Milford and Carrowkeel, is the short notch at about 300 feet, O.D., about one-and-a-half miles south of the latter place. A series of morainic mounds was observed south of Milford and east of Maggy's Burn; corresponding with this ice position is the short glen, now streamless, falling to the Quay, and ending at about 50 feet, O.D.

The shrinkage of the western margin of the Mulroy Glacier is wrapped in obscurity, one channel only, that to the west of Devlinmore Hill, furnishing any indication of the mode of retreat, though the valleys to the west of Milford were probably to some extent modified by streams draining directly from the ice-front.

Marginal channels mark the progress of the recession of this glacier along the Lennan valley; they all occur along its western side and fall north. Among these may be mentioned the gash on the eastern slopes of Cabra Hill, notching the 300- and 200-foot contours, and the glen west of Cottan; the valley at Treantagh is less clearly glacial in origin.[1]

With the single exception of a small channel falling north from Leadbeg Hill (about two-and-a-half miles N.-E. of Carrigart), no trace of the retreat was discovered in the Fanad, Rosguill, or Horn Head peninsulas. Two channels discovered in the country between Dunfanaghy and Barnes Gap, though small in themselves, are important as furnishing clues to the mode of recession of the Sheephaven Glacier. The one occurs at Cashelmore, the other[2] intakes at 200 feet, O.D., at the School, two miles south of Creeslough; they fall north.

The mass of ice north of the Muckish range cleaved somewhere on the line Muckish, Dunfanaghy, Horn Head, the one part shrinking eastward to form the Sheephaven Glacier, the other falling away westward and retreating through the breaks in the Muckish range and by the Glenna valley. Of this retreat a few traces exist. A small lake was held up in the Augher River

[1] Some melt waters would seem to have availed themselves of the Barnes Gap, as the ice shrank off the Salt range.

[2] The railway runs along its western side.

and drained by the unmistakable overflow valley which falls north-west, and which is situated rather more than one mile S.-W. of Derryreel Lough. These waters probably escaped by the valley falling northward to Blackburrow. The morainic mounds[1] encountered on the Dunfanaghy-Falcarragh road, about one-and-a-half-miles N.-E. of Ray, mark a slightly earlier position of the ice-front.

With the waning of the ice-sheet, the snow-clad peaks of the Errigal-Muckish ridge would project above the surrounding ice, and the glaciers from the Derryveagh Hills have access to the lowland plain of the west by the large transverse valleys of Alton Lough and Muckish Gap, and unite to form a large Piedmont glacier west of the quartzite ridge. The retreat of this ice is especially well seen in the valley of the Ray River. The earliest recognisable moraine of this glacier was noted at Falcarragh Station. This is, however, greatly exceeded in size by the large terminal moraine which spans this valley obliquely[2] some two miles west of Muckish Gap. Just within the Gap is tumultuously heaped up a series of large morainic mounds, consisting very largely of the local quartzite, and doubtless derived from the widening of the Gap.

The shrunken remnant of the Sheephaven Glacier formed the glacier in occupation of Glenveagh. One of its recessional moraines is thrown across the valley just below Glenveagh Bridge; a second, including an outwash fan, spans the valley just below the entrance of the Ashelleen Burn and above the head of Lough Veagh. A lateral moraine skirts the east side of the glen below Glenveagh Cottage.

The Glenna Glacier parted to the north of Errigal from the Alton Lough glacier, its neighbour on the east, and withdrew southward between that mountain and the hill-mass of Tievealehid towards the Dunlewy valley. Its retreat is marked by two doubtful "dry" valleys: the one south of Cashel Hill, the other taken by the railway, and containing Lough Trusk.

The steep and precipitous scree-covered faces of Muckish, Aghla More and Aghla Beg are probably partly due to the frost action of late-glacial times, which appears to have told more severely on the angularly-jointed quartzite than on the other rocks of this region. There is also a suggestion of snow screes below the summit of Aghla More and Aghla Beg, those of the latter forming a fairly considerable feature; this may, indeed, be morainic.

[1] They contain well stratified sand and gravel, derived chiefly from the break-down of quartzites (probably Muckish), though they also include pebbles of diorite, granite and schist. Drumlesk L. rests in a slight depression in outwash sands and gravels.

[2] It has driven the river across to the side of the valley and into the quartzite. The lake, which clearly existed originally above this morainic dam after the disappearance of the ice, was subsequently drained by the trenching of the barrier.

Of the comparatively early emergence of Errigal as nunatak above the *mer-de-glace* there can be little doubt. At its northern foot are heaped up ridges and irregular mounds, burying almost all the floor of the recess between this mountain and Mackoght. These accumulations probably represent snow talus, yet may possibly be the moraine of a small corrie glacier. The material consists almost exclusively of quartzite. The formation of the angular block-débris covering the summits of Errigal and Muckish is probably to be ascribed to disintegration by frost, acting in late-glacial times.

8. *The Rosses, Dunlewy and Gweebarra Glaciers.*

The Rosses and Glenna glaciers parted from each other in the lee of the Tievealehid hill. The earliest halt in the retreat of the former is represented by the "line of erratic boulders" of the Geological Survey map (one-inch, Sheet 9). This wall-like ridge is, without doubt, a block moraine formed along the edge of the ice standing at the foot of Bloody Foreland, and indicates a very early halt in the retreat.[1] A smaller ridge, farther north, and of practically the same composition, though possessing a greater proportion of quartzite and diorite to granite, represents a slightly earlier pause. With these features are probably to be correlated the sea of huge granite boulders strewn along the western flank of Bloody Foreland at an altitude of about 300 feet, O.D.[2]

The east and west direction of this morainic ridge characterizes the drift underlying the moorland extending south-eastward from Bloody Foreland. These ridges[3] may denote halts in the southward retreat of the ice. In correspondence with one or more of these is the very fine overflow channel at the head of Glenhoola, which drained an extra-glacial lake held up immediately to the west. It intakes at 293 feet, O.D. The gravels exposed beneath the peats in the area south-west of this valley doubtless represent the water-washed material carried into this temporary lake.

No further indication of the retreat of this glacier was noted north of the latitude of the Gweedore valley. Beyond the mouth of the latter, the ice which was retreating southward along the Rosses, parted from that which issued from the Derryveagh Mountains at the head of the Poisoned Glen and streamed along the Dunlewy and Gweedore valleys to form the large "Dunlewy

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[1] In the Geological Survey Memoirs (Sheets 3, 4, 5, 9, 10, 11, 15 and 16, page 110) this line of granite blocks is regarded as marking "the northern margin of the ice-sheet."

[2] L. Tirrim would appear to owe its origin to this accumulation of boulders.

[3] L. Doo, L. Veigha and other lakes in this moorland owe their existence to these drift irregularities.

Glacier." Of the retreat of the latter, several very clear records still remain. The earliest and finest memorial is the magnificent lateral moraine, which forms a chain of irregular hillocks skirting the hill at an altitude of about 400 to 500 feet, O.D., opposite Gweedore and on the south side of the Claudy River.[1] Corresponding with this large feature is the low terminal moraine which runs south from the Claudy River and spans the mouth of the valley (about three-quarters of a mile W. of Gweedore) where the great glacier debouched upon the open country. The smallness of this ridge as compared with the lateral moraine is doubtless to be explained by the destruction of morainic material by the powerful streams which issued from the snout of the glacier.

At a slightly earlier stage some water flowed along the valley which runs east of the hill of Cregmore, on the north side of the valley. The "Cung," separating Dunlewy Lough from Lough Nacung Upper, is, as E. Hull pointed out, a moraine marking the position of a second pause in the retreat of the Dunlewy Glacier. It is probably to be correlated with the upper moraine in Glenveagh, while the lateral and terminal moraines at Gweedore are of the same age as the terminal moraine at Glenveagh Bridge. If this correlation be correct, almost exactly the same rate of recession would appear to have characterized the glaciers in the two valleys.

Of the southward recession of the ice along the Rosses to Gweebarra Bay but few indications were observed. Many of the straight joint valleys, dissecting this plain and bearing west of north, must have carried the waters streaming from the southward receding ice-front. The recognition of those which were so employed is a matter of great difficulty, and having but little confidence in the results obtained, I refrain from mention of them.

The large accumulation of granitic blocks, at the western foot of the hill of Crockator, most probably represents the lateral moraine of the ice which proceeded northward along the Rosses, and which, farther north, deposited the enormous numbers of large cuboidal blocks of granite, weighing tens of tons, which lie scattered over the country where the granite hills fall steeply to the plain. A stream of considerable size, issuing from the edge of the ice, flowed along the large valley which contains Lough Keel and falls northward to Crolly.

The small sand and gravel moraines encircling Lough Nasnahida, west of Doochary, were laid down along the front of a small ice-lobe thrust into the depression north of Croaghleconnell.

The retreat of the ice from the great Gweebarra depression carried the

[1] L. Aleen is held up by this moraine.

melting front step by step backwards up the southern and eastern slopes of the valley until it drew completely behind the crest of the hills forming the western side of the Shallogan valley. As the ice-front fell back behind the watershed, streams flowing from the melting ice cut steadily southward through the crest-line, and produced a few overflow channels discharging a series of small lakelets formed along the ice-margin. One or two failed to cut through the watershed, e.g., that to the east of Denkbeg Hill, which simply carried off the water from the melting ice, and makes only a slight breach in the watershed. Some water escaped by the Carbat Gap.

A large glacier lingered in the Shallogan valley. It deposited a terminal moraine south-east of Denkbeg Hill and lateral moraines along its southern side, though these are probably built upon " tails " from the Knockrawer and Sculloge mountains. The finest of these moraines in the Shallogan valley forms a conspicuous feature at the south-west or upper end of Lough Finn,[1] stretching as a linear hillock across the valley from the foot of Sculloge to the base of the Curreen Hill. A later terminal moraine occurs on the northern shore of the lake opposite Crockannaragoun.

A morainic mound occurs at the eastern end of Lough Muck, south of Scraigs. It is in part the cause of the existence of the lake, though glacial erosion is doubtless the primary cause.

9. *Retreat from the Glengesh Plateau and the Country North of Donegal Bay.*

On the Glengesh Plateau no moraines were noted and but few overflow valleys. These, of different value, suggest a progressive recession eastward towards the great rampart of hills bounding the plateau in this direction.

A lake of considerable size was held up in the valley running south from Lougheraherk, and drained by a valley falling towards Kiltyfanned Lough. Some water from the ice-edge farther south would appear to have discharged over the col between Croaghnaleaba and Croaghloughdivna and some into the valley leading to Malin More. The overflow at the head of the Owenwee River took the surplus waters of a small lake held up to the north of Stravally, while the valley of the Meentashesk acted as a gutter carrying off the waters from the ice-front. Finally contracting to a glacier in the valley of the Glen River, the ice brushed passed the south-east shoulder of Slieve League, forming a drift feature, in part possibly a "tail," in part a

[1] It originally impounded a lake on its western side, which was subsequently drained by the stream which has cut through the barrier. The site of the lake is now occupied by a large alluvial flat.

Most of the mounds and ridges in this valley, west of Lough Finn, are apparently residual or denudation features.

lateral moraine. This has impounded the drainage of this slope of Slieve League, giving rise to Croleary Lough, a lakelet in the corrie recess.[1]

Ice proceeding towards Donegal Bay from the hills to the south of Glenties and the Binbane range would have a strong south-westerly component in its motion, the effect of which would be to cause the glacier to stand well away from the eastern escarpment of the Glengesh Plateau at its northern end, while pressing closely against the face of the hills on the west and south-west; in the north a large lake would in consequence be formed discharging through the "Neck of the Ballagh," to Ardara, while along the west and south-west edge there would be space only for marginal streams carrying off the waters from the melting ice-front—e.g., the valley west of Sheannacon Hill.

At Clogher, N.-E. of Muckros, enormous numbers of blocks of all sizes strew the ground, showing some tendency to linear arrangement. These may represent moraines, as J. F. Campbell suggested,[2] yet they may, with more probability, be regarded as a measure of the rock destruction of the maximum phase of the glaciation.

Over the whole of the drumlin country north and east of Donegal Bay I have been unable to detect any sign of the mode of the withdrawal of the ice.[3] The plain north of Ardara is almost equally destitute of memorials of the retreat. South of Wood Hill (Ardara) and along the foot of Mogumna Hill there runs a morainic ridge; the course taken by the marginal stream can also be clearly seen. Another short lateral moraine margins this plain to the east of Kilrean (about one-and-a-quarter miles S.-W. of Glenties). Lough Kip (one-and-a-half miles W. of Glenties) is held up by a similar morainic ridge. The large valley, now quite streamless in its upper portion, leading from Letterly Ho. to Maas, may have served as the means of escape for the melt waters when the ice spread out over the country to the west of Glenties, and may have been in action at the time of the formation of the morainic ridge south of Lough Kip.

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[1] This moraine, according to another view (Geol. Survey Mem., Sheet 22, 23, 30, and 31 (in part), p. 55), was formed by a corrie glacier descending from the heights of Slieve League.

[2] "The most conspicuous moraine that I have seen in the British Isles is at a point at the northern horn of Donegal Bay at a place called Clogher . . . ; it consists of at least six parallel ridges of angular stones. The largest of these are as big as small houses, and they rest where they were tilted off the ice." (Quar. Jour. Geol. Soc., vol. xxix (1873), p. 211.)

[3] The N.-S. ridges in the valley of the Eanybeg Water, about half a mile N.-W. of Drumagraa L., externally resemble moraines. The material is very angular, shows no stratification, and may represent the broken and jumbled rock masses shattered by the overriding glaciers.

The small morainic mounds, observed north of the Silver Hill-Binbane range, e.g. in the valley of the Owenoe River, just S. of Doobin, to the S.-E. of Meenagushoge Hill, and to the S. of Lough Magrath More, prove that the ice cleaved north and south along the line of this ridge.

A small terminal moraine of the glacier flowing along the valley of the Owenea River was observed about one mile S. of Glenties. Larger moraines, above and below Martin's Bridge, were deposited by the same glacier at a later stage. These may perhaps be correlated with the moraine at the western end of Lough Finn.

10. *The Great Finn Glacier.*

The retreat from the region now to be described is largely bound up with the recession of the great mass of ice in occupation of the Finn valley, which at an earlier stage spread over the intervening watersheds into the valleys of the Derg and Swilly. It is here comprehensively denoted the "Great Finn Glacier." As moraines are practically absent, the manner of its withdrawal has been largely determined by the magnificent "dry valleys" of the area.

After the emergence of the higher part of the Omagh range and the separation of the Fintona and Drumquin glaciers, these for some time continued to flow round the eastern shoulders of the range, west of the town of Omagh; and abut against the lower and south-east slopes of Mullaghcarn. Proof of this is furnished by the sweep of the moraines from the east of Omagh northwards along the sides of the hills in the direction of Deer's Leap.

Further evidence is forthcoming in the occurrence of overflow channels at the south-west foot of Mullaghcarn. The highest of these was observed near Tirquin. It intakes just below 500 feet, O.D. A second and slightly later channel intakes near Cornary at an altitude of about 450 feet, O.D., beginning as a shelf on the hill-side. The small glen, which intakes just below the last-mentioned channel and pursues a course down the natural slope, marks a somewhat later position. Yet another "dry" valley was observed at Killybrack. These channels, all cut in "solid" and falling north, show that the ice had retreated from the terrain in that direction.

The further shrinkage of the ice from this hill-side caused, at a somewhat later stage, the complete severance of the glaciers streaming to the north and south of the Omagh range and the development of an ice-free area about Omagh.

The retreat of the ice-lobe south of the range—the "Fintona Glacier"—was sketched in an earlier section. The wide glacier of Drumquin, north of the range, extended down the valley of the Strule in the direction of

Newtownstewart, resting on the eastern flanks of Bessy Bell and on Deer's Leap, at one stage depositing a moraine spanning the valley. Most probably corresponding with this position of the ice-front is the overflow valley, falling north, observed east of the hill of Deer's Leap. Larger morainic belts mark the successive halts in the retreat from the hills to the east of this valley. The finest is that which is crowned by the Mountjoy Forest and which is partially responsible for the southerly course taken by the Fairy Water. It sweeps northwards under the village of Mountjoy and on to the southern slopes of Bessy Bell.

A similar series of moraines was noted along the foot of the northern flanks of the Omagh range to the east and west of Drumquin.[1] At one stage a lake was impounded in the embayment south-east of Drumquin; its surplus waters escaped by the valley followed by the Omagh-Drumquin road.

To the west of Drumquin the glacier appears to have split into two, one branch receding towards the head of the large recess drained by the Blackwater, the other, the major glacier, keeping to the broad depression of the Fairy Water. A series of recessional moraines flung across the Blackwater valley marks the retreat of the smaller glacier. One of these has so obliterated the old course of the river that the stream now escapes across the barrier by falls and a gorge cut in the "solid" rock at the Carrickaness Bridge.

As a result of the emergence of Bessy Bell from the surrounding ice and the cleavage in the ice to the north-east of this hill, the lobe withdrawing southwards along the Strule valley towards Mountjoy became separated from the glacier occupying the valley of the Derg. This glacier had at the same time parted from the main Finn Glacier somewhere on the line of the present watershed between the valleys of the Finn and Derg. The broad and almost streamless valley east of Raws Hill possibly drained a shallow glacial lake located on the site of the present Moneygal Bog and held up between the glaciers filling the Finn and Derg depressions. The position of the northern edge of the latter glacier is given by the huge Fyfin-Victoria Bridge overflow valley,[2] which intakes N.-E. of Fyfin Station at an altitude of just below 300 feet, O.D.

The position of the ice-front at this stage of the retreat is further indicated by the pronouncedly morainic belt skirting the southern foot of Clady Hill. This broad strip of very hummocky country, studded with small pools and forming a most conspicuous feature in the landscape, runs as a series of ridges

[1] These are the "drift hillocks of irregular shapes" of the Geological Survey Memoir (Sheet 33, p. 19).

[2] The Castle Derg and Victoria Bridge Tramway skirts the northern side of the valley over the stretch from Fyfin Station to Victoria Bridge.

from north of Ardstraw across the Derg River, which breaches the moraine just above its confluence with the Foyle, and continues by Mullaghamley to Wood Hill and the slopes of Bessy Bell at Harry Avery's Castle. It is most magnificently displayed at Wood Hill, where it rises roughly 100 feet above the adjacent country. It contains great quantities of sand, and exhibits other features indicative of water action.

The ice in its further withdrawal shrank into the valleys to form a couple of glaciers, the one retreating up the valley of the Mourne Beg River, the other along that of the Derg. Evidence of the former of these two glaciers was not obtained till it had withdrawn almost to its place of divergence from the glacier streaming to Stranorlar; unmistakable witness of the latter is borne by the "dry valley" at Aghalunny, about one-and-a half miles west of Killeter.[1] It intakes at about 370 feet, O.D., and carried off the surplus waters of a lake held up in the recess now drained by the Glasgagh Burn.[2] This channel, situated on the south side of the Derg valley, and the "Fyfin-Victoria Bridge channel" on the north side, prove most conclusively the existence of a Derg glacier.

The great mass of ice standing on the site of Lough Erne, and which at an earlier stage had thrust large lobes into the Clogher valley, the Fintona Plain and along the Erne depression, above Enniskillen, shrank behind the watershed and down the hill-slopes north-east of Kesh, forming a few extra-glacial lakes. The highest of these discharged by Killen Gap, while the wide valley north of Tappaghan Mountain, falling east, drained a lake held up in the recess to the west. A later phase of this retreat is marked by the valley falling east from the village of Lack. No further indications of the mode of retreat of the ice covering this great depression were observed.

The retreat of the northern edge of the "Great Finn Glacier" may now be briefly sketched. The mounds near Church Town in the valley of the Foyle are morainic features. Of similar origin are the mounds, about two miles S.-W. of Lifford, the ridges at Clady and Cloghfin (the current bedding in the mounds of the latter, as seen in the railway cutting, indicating ice to the west), the mounds near Prospect Hill, and the low ridge of gravel and sand half a mile long observed S.-W. of Carrigans.[3] These moraines were produced by the ice receding southward along the valley of the Foyle into that of the Finn.

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[1] The main road from Castle Derg to Pettigo runs along the valley.

[2] The channels draining into this lake and situated farther south, though recognizable, are not well developed.

[3] These were regarded as eskers in the Londonderry Memoir, p. 39. Some of the sands and gravels at Carrigans probably represent outwash material.

The "Finn Glacier" gradually shrank towards the west and from the watersheds bounding the valley on north and south, impounding the drainage to form a fine series of lakes and overflow valleys. The successive stages of the retreat of the northern edge of the glacier are represented on the map (fig. 3).

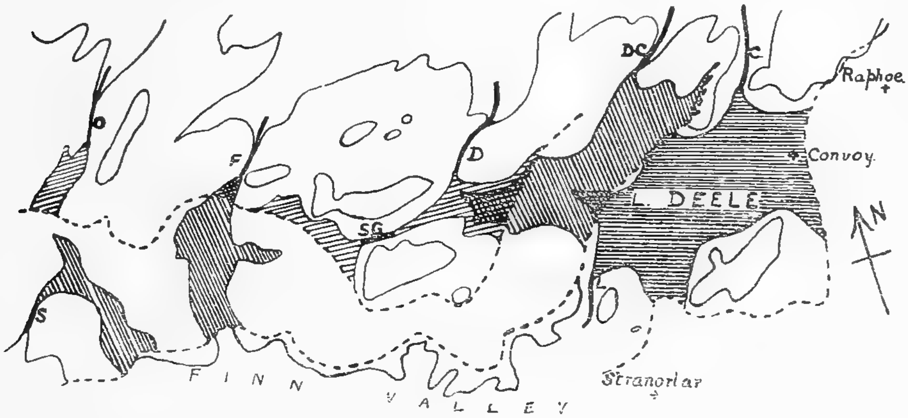

FIG. 3.

Map representing the retreat of the northern edge of the Finn Glacier. The variously-shaded areas represent the size of the extra-glacial lakes at different stages of the retreat. Scale—4 miles = 1 inch.

The earliest evidence of this retreat is furnished by the Sruffannagallagh glen, running to the south of Cark Mountain. This broad valley (S.G.), streamless in its upper part, intakes at an altitude just above 800 feet, O.D., and poured its waters into a "Lake Deele," held up in the Deele valley. Sections in the lower part of the Sruffannagallagh valley, about three-quarters of a mile above Cark Bridge, show boulder clay in the lower portion of the section, and in the upper, several feet of stratified gravel and lenticles of coarse sand. These represent the deltaic deposits thrown down in the lake by the waters flowing through the "Sruffannagallagh channel." "Lake Deele" at this stage discharged into the Swilly valley by the broad and flat-floored depression (D.), situated S.-E. of Drumanaught Hill, and intaking at about 660 feet, O.D.

The "Sruffannagallagh overflow" served as the outlet of a lake held up by an ice-barrier resting on the slopes of Tullytresna and Cronaglack. A small retreat from the latter uncovered the col over the watershed between it and Altinierin, and put out of action the "Sruffannagallagh channel." Its successor, the "Farnoge channel" (F.), has an intake just below 600 feet, O.D., and falls rapidly northward into the Swilly valley. It continued to act as the ice receded out of the Elatagh glen, for not until the lobe thrust into this depression had completely withdrawn to the valley of the Finn—a distance exceeding three miles—was a lower outlet possible.[1]

A similar lobe impounded a lake in the recess of the Sruhanpollandoo, which drained by a broad valley W. of Binswilly—the "Owenbeg channel" (O.); it intakes below 700 feet, O.D. This position of the ice-front probably coincides with the Finn moraine west of Lough Finn. A later position is represented by the broad channel (S.) falling S.-W. into the valley of the Scallan River and intaking at about 590 feet, O.D. This served as the outlet of a large lake held up in the Cummirk valley.

With progressive recession of the ice and by the opening of lower cols, the level of "Lake Deele" was gradually lowered. One of its drainage channels occurs west of the hill 781 (D.C.); it intakes at 570 feet, O.D., and falls north into the Dooballagh Burn and the valley of the Swilly. The last, lowest and largest is the very broad and flat-floored valley (C.),[2] which intakes about two miles N.-N.-W. of Convoy at about 370 feet, O.D., and falls northwards into the Swilly valley.

"Lake Deele," at the stage represented by this "dry" valley, received a feeder flowing via the depression situated east of Liskeran (L.) and two or three miles N.-N.-W. of Stranorlar.

It is difficult to correlate the phases of the retreat of the ice in this area with those positions marked by the marginal drainage along the western foot of the Sperrin Mountains already recorded. The ice position given by the two channels just described may, with some probability, be correlated with that indicated by the "Strabane Glen," when the great ice-lobe terminated somewhere in the neighbourhood of Broomfield.

The moraines at Clady and those on the northern slopes of the Finn valley, east of Liscooly, and in the bottom of the valley near Castlefinn, mark later stages of the retreat of the "Great Finn Glacier."

Still further withdrawal caused the disintegration of this glacier into the separate streams feeding it, chiefly those issuing along the Reelan and Daurnett valleys from the Barnesmore Hills. The morainic ridge east of Cloghan Station was formed by the Reelan Glacier just before its withdrawal

[1] Therefore, both during the maximum and late-glacial phases, the direction of ice-motion was towards the N.-E. Yet on the Geological Survey Map (Sheet 16), an arrow is engraved indicating ice movement to the S.-W. in the Elatagh valley. A similar error was noted in Mulroy Bay; an arrow on the Geological Survey Map denotes ice proceeding southwards in the southern part of the bay, though from all the evidence it is abundantly clear that no ice flowed from the sea *up* the fiord.

[2] This valley, south of Glenmaquin Station, is traversed for roughly two miles by the Strabane and Letterkenny Railway.

from the valley of the Finn. The irregular mounds in the Reelan valley (e.g., E. of Meenasrone South) are probably not to be regarded as due to unevenness of the original deposition but as residual features produced by river erosion.

The glacier, which receded southwards along the Daurnett valley, impounded a lake on the site of the present Mourne Lough, which drained northward by an indubitable "dry" valley, excavated in rock, at the head of the Burn Daurnett. The large glacier retreating westwards up the valley of the Mourne Beg River, after parting from the Derg Glacier, formed a temporary lake south of Meenglass, which discharged northward along the glen west of Trusk Hill.

The series of marginal lakes on the northern edge of the "Great Finn Glacier" discharged therefore by a number of channels into the Swilly valley, from which, in the absence of channels along its southern side, it may be inferred the ice had already retreated.

11. *The Barnesmore Hills.*

Moraines are only found in the valleys on the northern side of the Barnesmore Hills where the ice would seem to have lingered longer than on the southern side.

The finest of these are associated with the Barnesmore Gap. While the hummocky country to the south of the Gap is doubtless primarily due to the irregular outcropping of schist and less to the occurrence of morainic material, the irregular ridges and mounds, encountered S.-E. of Ardeevin and seen to consist of angular local material, may represent one of the earliest of these moraines.

A pronounced ridge of hummocky aspect and convex to the south occurs at the southern end of the Gap. It represents a terminal moraine of a glacier occupying the Gap. No sign of an intermediate halt is observed till the northern end is reached, where the Barnes River enters from the west. Here, magnificent morainic heaps and ridges occur, presenting a chaotic and tumbled appearance, strongly contrasting with the more regular surface of the adjacent country, and are probably to be regarded as one more or less continuous moraine, convex eastwards.

These great accumulations are without doubt, as suggested by J. R. Kilroe,[1] the product of a glacier advancing down the valley of the Barnes River. The water-worn and stratified sands and gravels exposed in the large railway ballast-pit are clearly part of the outwash-fan of the ice.

[1] An attempted restoration of these glaciers is given in the Donegal Memoir (Map, p. 41).

Barnes Lough, in the transverse valley of the Barnes River, owes its existence in part to the morainic ridge which probably originally spanned the valley as a terminal moraine, but of which, owing to the activity of the Barnes River, only a small part now remains. The remnant of the lateral moraine of a slightly earlier period runs along the foot of Brown's Hill.

Terminal moraines were observed in the Owengarve valley. The large valley, containing Croaghanard Lough, possesses a broad and low morainic mound situated at the lower end of the lake. The mound is probably partially responsible for the lake's existence.

The main lines of the retreat of the great Donegal Ice-sheet from the several boundaries limiting the region investigated in this work have now been traced. Some points are still obscure. Of these the greatest is the relative importance of the Barnesmore and Derryveagh centres during the later stages. Though this has in the main been clearly solved in favour of the former, it has been found impossible to determine with any satisfactory degree of certainty the mode of retreat in the critical area immediately S.-E. of the Derryveagh Mountains.

VIII.—The Re-advance of the Scottish Ice.

It is proposed in this section to sketch very briefly the scanty evidence suggestive of a re-advance of the Scottish Ice. The first indication of such an advance is furnished by the occurrence of a number of very fine *roches moutonnées* which were observed in several places along the coastal strip extending N.-E. from Moville,[1] and which were most clearly produced by ice proceeding from the N.-E.

In the great sinus south of the Foyle estuary there extends a great gravel sheet, the "detritic flat" of Portlock.[2] Covering many square miles of country, it stretches from the foot of the hills, where it rests against rock or hummocky drift, out over the gently-shelving bottom of Lough Foyle, forming an extensive coastal plain skirting the southern shores of the estuary from its head to the Roe at Limavady, and continuing southwards as a narrow strip to the east of the Culmore section of the Foyle as far as Londonderry.[3] It sends tongue-like projections into the valleys and bays of the higher ground, e.g., round the mouth and as patches along the sides of the valley of the Faughan. The present streams, e.g., the Faughan and the Roe,[4] have carved out of it a number of alluvial flats and terraces bordered by miniature escarpments.

[1] E.g., by the edge of the sea, just out of Moville, on the north side.

[2] Report, p. 636.

[3] The military barracks of this city are built upon it.

[4] Those of the Roe are referred to by Portlock (Report, p. 636).

This great deposit is quite flat,[1] save for some depressions which, usually mall and filled with water, and on the whole singularly few in number, stud the surface in certain parts, e.g., Lough Enagh Eastern,[2] and two or three smaller ones in this immediate neighbourhood (N. of Londonderry), and those which occur as far east as Limavady and along the valley of the Faughan to near Drumahoe. Though the height of the terrace at this locality is about 120 feet, O.D., it falls gradually down the valleys, attaining over the greater part of its area an altitude of roughly 50 feet above sea-level.

A very good section, exceeding 20 feet in depth, occurs near the roadside at Stradreagh, where the deposit is seen to consist of stratified and well water-worn sands and gravels, in places current-bedded and calcreted. The pebbles include all the rocks found in the drift of the country to the south. At Faughan Bridge and a few other places shingly accumulations of similar material suggest by their nature and their current-bedding (from the south) deposition by powerful currents issuing from the Faughan and other valleys. Various opinions on the origin of this very extensive terrace have been expressed. In the Geological Survey Memoir, descriptive of the Limavady area, the following passage occurs[3] :—

> "It [the terrace] has been sometimes regarded as a recent raised beach. A little examination, however, shows that this is not the case, as its contents are precisely similar to those of the gravel terraces above it, and differ widely from those in the raised beach."

With this view of the nature of the deposit and its non-marine origin—shells are entirely absent, though present in considerable quantities in the raised beach—I am in complete agreement. Its glacial or late-glacial origin would seem indeed to be beyond question, as was recognized by J. R. Kilroe, whose view on its mode of formation is expressed as follows[4] :—

> "The materials have obviously been distributed by flood waters issuing from receding glaciers over the valley floor and the low ground bordering the coast during the final disappearance of the permanent ice from the region."

He finds support for this view in the existence of kettle-holes.

This theory of the origin of the great gravel spread is consistent with

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[1] This is especially well seen in the bay of Eglinton and in the stretch to the west of the Londonderry-Limavady road.

[2] A photograph of one of these depressions is given in the Londonderry Memoir (1908, Pl. VI, facing p. 60).

[3] Sheet 12, p. 26.

[4] Londonderry Memoir, p. 60.

J. R. Kilroe's view of the glaciation of the area, which postulated, as has been already observed, the retreat of the ice *up* the valleys and *towards* the main watershed of the Sperrin Mountains. Had such been the mode of recession, there can be little doubt but that vast quantities of sand and gravel would have been swept out of the ice and deposited as great outwash fans in the valleys and along the estuary; the huge quantities of sand and gravel deposited in "Lake Claudy" are sufficient proof of this. In this paper it has, however, been proved that the ice shrank off this mountain group and retreated *down* the valleys; the marginal phenomena observed in this region and sketched in an earlier section can, it is submitted, have no other interpretation.

The whole appearance of this great sheet is indeed that of a deposit laid down in the tranquil waters of a lake; the terrace is still remarkably fresh in outline and has not assumed the moundy form associated with topographical maturity. It is suggested that the materials were accumulated in late-glacial times by the rivers draining from the Sperrin Mountains to the south, and charged with a superabundance of sand and gravel, obtained from the rapid demolition of the terraces formed at higher levels in the temporary ice-dammed lakes. Indubitably some of the material, though what proportion it is impossible to estimate, was deposited on the ice-retreat by the rivers issuing from the lowest of these lakes. From the great development of the higher terraces it is quite clear that vast quantities of sand and gravel were thrown down in these settling tanks, and that the greater bulk of the material brought down by the streams—those pouring out of still higher lakes, or flowing normally down the hill-sides, or again issuing from the ice itself—was, during the retreat of the glaciers, effectually trapped, and unable to escape to lower levels until the normal drainage had been reopened. It would seem, therefore, that erosion of the valleys, carrying the surplus waters of the lowest lakes and the streams pouring off the ice standing in the Foyle estuary, were the sole contributors to any accumulations formed prior to the complete withdrawal of the ice from these hills.

A shelf-like feature corresponding with this great accumulation extends discontinuously along the Inishowen coast of the Foyle estuary, e.g., about Ture and at Greenbank. The best of these deposits is the terrace of gravel, which stretches along the coast for about three miles S.-W. of Moville, the materials of which were derived from the drift which masked the hill-flanks behind. A few of the streams, moreover, flowing down the Inishowen slopes of Lough Foyle, have built up deltas at the outfall of their valleys, e.g., the well-marked terrace composed of well-stratified sand and gravel observed at Muff, a few miles N. of Londonderry. This fan was, without doubt, laid down at the embouchure of the stream where it left its gorge and entered the lake.[1] About one-and-a-half miles farther north another stream (entering Lough Foyle at Sand Point) shows a section in a similar accumulation exhibiting current-bedded and water-worn sand and gravel.

During the formation of the huge terrace skirting the southern shores of Lough Foyle and of the discontinuous strips of shelf fringing the Inishowen shores of the estuary, it seems necessary to suppose the existence of a great lake held up by an ice-barrier blocking the mouth of the lough.

The outlet of this lake is to be sought in the valley running north-west from Londonderry to Burnfoot and to Lough Swilly, and traversed by the Londonderry and Lough Swilly Railway. Throughout the greater part of its length it is quite streamless, yet it possesses the form of a large river valley, and was clearly produced by a stream of considerable magnitude which flowed in wide-swinging curves towards the Swilly. The highest point in its floor is 50 feet, O.D. This depression may be regarded as the overflow channel which carried off the waters of the huge lake impounded in Lough Foyle, and which has been deserted save, perhaps, by the sea of raised beach times, since the final retreat of the Scottish Ice.[2]

The latter, proceeding westwards off the north of Ireland, east of the mouth of Lough Foyle, hugged the Antrim coast, spreading on to the land only where this was of small elevation; the great dome-shaped mass of Knocklayd, south of Ballycastle, the towering bastion of Benevenagh and the heights of Inishowen Head obstructed its landward progress. East of Knocklayd, as Dr. A. R. Dwerryhouse has shown, the ice pressed southwards, causing the drainage to pass behind this mountain, while over the extensive moorland, stretching southward between Knocklayd and Benevenagh, was thrust a great lobe of Scottish Ice, which threw down at its edge the Ballymoney-Capecastle moraine, charged with the Ailsa Craig paisanite and Scottish rocks. Sweeping round the mass of Benevenagh, the Scottish Ice advanced across the wide mouth of Lough Foyle. Pressing as a great ice-lobe up the slowly-shelving shore of this estuary, it ponded back the normal drainage of the country, converting the estuary into a lake—"Lake Foyle." The ice did not apparently extend as far westward as the Culdaff depression where the drumlins trend south-north. The direction of the ice thrusts, the

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[1] This deposit is described as "River Gravels" in the Londonderry Memoir, p. 31. It would seem to be impossible to produce this terrace with the present relative position of the stream and sea level.

[2] The wide depression—the "Pennyburn depression"—in which this smaller valley lies, is obviously pre-glacial; the floor is formed of boulder clay, both Scottish and Donegal, and of gravels and sands.

margin of the great lobes and the location of the obstructing bastions are inserted in the map (fig. 4).[1]

The remarkable sand-tract of Magilligan may represent the re-sorted moraine of this Scottish lobe thrown down after a retreat from its furthest position, while from the same source may have been similarly derived the material forming the raised beach (25 foot) upon which the sand dunes, &c., now rest.

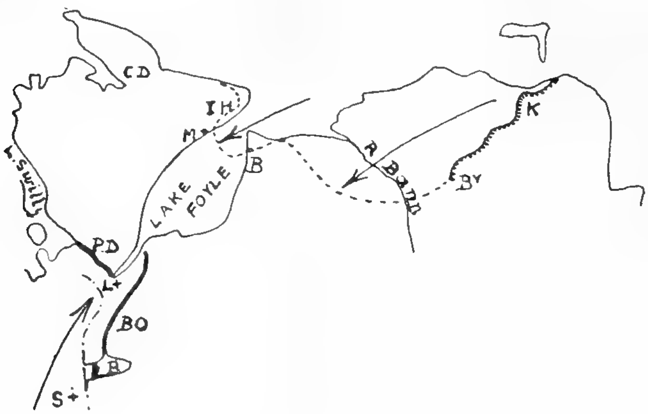

Fig. 4.

Map illustrating the re-advance of the Scottish Ice. Dotted line denotes margin of ice; comb-line the Ballymoney moraine; arrows give direction of ice-thrusts. K. = Knocklayd; B. = Benevenagh; I. H. = Inishowen Head; By. = Ballymoney; M. = Moville; L. = Londonderry; S. = Strabane; P. D. = Pennyburn Depression; B. O. = Burngibbagh overflow; L.B. = "Lake Burndennet"; C. D. = Culdaff Depression. Scale—20 miles = 1 inch.

The existence of a lake in Lough Foyle, discharging its surplus waters into Lough Swilly, demands a retreat of the Donegal ice to a position at least south of the line of the "Pennyburn depression." The extension of the terracic deposits up the Burngibbagh valley, for a slight distance beyond its confluence with that of the Faughan, suggests that, at the period of the re-advance of the Scottish Ice and of the formation of "Lake Foyle," the "Burngibbagh channel" was in operation; that "Lake Burndennet" was still in existence, though about to be abandoned; and that the edge of

[1] I arrived at the above conclusion on the evidence here submitted some six years ago, and presented it to the Cardiff meeting of the British Association in 1920. Though Professor P. F. Kendall, who has accompanied me over part of the ground, and to whom I outlined all the evidence, regarded the deduction as sound, Dr. A. R. Dwerryhouse at that time refused to entertain it. The strength of the view is therefore enhanced by its recent adoption in Dr. Dwerryhouse's paper already quoted.

the Donegal Ice skirted the hills rising from the eastern bank of the River Foyle.

The retreat of the Donegal Ice from the mouth of the Foyle estuary to the position south-east of Londonderry, as represented on the map above (fig. 4), is a measure of the interval separating this recession from the re-advance of the Scottish Ice.

The Scottish Ice was now less powerful than in the earlier phases of the glaciation, and was no longer able to surmount hills of any considerable altitude, but merely to skirt the coast, to spread over any comparatively low ground, and to protrude into the mouths of the larger inlets. It is significant that the area of re-advance lies in the direction of the maximum thrust which was exerted by the Scottish ice during its earlier invasion.

IX.—Glacial Stream Diversions.

Upon the disappearance of the ice from this region, the streams resumed their flow, cutting rapidly into the superficial smear of incoherent glacial deposits, in some places succeeding in reaching the pre-glacial rock floor, in the majority of cases, however, still flowing well above this. Their courses, in position and trend, are in general coincident with those of their pre-glacial predecessors. Some streams, meandering over the glacial accumulations which, after the withdrawal of the ice, thickly covered the floor and sides of the valleys, even to their complete obliteration, have failed to discover the pre-glacial bed, and have cut into the rock, while others have been diverted by morainic barriers. A few of the more prominent instances of such stream diversions may be briefly noticed.

Above and below the Carrick Rocks the valley of the Roe is broad and open. At the Rocks the river passes through a very deep gorge, hemmed in between sheer walls of gnarled and contorted schist. The old valley site is just to the east, as suggested by the drift-hollows running up the sides of the valleys at the abrupt bends in the stream-course.

As noted by Portlock,[1] traces of terraces are preserved above this gorge; these are possibly to be attributed to the slow down-cutting of the River Roe through the schist barrier. The River Roe has deviated from the line of its pre-glacial valley at two other places below this point, namely, at the Dog's Leap, and at O'Cahan's Rock.

The "Ness Waterfall,"[2] in County Londonderry, is due to the wandering

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[1] Those terraces mentioned by Portlock (Report, p. 633), as occurring below the "Ness Waterfall," are lake deposits of "Lake Claudy," their material derived in large measure from the receding ice.

[2] A description of this waterfall is given in the Londonderry Memoir, p. 82.

of the Burntollet River out of its pre-glacial valley, which lay just south of the present position, as is indicated by the fine drift section, sixty feet high, exposed just south of the fall.

The Dungeon Waterfall, south of the Faughan Valley, is probably of the same origin, much gravel occurring at its side.

The Ballinderry River would appear to have lost its way in that part of its course which runs from Corkhill to Kildress Bridge (about three miles W. of Cookstown), its former valley, infilled with drift, lying to the south, near the road skirting the Drummanor demesne.

The Glenelly and Owenkillew Rivers have been diverted from their pre-glacial courses by lake deposits and transverse morainic ridges. The position of the pre-glacial channel of the Owenkillew River is probably indicated by the present small stream entering the river below Athahole. The general direction of these obliterated channels is given on the map (fig. 5).

Fig. 5.

Map showing the pre-glacial course of the Glenelly and Owenkillew rivers. Scale—2 miles = 1 inch.

Numerous other post-glacial diversions were observed, e.g., the gorge in the O.R.S. at the "Leap" on the Camowen River, to the S.E. of Omagh, the pre-glacial valley lying somewhere to the east of this; the Termon River, near Pettigo, which flows through a small gorge in the gently-dipping, thick-bedded Carboniferous Limestone; the Owenbrack River, at the "Mills," S.-E. of Six Mile Cross, which has bitten into the O.R.S. and formed a small gorge; the Mill River, which has cut into the rock, some miles N.-E. of Buncrana; the River Deele, which has missed its old valley in two places above Drumkeen and also near Convoy; the Lennan River, which has been deflected into the rock by drumlin mounds, east of Garton Bridge; the River Faughan, which has cut into the rock in one or two places below its confluence with Bond's Glen.

The River Erne, above Belleek, flows in a wide, open and drift-floored valley. At this place it suddenly changes its direction, pursuing a south-north instead of the east-west course which had previously characterized it, crossing the Carboniferous Limestone and other rocks of this formation to their boundary with the members of the metamorphic series, then following the line of junction to the sea. This change of direction is accompanied by an equally pronounced transformation in the character of the valley, the river, below Belleek, flowing by a series of falls and rapids along a rocky gorge bounded by lofty and precipitous sides to the Falls of Ballyshannon near the sea. Between Belleek and Ballyshannon, a distance of some six miles, the River Erne falls 143 feet; from Enniskillen to Belleek, a distance of roughly twenty-four miles, the fall is 10 feet.

This coincidence in the abrupt change in direction with the remarkable change in the scenery and type of valley is highly suggestive of a glacial diversion below Belleek, and of the existence of an old pre-glacial line of drainage west of Belleek in a line roughly continuous with that of the valley above this town. The great areas of very thick turf, which conceals both the "solid" and the drift of this country, render it impossible to trace the course of such a drift-filled valley,[1] while the vast accumulations of sand, forming the present coast-line north of Bundoran, forbid all attempts to discover its seaward termination. The adequacy of post-glacial erosion to excavate a gorge of such magnitude can scarcely be questioned when the well-jointed and bedded nature of the Carboniferous Limestone and the volume of the Erne are remembered. On any other view the coincidence in the change of direction and character of the present Erne valley would be remarkable indeed.

An examination of the Admiralty Chart of Lough Erne shows a small area of the lake floor to be below sea-level; the greatest depth is 226 feet;[2] the lake surface is 149 feet above sea-level. Were the gorge of the River Erne below Belleek a diversion feature, and the pre-glacial river perfectly graded, it would seem that Lough Erne, except as a very small and comparatively shallow lake, could not have had a pre-glacial existence.[3]

Another factor, which can be only briefly referred to in this paper, may, however, not be lost sight of, namely, a pronounced and unmistakable rejuvenation of the rivers of N.-W. Ireland, more especially of those mouthing

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[1] The Geological Survey suppose a considerable fault to run along or near this line, throwing down the Calp against the L. Limestone Group. This would appear to have some significance. The fault probably guided the pre-glacial drainage.

[2] The deepest spot is located slightly over half a mile almost due north of Cloyaduff Point.

[3] *A fortiori* would this be the case if the bed of the valley, like that of the Liffey or Lagan were below sea-level; the pre-glacial floor of the Liffey is about 30 feet below sea-level (Mem. Geol. Surv., Geology of the Country around Dublin (1903), p. 89), that of the Lagan, about 200 feet. (Mem. Geol. Surv., Geology of the Country around Belfast (1904), p. 64.)

along the western coast, e.g., among many others, the Clady, Gweedore, Ballaghdoo and Eske Rivers.[1] The rivers of Sligo show the same features. To this the Erne can be no exception, and if a buried channel exists south of the present line, it would seem that it must also possess rejuvenated characters.

The drainage system of the Sperrin Mountains presents many anomalies. As already elaborated, the retreating Donegal ice-sheet, abutting against these hills, shut the natural exits to the north, and barred all direct egress of the drainage. The channels, excavated by the glacially-derived streams, have in several cases been cut to such a depth as permanently to divert and influence the plan of the drainage of the hills. The course of the normal drainage is generally to the north-west; that of the glacial overflow channels is in almost all cases north-eastwards.

A notable example of this aberration is furnished by the Finglen River. This river, instead of pursuing its course straight forward to Fincarn down the wide and open valley of the Sruhan Meenard river, to which it obviously belongs, swerves sharply to the east through the narrow, gorge-like valley of the Cushcapal Water, finally falling into the deep glen of the Owenrigh River. This diversion is aided by the morainic accumulation in the floor of the major valley.

Among other very good instances may be cited the Glenrandal River, diverted near Stranagalwilly, and the Ballydonegan River, west of Mullaghash.

These anomalous drainage lines of the Sperrin Mountains are therefore vestigial inheritances of the glacial period, the streams remaining in occupancy of glacial marginal channels.

Running to the west of Bessy Bell and between this hill and Mullaghcroy on the west, is a very large depression in which are situated the park and ducal house of Baronscourt. It is wide and flat-floored, with very little fall (about 6 feet in three miles), while drift occurs against its sides and on its floor. Its present stream is small and wholly incapable of excavating such a large feature. The valley is undoubtedly pre-glacial in origin.

The valley of the Strule River from north of Mountjoy to Newtown Stewart is in places a rock gorge, and in general so narrow as to forbid the supposition that this was the ancient course of the northward-flowing drainage.

The ice shrinking westward along the broad flat of the Fairy Water, as already shown, impounded the drainage of the high land of Mullaghcarn and

[1] The waterfalls and deep gorges exhibited by the streams flowing into Lough Foyle down the eastern slopes of Inishowen would also seem to be due to rejuvenation.

the country to the south of Omagh, producing a lake of uncertain extent, which extended over a considerable area south of Omagh and drained by the valley east of Bessy Bell. Most probably two not inconsiderable valleys existed pre-glacially on this line, the one falling southward, the other northward, the latter tributary north-west of Newtownstewart to the main stream flowing along the Baronscourt valley. The contour of the country is suggestive of such a stream arrangement.

The glacial flood waters lowered the watershed and deepened the valley to such an extent that by the time the ice had shrunk sufficiently westward to uncover the mouth of the Baronscourt valley, the floor of the Strule valley was below the critical level of the intake of its western neighbour. Hence the westward withdrawal of the ice could not affect the new direction of drainage, and a resumption of the earlier line of flow was in consequence rendered impossible.

The Fairy Water winds its way over an extensive boggy and alluvial flat, varied only by a number of irregularly-shaped morainic mounds. It would seem that pre-glacially the drainage of the area south of Omagh found its way westward along this flat plain to the Baronscourt valley, and that over this stretch of the Fairy Water a reversal of drainage direction has taken place; the present Fairy Water enters the Strule River with its entrant angle acute up stream, though this anomalous confluence is largely the result, as already pointed out, of the obstruction offered by the Mountjoy moraine.

The great morainic accumulations and associated fluvio-glacial deposits at the head of Barnesmore Gap have altered the course of the Barnes River. This stream would seem to have originally passed into the broad and open valley now occupied by the Mourne Beg River; this old course being blocked by the moraines, the river has been diverted into Barnesmore Gap.

The Culmore stretch of the River Foyle below Londonderry is cut in rock. It was possibly initiated and to some unknown extent carved out by sub-glacial streams, and later by waters streaming from the ice-front. A buried valley of uncertain depth would seem to run beneath Lough Eanagh to the east of this, and may be the pre-glacial course of the River Foyle.

Post-glacial denudation has on the whole effected so little that almost all the details of the present surface are due to ice action, either erosive or accumulative. The remarkable freshness of the striated and polished surfaces, the preservation in their original form of the coastal gravel-spreads bordering Lough Foyle, and of the drumlins of Donegal and the moraines of Fermanagh and Tyrone are, in view of the incoherence of the deposits, eloquent of the recency of their formation. Changes have been chiefly confined to the formation of talus slopes, the deposition of deltaic fans, and the erosion of small gorges in "solid" and in drift materials.

The greatest modification of the scenery has been the production of landslips, the finest of which tower before Benevenagh. They were produced in post-glacial times. Their pre-glacial predecessors, which probably rose up the cliff almost to its summit, were doubtless summarily swept away by the great ice masses which streamed northward out of the Foyle. These, by the erosion of the soft Triassic and Liassic strata, over-steepened the cliff face, so that almost immediately after the removal of the pressure of the ice, consequent upon the retreat, the insufficiently-supported, unstable, and heavy superstructure of basalt was precipitated into the valley.[1]

The slips resting against the face of Shean North (locally known as Magho), rising from the shores of Lough Erne, are similarly the product of post-glacial erosion, caused by the removal of the pre-glacial material, the glacial steepening of the sides, and the erosion of Lough Erne.

X.—Some General Considerations.

Nowhere in Donegal or in the north-west of Ireland were signs of the melting *in situ* of stagnant ice observed; on the contrary, as the marginal drainage phenomena and the arrangement of the moraines most conclusively show, with the single exception of the Lough Erne area, where the manner of disappearance is somewhat obscure, evidence of a constant recession of moving glaciers in active continuity with the great centre of dispersal was everywhere obtained.

The severe glaciation to which the north-west of Ireland has been subject has produced by erosion and deposition profound modifications in the topography and physical relief. Over the greater part of the area the ice drowning the hills from top to bottom was powerful and capable of free outward movement. The mountain tops and ridge summits are characterized by beautifully-rounded outlines, e.g., the Barnesmore and Derryveagh mountains; crags and projecting bosses have had their asperities removed, while the flanks and summits have been dressed and rounded. By ice-moulding the valleys of the upland region have been simplified, widened and deepened, their profiles reduced or modified, and the ends of their projecting spurs destroyed by lateral erosion with the evolution of straightened and steep-sided valleys. These are prevalently trough-shaped, especially in the granite and mountainous region, or wide and open in the country composed of schist.

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[1] This slipping was regarded by J. R. Kilroe as intermediate in age between his second and third glaciations (*op. cit.*, B.N.F.C., p. 652).

The ice caused the removal of the loose *débris* which had accumulated in pre-glacial times as talus slopes at the foot of the inland cliffs, and of the local sub-soil formed by the disintegration of rock *in situ*. This material, carried on to the peripheral plains, choked the valleys and served as a mask, obscuring and obliterating the inequalities in the surface. This suggests that prior to the period of glaciation the dependence of the contour of the country on its geological structure was closer than at present, and its relief considerably more pronounced. Yet in many areas, where rocks of varying resistance crop out, glacial action has greatly accentuated the differential effect on the physical features, e.g., in the Glenalla and Rathmullan areas.

It is not my purpose here to discuss at any length the perennial question, "does ice erode?" but to state as concisely as may be the impressions formed during this glacial investigation. The valleys of N.-W. Ireland are demonstrably, like those of N.-E. Ireland, post-Eocene. They cut through the basalt dykes of Derryveagh and the Barnesmore granite of Tertiary age.[1] They possess in the Donegal hills hanging tributary valleys, and exhibit typical U-shaped cross-sections. These the writer regards as rejuvenation features produced anterior to the glacial period and modified only by ice erosion.

A coastal strip of varying width and of an average altitude of about 200 feet, O.D., or rather less, fringes Donegal on the north and west. This plain is well seen in the area of the River Erne below Belleek; it skirts the eastern shores of Donegal Bay, where it is largely covered with drumlins, and forms all the floor of the amphitheatre in which lies Lough Eske, extending to the foot of the schist hills north of this lake; it is very well developed over the country north of Ardara, running inland to Glenties and the mouths of the valleys of the Shallogan and Owenea rivers; to it belongs the whole of the Rosses, where it is bounded on the east by the fall-line passing by Crolly; it extends bay-like up the Gweebarra depression and includes the flat country stretching inland from the northern coast almost to the foot of the Derryreel Ridge, and from Sheephaven almost as far as Glenveagh.

This plain is not due to differential weathering; it cuts across all boundaries, and affects Carboniferous rocks, schist and granite; the two strongly-contrasted types of scenery of the Donegal granite country, the mountainous Derryveagh on the one hand, and the low reliefless Rosses on the other, cannot be explained by this process.

This country is a peneplain into which, as the result of late-Tertiary uplift,

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[1] Compare the argument of Sir A. Geikie (Ancient Volcanoes of Great Britain, vol. ii, p. 459).

the rejuvenated rivers, e.g., Gweedore, Eske, Erne, etc., have cut deep gorges. With this coastal peneplain—probably because of the steepness in places of its inner margin to be regarded in part as a plain of marine denudation—were graded the floors of the deep U-valleys. These have profoundly dissected an older surface several hundreds of feet higher than their floors and the level of the coastal plain. To this older rejuvenation is in the main to be attributed the size and to a less extent the form of these striking valleys.

The largely non-glacial origin of these features is also clearly to be seen in the case of the Glengesh Plateau. Here there occurs at least one great U-valley, that of the Owenwee River, cut into the northern face, which lay obliquely, roughly 70° or 80°, to the direction of ice-flow. As a great press of ice was passing westward along the face of the Plateau and across the mouth of the valley, little ice motion can have taken place in the deeper layers along the length of the valley. Though indistinguishable in form from the other U-valleys of Donegal, this depression cannot in consequence have been seriously modified by glacial erosion.

Yet were the U-valleys now perfectly graded to the coastal plain, some glacial erosion may nevertheless have taken place, for this plain has itself been lowered, though by how much is indeterminate; in view of the soft (e.g., schist and Carboniferous rocks) or greatly jointed (e.g., granite) character of its rocks, it may be not inconsiderable.

The floors of the U-valleys are, however, no longer graded to this plain; Glenveagh clearly illustrates this. Lough Veagh is a rock basin carved out of the floor of the valley to a depth of 139 feet;[1] the islands at its lower end are *roches moutonnées,* while granite can be traced completely across the valley of the Owencarrow River. In this glen, glacial over-deepening of some 200 feet would appear to have taken place, though the amount of fresh and hard rock, unweakened by pre-glacial disintegration, may be somewhat less. The other large lakes of this highland region are similar rock basins, proving glacial erosion in these valleys of approximately the same extent. They are largely confined to the valleys of the hilly tract, where the erosive power of the ice was greatest; where the valleys open out, the erosion diminished, and the over-deepening was lessened in amount.

It is significant that in the valley of the Gweebarra River, where free outward motion of the ice was, in general, impossible, on account of the glaciers streaming from the Barnesmore Hills, no rock basin has been produced; the shallow Lough Barra is held up by morainic accumulations.

Hence, apart from the excavation of these basins, comparatively little

[1] Mem. Geol. Survey, Sheets 3, &c., p. 10.

deepening of the valleys has taken place. They have been merely moulded, the gradient modified, the spurs truncated or blunted—though those in the narrow glens of the granite region can never have been very pronounced—and the sides straightened and somewhat over-steepened. This view of the comparatively slight glacial erosion of the U-valleys is in general agreement with that of Professor J. W. Gregory, which he based on observations on the valleys of Arran and North Wales.[1]

Lough Eske is likewise a rock basin, for Carboniferous rocks can be traced all round its shores. Its maximum depth, which I have ascertained by a careful sounding of the lake, is $101\frac{1}{2}$ feet; its surface is just 100 feet above sea-level. Its existence is to be chiefly ascribed to ice erosion.

Lough Erne also owes its existence to glacial scooping which, neglecting late and post-glacial infillings, has carried the floor to a maximum depth of 77 feet below sea-level.

Though many of the smaller Donegal lakes are due to the impounding of drainage by drift accumulations, more especially in the schist country and the peripheral area of deposition, some being certainly so held up entirely, others only partially so, and though the origin of many others, as Lough Garton in the Crohy peninsula and to some extent Lough Salt, may be attributed to solution of soluble limestone, either metamorphic or carboniferous, great numbers are doubtless true rock basins.

Though the excavation of some of these hollows is indubitably due to grinding, others are as certainly the result of plucking, e.g., the lakes of the Rosses. The result of this operation is very well seen in the case of Lough Magrath Beg (S. of the Owen River). Here the schist beds, dipping at high angles (about 70°) to the north-east, were ripped off by the Barnesmore ice flowing roughly at right angles to the line of strike, the successive plucking causing the continued eastward retreat of the eastern end of the hollow in which the lake now lies. In similar fashion, great masses of the steeply-dipping quartzites of Errigal have been carried away and the southern and western flanks considerably over-steepened.

This erosion has been greatly facilitated by the contact of rocks possessing different powers of resistance to erosion. Many junction lakes have so arisen; of these, the finest is, perhaps, that of Lough Nabrackbaddy, where schist and diorite are in contact, the former being situated on the lee-side. The glaciers have readily eroded the relatively softer schist, the harder diorite, on the contrary, persisting as a pronounced ridge overlooking the lake.

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[1] The Pre-glacial Valleys of Arran and Snowdon. Geol. Mag., vol. lvii (1920), pp. 145–164.

A number of corrie-like depressions occur in Donegal, placed laterally, and in a hanging position, on the sides of the major U-valleys. They are independent of the structure and nature of the country rock, though chiefly occurring in the granite and quartzite areas, as these form the greatest elevations. They face all points of the compass, including south, south-west, and south-east (e.g., those in the sides of the Gweebarra depression and the hollow in the S.-E. face of Slieve League), though the majority face N. or N.-E. Traces of lingering ice in these recesses are remarkably scanty; with the possible exception of the drift ridge at the mouth of the eastern depression in Slieve League—a ridge totally insignificant in size as compared with the recess behind—no true moraine was noted in connexion with these features. Certain ridges observed at the mouths of some of these when closely examined are seen to be "solid" and indicative of erosion behind them. In the absence of moraines these great hollows are clearly not to be attributed to late-glacial erosion. They lack, moreover, the sharp and serrated edge along their upper rim, which, with the single exception of Slieve League, is invariably beautifully rounded and covered with striae and *moutonnée* forms. The rounding is in all cases due to ice pouring into the hollow over the top of the bounding wall. As magnificent instances of corries, showing the smooth and rounded rims curving into the back of the recess, may be cited the huge amphitheatre, about three miles south-west of Ardara, the two recesses in which lie Lough Croagh-ballaghdown and Lough Adoochro respectively, in the Slievetooey Hill, the depression containing Glentornan Lough, and Lough Belshade in the Barnesmore Hills. As this rounding took place during the maximum phase, and as corrie moraines are absent, it would appear that these depressions must be either pre- or early-glacial features, moulded by the plunging glaciers of the maximum period.

The altitude of the floors of these depressions varies somewhat over the region, the highest being about 1,000 feet above sea-level, the lowest some 500 or 600 feet. Like the U-valleys, they are modified rejuvenation features, running into the hills from the higher peneplain. They have been widened and deepened by glacial erosion, acting chiefly during the maximum stage, though, in the case of the cirques, most probably also by the corrie glaciers of the earlier stages of the glaciation. Any arrêtes so produced, however, would be rounded by the plunging ice, any morainic mounds and ridges transported far beyond the mouth of the corries. In this way they differ from the cwms of Snowdonia, where the corrie stage persisted throughout the glacial period.

The absence of corrie moraines, except in Slieve League, and the perfect state of preservation of the striated surfaces produced at the maximum phase, would seem to prove the shortness, or possibly entire absence, of a late-glacial corrie period, and the rapid melting of the ice and passing away of glacial conditions.

Slieve League is only a partial exception to these general statements. Its two recesses, the one on the northern flank and containing Lough Agha, the other on the southern side, with Lough Croleary nestling in the bottom, are rejuvenation features, which were occupied in early- and possibly in late-glacial times by corrie glaciers. Above the wide cirque on the southern side extends a fairly sharp, steep-sided and serrated ridge, the "One Man's Pass," the one ridge to be found in Donegal which even remotely resembles an Alpine arrête. The presence of this feature is to be explained by the fact that Slieve League, though buried under its own ice, was probably never completely overridden by extraneous ice. The asymmetry of the ridges, noticeable in countless cases in Donegal, is only in small measure to be ascribed to glacial erosion, as desk-structure has played a far more important rôle.

The preceding considerations suggest glacial erosion on only a moderate scale. Uncertainty as to its amount is introduced by inability to give a value for the glacial degradation of the coastal peneplain, and by the great difficulty of ascertaining the pre-glacial gradient of the valleys originally accordant with this feature.

That glacial erosion under certain conditions is almost negligible is suggested by the cross-striations on Croaghleconnell, also by the preservation of the striae on Doagh Island, which have been regarded as relics of the earlier Scottish glaciation. The preservation intact of an older drift in the valleys south of the Foyle estuary, despite the passage of the Donegal Ice, would seem to confirm this view.

Of true fiords there are in the north-west of Ireland but two—Mulroy Bay and Lough Swilly. Though they are comparatively shallow features, the distribution of their depths demonstrates glacial modification.

Mulroy Bay is practically an inland lake, connected with the sea by a tortuous channel which, between the peninsulas of Rosguill and Fanad, is 9 fathoms deep, though on the seaward side its maximum depth decreases to 2 fathoms. It likewise shallows southwards towards the Narrows, where it is only some 350 yards across, and 2 fathoms deep. Farther up, where the inlet widens, the floor again sinks to 14 fathoms (N.-E. of Cranford). A deep pool of 10 fathoms lies still farther south (S.-W. of Carrowkeel), and is bounded on the north by a ridge covered by only 2 fathoms of water.

Though drift undoubtedly obscures the real depth to the rock-floor, the deeper parts most probably represent true rock basins scooped out by the ice as it ploughed its way northward down the valley. These three deep basins, 10, 14, and 9 fathoms deep respectively, are situated just where the three quartzite ridges of Knockalla, Croaghnadownies and Rosguill are severed by the fiord. There would appear to be a third such depression on this line, namely, that underlying Lough Fern and now largely filled with drift material. Milford stands on a rock bar.

The Admiralty chart of Lough Swilly shows the existence of deeper isolated basins separated from each other and from the deeper sea by shallow bars. These deeper pools are located not, as might perhaps be expected, in the areas underlain by the softer schist, but just where the constrictions in the fiord take place, i.e. where the hard quartzite ridges strike obliquely across the lough. There are two such deep places marking the positions of greatest erosion, the more southerly forming the deep channel between the quartzites of Rathmullan and of Inch Island, the more northerly lying where the quartzite ridge of Knockalla is broken across by the Swilly. In the former, a maximum depth of 11 and several soundings of 10 fathoms are recorded. South of the line of the Knockalla ridge the depth decreases to 6 fathoms. Yet along the Knockalla line a string of 10-fathom soundings is charted, to the north of which the floor again rises to within 6 fathoms of the surface.

XI.—Summary of Conclusions.

In the north-west of Ireland there is unmistakable proof of a severe and wide-spread glaciation; its successive phases just passed in review, and some of the more general conclusions drawn from this study, may be briefly summarized.

The earliest phase of the glaciation is represented by the advance of ice from the east over the easterly part of the region, i.e. Inishowen, the western portions of the counties of Londonderry, Tyrone and Monaghan. This ice of the earlier Scottish glaciation did not override the whole of North Ireland. Its western limit, assumed as coincident with that of the dispersal of erratics from exclusively eastern sources, such as chalk, chalk-flint, Antrim basalt, and Scottish rocks, e.g., the Ailsa Craig paisanite, is given by a line running along the lower reaches of Lough Swilly to Inch Island and Londonderry, across the northern foot-hills of the Sperrin Mountains, east of Draperstown, and south-westerly across County Tyrone to Slieve Beagh and County Monaghan (Pl. IX). The re-entrant angle in this line, formed by the Sperrin Mountains, is probably to be ascribed to obstruction offered by a local ice-cap crowning these hills at this period.

Pene-contemporaneous with or of slightly later date than this glaciation was a radiation centred chiefly in the Barnesmore Hills and the mountains stretching in a south-easterly direction to Lough Derg, though extending also to the north-west, and at a somewhat later stage linking up with the glaciers of the Sligo hills and forming a huge pool of ice over the intervening depression of Lough Erne. Its lines of ice-flow were roughly coincident with the trend of the major valleys. Its confluent glaciers extended to the Atlantic and Donegal Bay on the west, suffering deflection by the Glengesh Plateau and the Derryveagh Mountains. They spread over the drainage basins of the Finn and Foyle, and down Lough Foyle and Lough Swilly; over Inishowen, the Sperrin Mountains, and Slieve Gallion, and down the valley of the Bann; across the plains of Tyrone to Lough Neagh and beyond; over the Fintona Plain, the Clogher valley, and Slieve Beagh, and up the valley of the Erne to the Central Plain.

There was no axis of dispersion along the line running north-east from the Erne valley to Lough Neagh and the Antrim coast as suggested by E. Hull, though the Sligo hills to the west most clearly acted as a radiation point.

Boulders of the Donegal, Barnesmore and Tyrone granites serve as the chief indicators of the lines of ice-flow from the Donegal centre. Those of the Barnesmore granite occur across north-west Ireland from sea to sea, from the southern extremity of the St. John's Peninsula in Donegal Bay to Inishowen Head, at the mouth of Lough Foyle, a distance of 77 miles; they cover an area of over 1,200 square miles. (Fig. 1, p. 219.)

The retreat of the Donegal ice is most clearly marked by moraines and marginal drainage channels; these connected with great numbers of extra-glacial lakes ranging up to some thirty-three square miles in surface extent and fifteen miles in length.

The wide valleys of the Sperrin Mountains were the sites of large glacier lakes, which drained by overflow valleys cut across spurs and cols, and which were successively thrown out of action by the continuous retreat of the ice. The withdrawal (Pl. VIII) was affected by a shrinkage off the highest peaks and the main watershed, an occasional extra-glacial lake being formed continuous over the cols. More rapid retreat on the northern flanks caused a drainage, northward across the cols, of lakes impounded in the deep recesses on the southern flanks. The waters from both the northern and southern sides of these mountains were carried into a lake, held up by ice standing along the Foyle side of the great basalt escarpment stretching south from Benevenagh to Benbradagh, the drainage finally escaping along the face of the former mountain. (Stage 1, Pl. VIII.)

Further retreat produced a series of large lakes standing at a lower level. Those on the southern side of the watershed, e.g., "Lake Glenelly," discharged by large overflows into the Moyola River, those on the northern side into the River Roe; these two systems of drainage were at this stage quite distinct. (Stage 2. Pl. VIII.)

With continued recession, the lakes on the southern side, e.g., "Lake Gortin" and "Lake Glenelly," drained by a large transverse valley—the "Inver Channel"—into similar lakes impounded on the northern side, e.g., those filling the valleys of the Burntollet and Faughan. This great connecting channel continued in operation during the whole of the remaining phases of the retreat from the Sperrin Mountains, so that all the drainage from the ice-free area on the north and south side of these hills and the melt waters from some forty to fifty miles of ice-front were carried into the Foyle estuary by the large valleys of Gortnessy and Burngibbagh. (Stages 3 and 4, Pl. VIII.)

The progressive recession of the ice along the country south of the Sperrin Mountains is displayed by the magnificent series of moraines which swing across the plains of Tyrone. The ice, spread over the country to the east, withdrew in the main behind the Beleevnamore Range and along the "Omagh-Draperstown Corridor"; the morainic ridges and mounds formed along the ends of the lobes, thrust through gaps in the Beleevnamore Range, are exceptionally well developed (Pl. IX).

The retreat from the southern region is marked by a succession of great morainic belts with outwash fans of gravel, the finest forming the tract of billowy country extending from Cookstown to Donaghmore and the south-west.

The ice withdrew northward off the Slieve Beagh hills, depositing moraines and impounding the drainage, its surplus waters escaping by a number of very fine valleys falling generally eastward or north-eastward. It retreated in a north-westerly direction to the Fintona hills, maintaining a bold, curving front, swinging obliquely along the Clogher valley, and throwing down its material as broad morainic belts. A series of very fine moraines marks the recession of the ice behind the Brougher Mountain Range of Fermanagh, while the mode of retreat off the Fintona hills is brought out by magnificent morainic mounds and ridges and marginal drainage phenomena. The most important overflow channel of this series traverses the range, south of Seskinore: it carried the whole of the drainage from many miles of the melting ice-front and from the ice-free hills stretching away to the east as far almost as Pomeroy.

The manner of the retreat of the ice along the Fintona Plain is shown by the morainic ridges spanning the depression, while similar features mark the successive halts in the recession of the Drumquin glacier.

The ice shrank off Inishowen to form two powerful glaciers—the one in occupation of Lough Foyle, the other of Lough Swilly; the withdrawal of these glaciers is indicated by marginal channels and morainic mounds, the largest lake—"Lake Mintiagh"—being held up in the great recess to the north-east of Buncrana. A similar withdrawal uncovered the smaller peninsulas farther west, and caused the formation of a series of glaciers in occupation of the larger depressions, e.g., those of Mulroy Bay and Sheephaven; the Gleuveagh glacier was the shrunken remnant of the latter.

The ice which buried the extreme north-west retreated southward along the Rosses, one of its principal feeders parting from it to the west of Gweedore to form the Dunlewy glacier, which shrank eastward to Dunlewy and the Poisoned Glen.

The great masses of ice, covering the Derg, Finn and Foyle country, split into a couple of large glaciers; the southern one, in occupation of the Derg valley, withdrew westward up the valley, passed Castlederg and Killeter to Lough Derg; the larger lobe shrank into the valley of the Finn, in its earlier retreat impounding in the Deele valley a large lake, the history of which has been clearly traced. (Fig. 3.)

Moraines in the Barnesmore Hills and Derryveagh Mountains represent the last stages in the waning of the Donegal ice-sheet.

While the Donegal Ice still lingered over the country south of Londonderry City, and skirted the western foot of the Sperrin Mountains, and while the "Burngibbagh channel" was still in operation, the Scottish Ice re-advanced along the northern coast. It thrust a large lobe into the mouth of the Foyle estuary and converted this into a lake, which drained by the valley running north-westward from Londonderry to Lough Swilly. The great gravel-spread skirting the southern shores of the estuary is, in part, the terrace of this large "Lake Foyle."

The effect of the glaciation was in the main to soften the relief, though in places it emphasized the surface features. Rock basins abound, especially in the large valleys of the Donegal hills, e.g., Lough Veagh, Lough Glen and Alton Lough. Lough Eske and Lough Erne are hollows scooped out of a Tertiary coastal peneplain.

The U-valleys of the Donegal Highlands owe their origin to a Tertiary uplift and rejuvenation. Glacial erosion has somewhat modified their form, having altered the gradients, widened, over-deepened and over-steepened the valleys, and blunted or truncated their spurs. The corries are likewise pre-glacial in date, their outlines having been merely modified by glacial erosion, possibly by early glacial corrie glaciers, more profoundly by the plunging ice of the maximum phase. There was virtually no late-glacial corrie period.

In conclusion, I wish to express my thanks to the Geological Society of London for the Daniel-Pidgeon award, made in the year 1916 to further this research; to my brother, George K. Charlesworth, for assistance in many ways; to Mr. W. B. Wright and Dr. A. R. Dwerryhouse, for helpful criticism and suggestions; and, above all, to Professor P. F. Kendall, for his inspiring lectures on Glacial Geology, both in the lecture-room and in the field, and for the great interest he has invariably evinced in the progress of this research.

DESCRIPTION OF PLATES VIII AND IX.

Plate VIII.

Map, showing the chief glacier-lakes and overflow channels in existence at four of the more important stages during the retreat of the ice-sheet off the Sperrin Mountains.

Scale: 5 miles = 1 inch (1 : 316,800).

Plate IX.

Map, illustrating the salient features of the Glaciation of N.-W. Ireland; the western limit of the Scottish Ice; the lines of ice-flow over the whole region from the Barnesmore centre of radiation and the Donegal Ice shed; the distribution of the Barnesmore granite boulders; the distribution of the shelly drift (S); the location of the superimposed boulder clays, eastern and western (asterisk); the positions of the moraines and overflow channels; the re-advance of the Scottish Ice.

Scale: 5 miles = 1 inch (1 : 316,800).

GLACIAL GEOLOGY OF NORTH-WEST IRELAND.
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MAP ILLUSTRATING —
THE GLACIAL GEOLOGY OF NORTH WEST IRELAND
— BY —

PROFESSOR J. KAYE CHARLESWORTH, D.Sc Ph.D, M.R.I.A, F.G.S

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XIII.

DICHROMONE AND DIBENZYLDICHROMONE.

BY JOSEPH ALGAR, D.Sc., FRANCIS FOGARTY, M.Sc.,

AND

HUGH RYAN, D.Sc.,

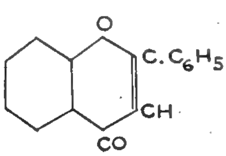
University College, Dublin.

[Read FEBRUARY 11. Published SEPTEMBER 15, 1924.]

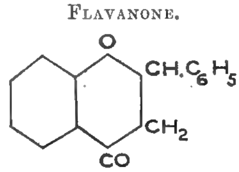
THE study of vegetable colouring matters during the past twenty-five years has shown that many of these are related in structure, and may be referred to the same parent type.

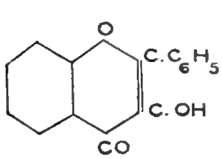
Chrysin, apigenin, lotoflavin, luteolin, and scutellarein are all derived from flavone; butein from flavanone; and kaempferid, kaempferol, galangin, quercetin, rhamnetin, rhamnazin, fisetin, morin, myricetin, gossypetin, and quercetagetin from flavonol. Again, the three substances, flavone, flavanone, and flavonol, may in turn be regarded as derivatives of chromone:—

FLAVONE.

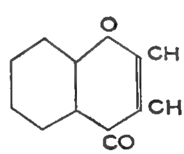


FLAVANONE.



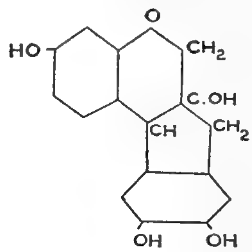


FLAVONOL.

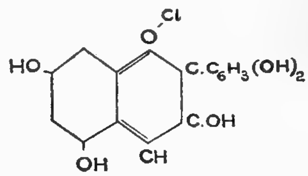


CHROMONE.

Euxanthone and gentisin are derived from a benzochromone and brazilin from a reduced chromone. Similarly, cyanidin, delphinidin, and pelargonidin, the chief tinctorial constituents of the anthocyan pigments, may be referred to a dihydrochromone :—

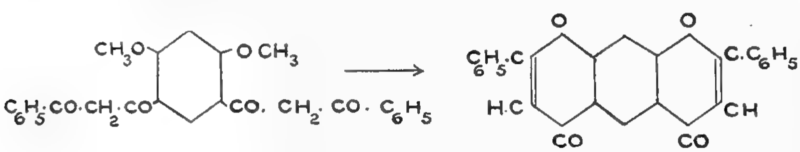


BRAZILIN.



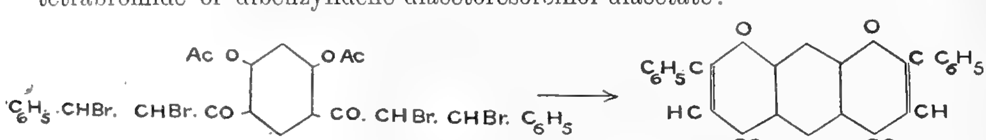
CYANIDIN CHLORIDE.

Attempts to prepare substances related to these colouring matters were made by H. Ryan and P. O'Neill (Proc. Roy. Ir. Acad., xxxii. B, pp. 48, 167). By condensing diacetoresorcinol-dimethylether with ethyl benzoate they obtained dibenzoylaceto-resorcinol-dimethylether, which was converted by hydriodic acid into diflavone :—

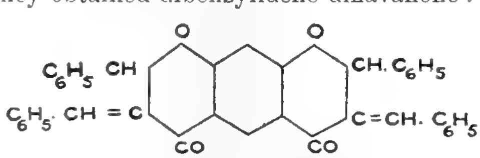


DIFLAVONE.

Diflavone was also obtained by the action of alcoholic potash on the tetrabromide of dibenzylidene-diacetoresorcinol-diacetate :—

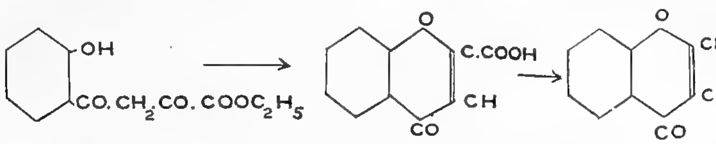


Although none of the four condensation products which they obtained from diacetoresorcinol and benzaldehyde appeared to be diflavanone, derivatives of the latter substance were formed by the action of aldehydes on the ketone in the presence of hydrochloric acid. Thus from benzaldehyde and diacetoresorcinol they obtained dibenzylidene-diflavanone :—



In 1916 one of us (J. Algar, Proc. Royal Irish Acad., xxxiii, B, p. 8) attempted to prepare dichromone by methods similar to those which had been already employed by von Kostanecki and his co-workers for the preparation of chromones.

Thus Heywang and von Kostanecki (Ber. Dtsch. Chem. Ges., xxxv, 1902, p. 2887) obtained chromone by the action of hydriodic acid on the diketone formed by the condensation of diethyl oxalate with o-hydroxy-acetophenone :—



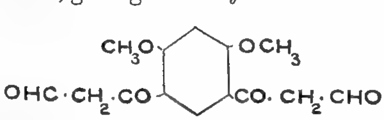
When diacetoresorcinol was employed instead of o-hydroxyacetophenone in this reaction, no indication of the formation of a diketone was, however, obtained. Diketones were, on the other hand, formed by the condensation of diacetoresorcinol-dimethylether with the esters of acetic, oxalic, and phenylacetic acids ; but the yields of these were so small that it was not practicable, at the time, to convert the diketones into the corresponding dichromones.

We have again prepared diketones of this type, but, as before, in very small yields, and it was only with considerable difficulty that we were able to obtain sufficient amounts of the substances for our purpose.

When the diketones formed by the condensation of diacetoresorcinol-dimethylether with dimethyl and diethyl oxalates were treated with the usual demethylating agents, hydriodic acid or aluminium chloride, red-coloured products were obtained, from which no pure substances could be isolated. But by prolonged boiling with concentrated hydrobromic acid, each of these diketones was converted into dichromone, and the synthesis of the parent member of the group was effected.

The yield of dichromone was small, the body being accompanied by a green substance, together with resinous products. It consists of light straw-yellow needles, which melt at 176–177° C. Its solution in concentrated sulphuric acid has a light yellow colour and a bright emerald-green fluorescence. The solution of chromone in sulphuric acid is colourless, and has a violet-blue fluorescence.

A second synthesis of dichromone was effected by means of ethyl formate and diacetoresorcinol-dimethylether. In the presence of metallic sodium these substances condensed, giving diformylaceto-resorcinol-dimethylether :—



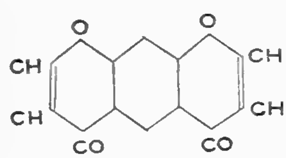
And when the latter body was heated with concentrated hydrobromic acid, it formed dichromone.

Dibenzyl-dichromone was prepared by boiling di-α-phenylacetyl-aceto-resorcinol-dimethylether with concentrated hydriodic acid. Its yield was better than that of dichromone, the substance being less contaminated by impurities. It consists of yellowish-white prismatic needles, which melt at 223–224° C., and give a faint yellow solution in sulphuric acid, with a well-marked heliotrope fluorescence.

Experimental.

A.—*Dichromone.*

Dichromone was obtained by the action of hydrobromic acid on the methyl and the ethyl esters of dimethoxyisophthaloyl-dipyruvic acid, on the one hand, and on diformyl-aceto-resorcinol-dimethylether, on the other hand.



I. A mixture of 2 g. of methyl dimethoxyisophthaloyl-dipyruvate and 80 c.c. of hydrobromic acid (sp. g. 1·46) was heated to 126° C. for 8 hours. On addition of the reaction product to a concentrated solution of sodium bisulphite a dark-coloured tarry precipitate was obtained. The mixture was extracted with chloroform, and the chloroform solution was dehydrated over anhydrous potassium carbonate. A greenish residue was obtained by evaporating the chloroform. It was recrystallised twice from a mixture of alcohol and acetone; but this treatment was insufficient to separate it from a green dye with which it was intimately mixed. When, however, ether was added to a chloroform solution of the mixture a colourless substance was precipitated. This substance, which proved to be dichromone, was re-crystallised from alcohol. It melted at 176–177° C., and gave on analysis the following results:—

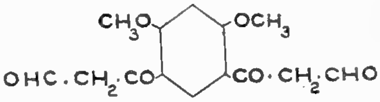
0·1739 substance gave 0·4281 CO_2 and 0·0438 H_2O,
corresponding to C 67·14, H 2·8.
$C_{12}H_6O_4$ requires C 67·10, H. 2·8.

Dichromone crystallises in long straw-coloured silky needles. It is scarcely soluble in ether, light petroleum, or ligroin; sparingly soluble in benzene, xylene, carbon disulphide, or cold alcohol; and readily soluble in hot alcohol, chloroform, or acetone. It is insoluble in cold aqueous alkali, but is decomposed by hot alkali. Its solution in concentrated sulphuric acid has a faint yellow colour, and an intense emerald-green fluorescence. This fluorescence is much impaired by the presence of even a small amount of impurity. An alcoholic solution of dichromone gives no colouration with ferric chloride, whereas the original diketone gives a brownish-red colouration with that reagent.

II. Ethyl dimethoxyisophthaloyl-dipyruvate when heated for several hours with concentrated hydrobromic acid also formed dichromone, which was isolated and purified by the method described in the last experiment.

The dipyruvic esters required for these experiments were prepared by the method already described by one of us (J. Algar, Proc. Royal Irish Acad., 1916, xxxiii, B, pp. 89–90).

III. (*a*) *Diformylaceto-resorcinoldimethylether.*

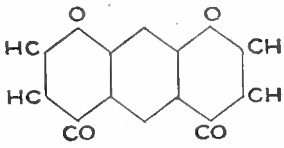


A mixture of 6 g. of diacetoresorcinol-dimethylether and 70 c.c. of ethyl formate was heated to 50° C. and 4·8 g. of sodium wire was added. A vigorous reaction ensued, and when this had subsided the mixture was heated to 85–90° C. for half an hour. A small quantity of ether was added and the mixture allowed to remain for twelve hours. It was then mixed with a further quantity of ether, and water was added until a clear dark red aqueous layer was obtained. On passing a current of carbon dioxide through the aqueous alkaline solution a light yellow solid was precipitated. This solid was filtered, washed with water, dried and crystallised first from a mixture of acetone and alcohol, afterwards from carbon tetrachloride. It melted at 98° C. and gave on analysis the following results :—

0·3083 substance gave 0·6826 CO_2 and 0·1387 H_2O,
corresponding to C 60·38, H 5·0.
$C_{14}H_{14}O_6$ requires C 60·43, H 5·0.

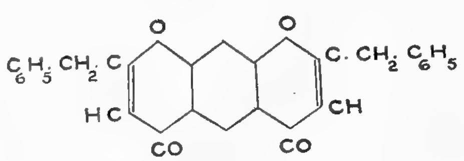
Diformylaceto-resorcinol-dimethylether crystallises in light yellow prismatic plates, melting at 98° C. It is sparingly soluble in ether, petroleum ether, ligroin or cold alcohol, and readily soluble in hot alcohol, chloroform, acetone, or carbon tetrachloride. In alcoholic solution it gives a deep red colour with ferric chloride. Concentrated sulphuric acid colours the crystals orange red, and they dissolve therein to a deep red solution.

(*b*) *Dichromone.*



Two grammes of diformylaceto-resorcinol-dimethylether were heated with 80 c.c. of hydrobromic acid (s. g. 1·46) to 126° C. for two and a half hours. The reaction product was poured into sodium bisulphite solution, and a tarry mass was precipitated. The solution was extracted with chloroform, and the chloroform solution was separated and dehydrated over anhydrous calcium chloride. On evaporation of the chloroform, a somewhat tarry amorphous solid was obtained. This was dissolved in absolute alcohol, and the solution was evaporated to one quarter of its volume. A whitish substance separated, which was crystallised from a mixture of chloroform and alcohol. This substance crystallised in straw yellow needles, melting at 176°–177° C., and its faint yellow solution in sulphuric acid showed an intense green fluorescence. A mixed melting-point of this substance with dichromone, prepared from dimethoxy-isophthaloyl-dipyruvic methyl ester, was taken, and the melting-point of this mixture was the same as that of either constituent. In other properties the two substances were also identical.

B.—*Dibenzyl-Dichromone.*



Two grammes of di-α-phenylacetyl-aceto-resorcinol-dimethylether[1] were heated with 40 c.c. of concentrated hydriodic acid (s. g. 1.7) to 135° C. for seven hours. On pouring the reaction product into sodium bisulphite solution, a brown precipitate was formed. The mixture was extracted with chloroform, the chloroform layer was separated and dehydrated over anhydrous calcium chloride. Filtration and evaporation of the chloroform gave a brown tarry mass. This was washed a few times with petroleum ether, and redissolved in chloroform. On adding to the chloroform solution a mixture of ether and petroleum ether (3 volumes of ether to 1 volume of petroleum ether) a dirty white solid was precipitated, which was filtered and dried. This was crystallised a few times from alcohol, and finally from benzene. On analysis it gave the following results :—

0·2049 of the substance gave 0·5945 CO_2 and 0·0837 H_2O
Corresponding to C. 79·13. H 4·54.
$C_{26}H_{18}O_4$ requires C. 79·18, H 4·57.

[1] Diphenyl-acetyl-aceto-resorcinol dimethyl ether was prepared from phenylacetic ester and diacetoresorcinol dimethylether by the method already described [J. Algar, *loc. cit.*].

Dibenzyl-dichromone crystallises in yellowish-white prismatic needles, aggregated into clusters, melting at 223°–224° C. It is insoluble in ether or petroleum ether, sparingly soluble in benzene, xylene, or cold alcohol, and readily soluble in hot alcohol, chloroform, acetone, or carbon-tetrachloride. It is also insoluble in water or cold alkali. With warm alkali it goes into solution, but on further heating a precipitate is formed, indicating decomposition. In alcoholic solution it gives no colouration with ferric chloride. It dissolves in concentrated sulphuric acid to a faint yellow solution, showing an intense violet-blue fluorescence.

C.—*Summary.*

I. Dimethyl oxalate, diethyl oxalate, and ethyl formate condensed in each case with diacetoresorcinol-dimethylether to form a diketone. Each of these diketones was converted by hydrobromic acid into dichromone.

II. Dibenzyldichromone was obtained similarly from the diketone produced by the condensation of phenylacetic ester with diacetoresorcinol-dimethylether.

III. The properties of dichromone and dibenzyldichromone resemble those of chromone, and, like the latter, these substances give a characteristic fluorescence in sulphuric acid solution.

XIV.

THE CONDENSATION OF ALDEHYDES WITH BUTYL-ACETOACETIC ESTER.

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AND

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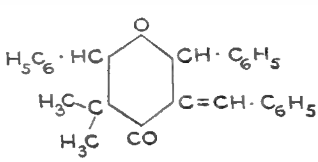
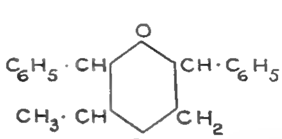
[Read February 25. Published September 15, 1924.]

In 1915, H. Ryan and J. M. Dunlea [Proc. R.I.A., xxx ii, B, 1915, p. 62] by the action of benzaldehyde on dimethyl-acetylacetone, in the presence of alcoholic hydrochloric acid, obtained a crystalline compound melting at 169°C. This body, which was regarded as the benzylidene derivative of a tetrahydropyrone, was afterwards prepared by H. Ryan and P. Ryan [Proc. R.I.A., xxxiii, B, 1917, p. 107] by the condensation of benzaldehyde with methylisopropyl-ketone. The mode of formation of the substance, as well as its behaviour towards bromine and hydroxylamine respectively, indicated that it is a benzylidene-diphenyldimethyl-tetrahyropyrone having the formula:—



An attempt was made by H. Ryan and A. Devine [Proc. R.I.A., xxxii, B, 1916, p. 208] to obtain a similar body by the action of benzaldehyde on methylethyl-ketone. In the presence of alkali these two substances interacted to form the diphenylmethyl-tetrahydropyrone:—



previously described by C. Harries and G. H. Müller [Ber. Dtsch. Chem. Ges., xxxv, 1902, p. 968]. This substance reacted, indeed, with benzaldehyde;

but, instead of forming the benzylidene derivative of the tetrahydropyrone, the condensation yielded a crystalline substance having the empirical formula $C_{25}H_{20}O$. The formation of the latter body from the tetrahydropyrone can be represented by the equation:—

$$C_{18}H_{18}O_2 + C_6H_5 . CHO = C_{25}H_{20}O + 2H_2O.$$

The substance was converted by bromine into a dibromide $C_{25}H_{20}Br_2O$; but, since it reacted neither with hydroxylamine nor with phenylhydrazine, it appeared to contain no keto radical.

H. Ryan and P. Ryan [*loc. cit.*] also obtained this substance by the condensation of benzaldehyde with methyl-acetylacetone in the presence of hydrochloric acid. With a view to throwing some light on the structure of this substance they attempted to prepare a tetrahydropyrone derivative by the condensation of benzaldehyde with ethyl-acetoacetic ester, but the investigation was not continued beyond the formation of a benzylidene-ethylacetoacetic acid.

In the present investigation the behaviour of some aldehydes towards n-butyl-acetoacetic ester was examined, without, however, our succeeding in the isolation of tetrahydropyrone derivatives.

In the presence of dilute alkali butyl-acetoacetic ester interacted with benzaldehyde to form a crystalline unsaturated ketonic acid,

$$C_6H_5CH : CH . CO . CH (C_4H_9) . COOH,$$

which, on more prolonged action, decomposed into the unsaturated ketone,

$$C_6H_5 . CH : CH . CO . CH_2 . C_4H_9.$$

Similar compounds were obtained from butyl-acetoacetic ester and anisaldehyde and piperonal respectively. No doubt the further condensation of these unsaturated ketones with the aldehydes would have yielded tetrahydropyrone derivatives similar to that got from benzaldehyde and benzylidene-methylethyl-ketone. Butyl-acetone, indeed, reacted with benzaldehyde and piperonal respectively, yielding crystalline compounds derived from one molecule of the ketone and three molecules of the aldehyde in each case—condensations similar to those between these aldehydes and methyl-ethyl-ketone.

Experimental.

A.—*Butyl-Acetoacetic Ester.*

$$CH_3 . CO . CH C_4 H_9 . COO C_2 H_5.$$

A solution of 23 grams of sodium in about ten times its weight of absolute alcohol was added to a mixture of 184 grams of re-distilled butyl iodide and 130 grams of acetoacetic ester, and the mixture was heated to boiling, under a reflux condenser, until its reaction was neutral. The precipitated sodium iodide was filtered, and the filtrate, after concentration, was mixed with water and extracted with ether. The solvent was evaporated, and the residual oil was dried with calcium chloride. It was then distilled, and the fraction which boiled above 215° C. was collected apart. On re-distillation the pure ester was obtained as a colourless, oily, sweet-smelling liquid, boiling at 225–226° C. The yield of the pure product was about 50 per cent. of the theoretical yield. The oil gave on analysis the following results:—

0·1898 substance gave 0·4486 CO_2 and 0·1684 H_2O,
corresponding to C 64·46 H 9·85.
$C_{10}H_{18}O_3$ requires C 64·51 H 9·68.

B.—*Action of Aldehydes on Butyl-Acetoacetic Ester in the Presence of Alkali.*

1. *Piperonylidene-butyl-acetone.*

$CH_2O_2 . C_6H_3CH : CH . CO . CH_2 . C_4H_9$.

About 5 grams of butyl-acetoacetic ester and 8 grams of piperonal were added to a solution of caustic soda in 100 c.c. of 50 per cent. alcohol. On remaining overnight, at the ordinary temperature, a solid separated. This was filtered and freed by means of boiling alcohol from a residue which consisted of sodium carbonate. Piperonylidene-butyl-acetone separated from the alcohol on cooling. It melted at 75° C., and gave on analysis the following results:—

0·1582 substance gave 0·4243 CO_2 and 0·1052 H_2O,
corresponding to C 73·14 H 7·38.
$C_{15}H_{18}O_3$ requires C 73·17 H 7·31.

Piperonylidene-butyl-acetone consists of light yellow prisms, readily soluble in warm alcohol or chloroform, soluble in acetone, ether, benzene, or acetic ester, and sparingly soluble in petroleum ether.

Its *oxime* was obtained by heating a dilute alcoholic solution of the ketone with hydroxylamine hydrochloride and sodium carbonate for six hours. The mixture was poured into excess of water and extracted with ether. The oxime separated from the ether as colourless needles, which, when recrystallised from alcohol, melted at 126–127° C., and gave on analysis the following results:—

0·1025 g. substance gave 5·1 c.c. nitrogen at 17·5° C. and 733 m.m.,
corresponding to N 5·68.
$C_{15}H_{19}O_3N$ requires N 5·36.

A chloroform solution of the ketone reacted with bromine to form a *dibromide*, which separated from alcohol as colourless, long, silky needles. These melted at 137° C., and gave on analysis the following results:—

0·2 g. substance, treated with sodium and alcohol by Stepanow's method, required 9·9 c.c. of $N/_{10}AgNO_3$ for the complete precipitation of the bromide,

corresponding to Br 39·6.
$C_{15}H_{18}O_3Br_2$ requires Br 39·4.

The *phenylhydrazone* of the ketone was formed by the interaction of its components in alcoholic solution. It consisted of light yellow crystals, which melted at 128–129° C., and gave on analysis:—

0·1437 g. substance gave 10·0 c.c. nitrogen at 17° C. and 741 m.m.,

corresponding to N 8·05.
$C_{21}H_{24}O_2N_2$ requires N 8·33.

2. *Piperonylidene-butyl-acetoacetic Acid.*

$CH_2O_2 . C_6H_3CH : CH . CO . CH (C_4H_9) . COOH.$

The alkaline parent liquid, from which the piperonylidene-butyl-acetone had been separated, was acidified with dilute hydrochloric acid. The yellow solid which was precipitated was redissolved in dilute alkali, and freed from traces of the ketone by extracting the latter with ether. The acid was then reprecipitated by dilute hydrochloric acid, and was recrystallised a few times from hot alcohol. It melted with effervescence at 184–185° C., and gave on analysis the following results:—

0·1431 substance gave 0·3468 CO_2 and 0·0814 H_2O,

corresponding to C 66·09 H 6·32.
$C_{16}H_{18}O_5$ requires C 66·21 H 6·21.

Piperonylidene-butyl-acetoacetic acid crystallises from alcohol as long, colourless prisms, which are fairly easily soluble in acetone, acetic ester, chloroform, or benzene.

3. *Anisylidene-butyl-acetoacetic Acid.*

$CH_3O . C_6H_4 . CH : CH . CO . CH (C_4H_9) . COOH.$

A mixture of 12 grams of butyl-acetoacetic ester, 9 grams of anisaldehyde, and 20 c.c. of 12 per cent. caustic soda solution, with 200 c.c. of water, was shaken mechanically for several days. The alkaline mixture was then extracted with ether, and the ether solution was set aside.

On acidifying the aqueous alkaline layer an oil was liberated. This was dissolved in warm alcohol, from which it separated as colourless prisms, melting at 171° C. with effervescence. It was almost insoluble in water or petroleum ether, dissolved in benzene or ether, and was readily soluble in hot alcohol.

4. *Anisylidene-butyl-acetone.*

$$CH_3O . C_6H_4 . CH : CH . CO . CH_2 . C_4H_9.$$

By evaporating the ethereal extract from the last experiment an oil was obtained. It separated from warm alcohol as colourless prisms, which melted at 60-61° C., dissolved in methyl alcohol or acetic ester, and was very readily soluble in ether, chloroform, alcohol, benzene, or acetone. On analysis it gave the following results:—

0·1293 substance gave 0·3670 CO_2 and 0·1019 H_2O,
corresponding to C 77·41 H 8·75.
$C_{15}H_{20}O_2$ requires C 77·58 H 8·62.

5. *Benzylidene-butyl-acetoacetic Acid.*

$$C_6H_5CH : CH . CO . CH (C_4H_9) . COOH.$$

A mixture of 7 grams of benzaldehyde and 12 grams of butyl-acetoacetic ester was shaken for several days with 200 c.c. of water, to which 12 per cent. caustic soda solution (20 c.c. in all) was added from time to time in quantities of 5 c.c. The oil which separated was extracted with ether, and the ether solution was reserved for the isolation of the ketone. (See below.)

A white solid was precipitated on acidifying the aqueous layer with dilute acid. It crystallised from alcohol as colourless prisms, which melted with effervescence at 158–159° C. It dissolved readily in alcohol, chloroform, acetic ester, or acetone, less easily in ether or benzene, and was nearly insoluble in petroleum ether. It gave on analysis the following results:—

0·1200 substance gave 0·3216 CO_2 and 0·0802 H_2O,
corresponding to C 73·09 H 7·59.
$C_{15}H_{18}O_3$ requires C 73·17 H 7·32.

6. *Benzylidene-butyl-acetone.*

$$C_6H_5 . CH : CH . CO . CH_2 . C_4H_9.$$

On evaporating the ether solution referred to above, an oily, semi-solid residue was left. When this was distilled in a current of steam, benzaldehyle came over first and finally; when the aldehyde had been distilled, the ketone solidified in the receiver as glistening, colourless plates, which melted at 48° C., and dissolved in the ordinary organic solvents. It gave on analysis:

0·1437 substance gave 0·4377 CO_2 and 0·1141 H_2O,

corresponding to C 83·09 H 8·82.

$C_{14}H_{18}O$ requires C 83·16 H 8·91.

Its *oxime*, which was obtained in the usual manner, crystallised from carbon tetrachloride as colourless needles, melting at 108–109° C., and it gave on analysis:—

0·1894 grams substance gave 10·4 c.c. moist nitrogen at 17·5° C. and 745 m.m.

corresponding to N 6·3.

$C_{14}H_{19}NO$ requires N 6·45.

C.—*Action of Aldehydes on Butyl-Acetone in the Presence of Hydrochloric Acid.*

1. *Action of Piperonal.*

Piperonal (21 grams) was dissolved in alcohol, saturated with anhydrous hydrochloric acid at − 5° C., and butyl-acetone (58 grams), prepared from butyl-acetoacetic ester, was added. The mixture, which was contained in a tightly-stoppered flask, turned purple in colour, and was allowed to remain in a freezing mixture for four days. The flask then contained a tarry liquid, together with a solid. The hydrochloric acid was allowed to evaporate, and by repeated crystallisation from hot alcohol, a yellowish solid was finally obtained. This solid separated from hot methyl-ethyl ketone as small, colourless prisms, melting at 237–239° C., soluble in acetone or chloroform, and very sparingly soluble in methyl alcohol, ether, or acetic ester. It gave on analysis the following results:—

0·1288 substance gave 0·3431 CO_2 and 0·0622 H_2O,

corresponding to C 72·65 H 5·36.

$C_{31}H_{26}O_7$ requires C 72·94 H 5·09.

Apparently the substance was formed in accordance with the equation:

$$CH_3 . CO . CH_2 . C_4H_9 + 3C_6H_3 (O_2CH_2) . CHO = C_{31}H_{26}O_7 + 3H_2O.$$

2. *Action of Benzaldehyde.*

A saturated solution of alcoholic hydrochloric acid was cooled to − 10° C., and to it 7 grams of butyl-acetone and 18 grams of benzaldehyde were added. After remaining four days in a freezing mixture, the tar which had formed was extracted with ether and washed with a dilute solution of caustic soda. The product was freed from benzaldehyde by distillation with steam. The residue was purified from methylated spirit, and was then dissolved in warm alcohol from which by addition of petroleum ether an oily solid separated. This was recrystallised from warm alcohol. The body finally obtained consisted of colourless prisms, melting at 176–177° C., soluble in alcohol, chloroform, or acetone, and sparingly soluble in ether or petroleum ether. Its analysis showed that it had a constitution analogous to that of the body obtained in the experiment last described:—

0·1575 substance gave 0·5143 CO_2 and 0·1017 H_2O,
corresponding to C 89·05, H 7·2.
$C_{28}H_{26}O$ requires C 88·88, H 6·87.

D.—*Summary.*

1. Butyl-aceto-acetic ester was obtained by the action of n-butyl iodide on the sodium derivative of aceto-acetic ester.

2. In the presence of alkalies butyl-aceto-acetic ester condensed with piperonal, anisaldehyde, and benzaldehyde to form respectively piperonylidene-, anisylidene-, and benzylidene-butyl-acetone together with piperonylidene-, anisylidene-, and benzylidene-butyl-acetoacetic acid.

3. Piperonal and benzaldehyde condensed with butyl-acetone, in the presence of alcoholic hydrochloric acid, and at a low temperature, to form crystalline substances apparently derived from three molecules of the aldehyde and one molecule of the ketone in each case.

XV.

ON THE CONDENSATION OF NITROSOPHENYLURETHANE WITH TOLUYLENEDIAMINE HYDROCHLORIDE.

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AND

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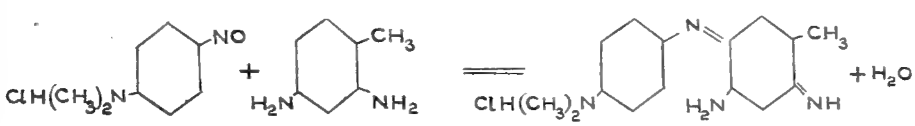
[Read February 25. Published September 15, 1924.]

By the action of nitrous fumes on a solution of phenylurethane in glacial acetic acid R. Willstaetter (Ber. Dtsch. Chem. Ges., xlii, 1909, p. 4876) obtained a very unstable phenylnitrosourethane $C_6H_5 . N(NO) . COOC_2H_5$. An isoneride of this, *p*-nitrosophenylurethane, was obtained by T. J. Nolan (private communication from Nobel's Explosives Company) by the action of sodium nitrite on a cold solution of phenylurethane in concentrated sulphuric acid. He also observed that the nitrosourethane gives red colourations with alcoholic solutions of the hydrochlorides of certain amines.

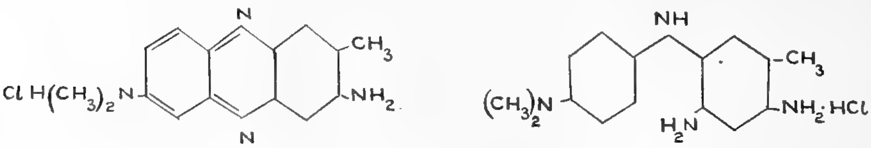
Since it seemed likely that the coloured products formed by the action of nitrosophenylurethane on aromatic metadiamines were substances of the nature of the indamine or the eurhodine dyestuffs, the behaviour of nitrosophenylurethane towards m-toluylenediamine was examined.

O. N. Witt (Ber. Dtsch. Chem. Ges., xii, 1879, p. 931) has shown that a warm, dilute aqueous solution of the hydrochloride of *p*-nitrosodimethylaniline reacts with *m*-toluylenediamine to form blue-black crystals of an indamine, Tolylene Blue :—



Tolylene Blue.

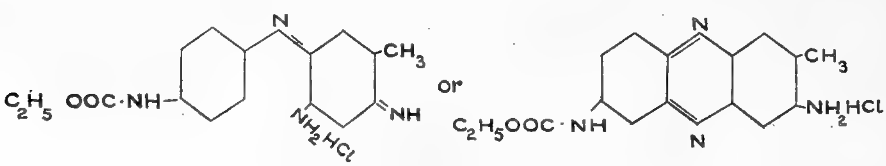
Witt also showed that when an aqueous solution of Tolylene Blue is boiled, the indamine is converted into an eurhodine, Neutral Red, mixed with the leuco compound of the indamine:—



Neutral Red. Leuco Tolylene Blue.

In a similar manner the indamine Phenylene Blue and the eurhodine Neutral Violet were obtained from the hydrochloride of nitrosodimethylaniline and *m*-phenylenediamine.

By causing nitrosophenylurethane and the hydrochloride of *m*-toluylenediamine to interact under conditions such as those which obtain in the preparation of the above dyestuffs, we hoped to prepare an indamine or an eurhodine of the formula

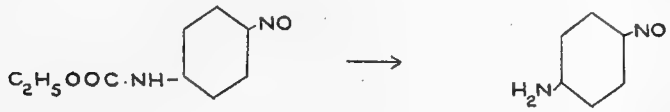


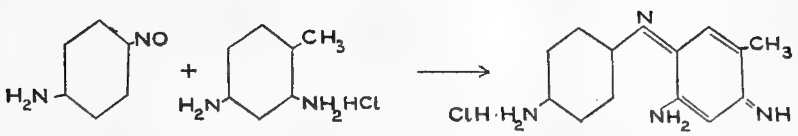
respectively.

When solutions of the two substances in warm methylated spirit were mixed and carefully concentrated, a small amount of bluish-black prismatic crystals with a purple lustre separated on cooling. It was not, however, found possible to obtain a satisfactory yield of the substance, slight variations in the method invariably giving a negative result. This crystalline substance proved to be the hydrochloride of an amorphous, reddish-brown, fluorescent base.

In addition to the hydrochloride of the base, a straw-coloured, crystalline, neutral substance was sometimes got by the action of *m*-toluylenediamine hydrochloride on the nitrosourethane. Although this substance has a percentage of nitrogen approximating to that of an indamine from the nitrosourethane and toluylenediamine, it cannot be regarded as a derivative of the amine, since the same substance was formed by the action of α-naphthylamine on the nitrosourethane. The body was, therefore, simply a derivative of the latter substance.

The analysis of the hydrochloride of the base showed clearly that the substance was neither an indamine nor an eurhodine from nitrosophenylurethane and *m*-toluylenediamine. As the formation of the straw-coloured by-product indicated that the nitrosourethane could also undergo a change, other than condensation, during the course of the reaction, it is probable that the urethane undergoes hydrolysis to nitrosoaniline, and that the latter then condenses with the amine, forming an indamine:—





An indamine having this formula has already been prepared by Bernthsen and Schweitzer (Liebig's Annalen, ccxxxvi, p. 343) by the oxidation of a mixture of the hydrochloride of *p*-phenylenediamine and *m*-toluylenediamine by means of ferric chloride. Although the description of the dye obtained by us differs slightly from that given by Bernthsen and Schweitzer for their substance, it is very probable that the two substances are identical.

EXPERIMENTAL.

1. *Preparation of Nitrosophenylurethane.*

A mixture of 600 c.c. of concentrated sulphuric acid and 400 c.c. of water was cooled to 30° C., and 20 g. of phenylurethane were added to it. The mixture was stirred until the solid had all dissolved. The solution was then cooled to – 15° C., and another solution of 8·4 g. of sodium nitrite, in 50 c.c. of water, was added to it drop by drop. The deep-red solution was removed from the freezing mixture and was allowed to remain for an hour at the temperature of the room. The mixture was then poured into a vessel containing 2 kilos of powdered ice, and the green solid which was precipitated was finally filtered and washed with iced water. The product was dried in a vacuum, and was freed from unchanged phenylurethane by extracting the latter with warm light petroleum. It was then dissolved in hot benzene, from which it separated as a dark-green powder, which melted at 147° C., and gave on analysis the following results:—

0·1620 g. substance gave 20·2 c.c. moist N at 16° C. and 756 m.m.,
corresponding to N 14·46.
$C_9H_{10}O_3N_2$ requires N 14·44.

Nitrosophenylurethane is almost insoluble in light petroleum, but dissolves easily in alcohol, ether, chloroform, or hot benzene.

2. *Action of Nitrosophenylurethane on Toluylenediamine Hydrochloride.*

A warm solution of 2 g. of nitrosophenylurethane in 30 c.c. of methylated spirit was added gradually to a similar solution of 1·57 g. of *m*-toluylene-diamine, to which an amount of hydrochloric acid had been added, sufficient to form the monohydrochloride of the amine. The bright-red coloured solution thus got was boiled for five minutes; but as no separation of solid occurred on then cooling the solution, the latter was concentrated carefully to about half its original volume. On cooling the solution, and allowing it to remain for some time at the room temperature, dark-blue prismatic crystals separated. A black, tarry mass was obtained from the filtrate from these crystals.

The dark-blue crystals did not melt below 340° C. They dissolved in water, forming a deep-purple solution, and when this solution was diluted, the colour changed to apricot. The substance gave on analysis the following results :—

0·1105 g. substance gave 20·7 c.c. moist N at 15·5° C. and 767 m.m.,
corresponding to N 22·1 ;

0·2519 g. substance gave 0·1253 g. AgCl,
corresponding to Cl 12·3.

$C_{13}H_{14}N_4HCl$ requires N 21·4, Cl 13·5.
$C_{16}H_{18}N_4O_2HCl$ requires N 16·7, Cl 10·6.

The percentages of nitrogen and chlorine are much too high for an indamine derived from the original urethane. The analysis indicates, on the other hand, that the body is the monohydrochloride of an indamine derived from nitrosoaniline and toluylenediamine contaminated with a small amount of the free base.

When dilute potash was added to an aqueous solution of the indamine hydrochloride the indamine was precipitated as a reddish-brown amorphous solid. The free base, which had a marked fluorescence, was purified by solution in alcohol. Acids readily redissolved it, forming deeply-coloured solutions. It gave on analysis the following results :—

0·1384 g. substance gave 28·6 c.c. moist N at 16·5° C. and 762 m.m.,
corresponding to N 24·1.
$C_{13}H_{14}N_4$ requires N 24·7.
$C_{16}H_{18}N_4O_2$ requires N 18·8.

A crystalline, straw-coloured, neutral substance was sometimes obtained in the experiments with nitrosophenylurethane and *m*-toluylenediamine, The neutral substance, which was readily soluble in ether, was separated from the indamine hydrochloride by means of this solvent. It was dissolved in hot alcohol, from which it separated on cooling as acicular prisms, which melted at 212° C., and gave on analysis the following results :—

0·1039 g. substance gave 14·6 c.c. moist N at 16° C. and 754 m.m., corresponding to N 16·25.

The percentage of nitrogen corresponds approximately to that required for the hydrochloride of an indamine from nitrosophenylurethane and *m*-toluylenediamine. The colour of the substance was too light for the hydrochloride of an indamine, and, moreover, the body was not a hydrochloride. The same substance was formed when toluylenediamine was replaced by α-naphthylamine in the reaction. Since, therefore, it was not a condensation derivative of the base, it was not further examined.

XVI.

THE CONDENSATION OF ALDEHYDES WITH METHYLETHYL-KETONE.

By HUGH RYAN, D.Sc.,

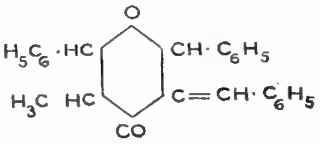
AND

PATRICK J. CAHILL, M.Sc.,

University College, Dublin.

[Read February 25. Published September 15, 1924.]

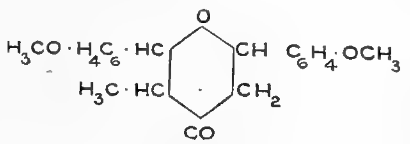
By the action of benzaldehyde on methylethyl-ketone in the presence of dilute alkali, H. Ryan and A. Devine (Proc. Royal Irish Acad., xxxii, B, p. 208) obtained α-benzylidene-methylethyl-ketone and diphenylmethyltetrahydropyrone, which had been previously described by C. Harries and G. H. Müller (Ber. Dtsch. Chem. Ges., xxxv, 1902, p. 968). Also during an attempt to prepare the benzylidene derivative of this tetrahydropyrone by the action of benzaldehyde on the hydropyrone in the presence of alcoholic hydrochloric acid, they found that instead of the compound



they obtained a crystalline substance with the empirical formula $C_{25}H_{20}O$, which contained a molecule of water less than that of the benzylidene-diphenylmethyltetrahydropyrone expected. The new condensation product formed a dibromide $C_{25}H_{20}O_2Br_2$; but as they failed to prove the presence of a CO group in the body, they were unable to assign a structural formula to the substance.

Using the same condensing agent (hydrochloric acid), Ryan and Devine (*loc. cit.*) by the interaction of α-benzylidene-methylethyl-ketone with anisaldehyde and piperonal obtained analogous substances having the formulae $C_{27}H_{24}O_3$ and $C_{27}H_{20}O_5$ respectively.

In continuation of this work we condensed anisaldehyde with methylethyl-ketone in the presence of dilute alkali, obtaining an anisylidene-methylethyl-ketone melting at 53° C. and a substance melting at 93–95° C., which is probably di-*p*-methoxyphenyl-methyltetrahydropyrone with the formula:—



When this substance was treated with excess of anisaldehyde in the presence of alcoholic hydrochloric acid, further condensation ensued, with, however, the elimination of two water molecules. The course of the reaction was therefore quite analogous to that by which Ryan and Devine had obtained the compound $C_{25}H_{20}O$ from benzaldehyde and diphenylmethyltetrahydropyrone.

This compound was also obtained by the acid condensation of excess of anisaldehyde with anisylidene-methylethyl-ketone or methylethyl-ketone. In the latter case the reactions may be represented thus:—

$$CH_3 . CO . CH_2 . CH_3 + CH_3O . C_6H_4 . CHO + HCl$$
$$= CH_3 . CO . CH(CH_3) . CHCl . C_6H_4 . OCH_3 + H_2O$$

$$CH_3 . CO . CH(CH_3) . CHCl . C_6H_4 . OCH_3 + CH_3O . C_6H_4 . CHO$$
$$= CH_3O . C_6H_4 . \underset{|\qquad\qquad\qquad\qquad|}{CH . CH_2 . CO . CH} . CH_3 + HCl$$
$$O \text{———————} CH . C_6H_4 . OCH_3$$

$$C_{20}H_{22}O_4 + CH_3O . C_6H_4 . CHO = C_{28}H_{26}O_4 + 2H_2O$$

A similar body having the empirical formula $C_{28}H_{22}O_6$ was formed by the action of excess of piperonal on anisylidene-methylethyl-ketone in the presence of alcoholic hydrochloric acid.

Experimental.

A.—*Action of Aldehydes on Methylethyl-Ketone in the Presence of Alkali.*

1. *Piperonal.*

Piperonylidene-methylethyl-ketone,

$$CH_2O_2 . C_6H_3CH : CH . CO . CH_2 . CH_3.$$

A mixture of 15 g. of methylethyl-ketone and 50 g. of piperonal with 750 c.c. of a dilute aqueous solution of sodium hydroxide was shaken mechanically for seven days. The yellow oily solid, which separated, was filtered, washed with water, and recrystallised several times from petroleum ether. It consisted of nearly colourless plates, which melted at 101–102° C., and gave on analysis the following results:—

0·1993 substance gave 0·5153 CO_2 and 0·1058 H_2O,

corresponding to	C 70·5, H 5·9.
$C_{12}H_{12}O_3$ requires	C 70·6, H 5·9.

Piperonylidene-methylethyl-ketone is insoluble in water, but dissolves easily in alcohol, ether, or chloroform. It is coloured red on contact with concentrated sulphuric acid, in which it dissolves, forming a red solution.

2. *Anisaldehyde.*

(a) *Anisylidene-methylethyl-ketone,*

$$CH_3O \cdot C_6H_4 \cdot CH : CH \cdot CO \cdot CH_2 \cdot CH_3.$$

A mixture of 130 g. of methylethyl-ketone and 150 g. of anisaldehyde with a dilute solution of sodium hydroxide in 500 c.c. of water was shaken for seven days. The oily solid which had formed separated from petroleum ether as colourless crystals, melting at 53° C. It gave on analysis the following results:—

0·1670 substance gave 0·4608 CO_2 and 0·1110 H_2O,

corresponding to	C 75·3, H 7·3.
$C_{12}H_{14}O_2$ requires	C 75·7, H 7·3.

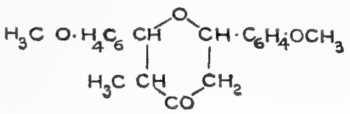
Anisylidene-methylethyl-ketone consists of large platy crystals, which are easily soluble in alcohol, ether, benzene, or chloroform, and insoluble in water. The crystals are coloured reddish-brown on contact with concentrated sulphuric acid, in which they dissolve, forming a reddish-brown solution.

The dibromide of anisylidene-methylethyl-ketone was prepared by the action of bromine on the ketone in chloroform solution. It separated from petroleum ether as colourless crystals, which melted at 85° C., and gave on analysis the following results:—

0·2250 g. substance treated with sodium and alcohol by Stepanow's method required 12·75 c.c. N/10 $AgNO_3$ for the complete precipitation of the bromide,

corresponding to	Br 45·4.
$C_{12}H_{14}O_2Br_2$ requires	Br 45·7.

(b) *Di-p-methoxyphenyl-methyltetrahydropyrone.*



A mixture of equivalent quantities of anisaldehyde and anisylidene-methylethyl-ketone was shaken with a large volume of dilute aqueous alkali for twenty-one days. The oil, which separated, was extracted with ether, and, after evaporation of the ether, the unchanged anisylidene-methylethyl-ketone was distilled in a current of superheated steam. The residue was extracted with ether. The oily residue left when the ether had evaporated crystallised after some days. It was purified by recrystallisation from petroleum ether or by distillation *in vacuo*. It melted at 93–95° C., and gave on analysis the following results:—

0·1339 substance gave 0·3621 CO_2 and 0·0820 H_2O,
corresponding to C 73·6, H 6·9.
$C_{20}H_{22}O_4$ requires C 73·7 H 6·7.

It crystallises in prisms, scarcely soluble in petroleum ether, soluble in ether or chloroform, and readily soluble in hot alcohol. The crystals are coloured reddish-yellow by contact with strong sulphuric acid, in which they dissolve to a reddish solution.

B.—*Action of Anisaldehyde on Methylethyl-Ketone in the Presence of Acids.*

1. A solution of 6 g. of methylethyl-ketone and 34 g. of anisaldehyde in 150 c.c. of alcohol was cooled in a freezing mixture, and saturated with gaseous hydrochloric acid. On standing in a tightly stoppered flask the solution turned a reddish colour, and gradually deposited an oily substance, which in the course of a few days solidified. The supernatant liquid was decanted and evaporated, leaving a resinous solid. The two solids were mixed and recrystallised from hot alcohol. This compound, which melted at 150°C., was also obtained by the action of anisaldehyde on both anisylidene-methylethyl-ketone and di-*p*-methoxyphenyl-methyltetrahydropyrone in the presence of alcoholic hydrochloric acid.

2. A solution of 2·5 g. of anisylidene-methylethyl-ketone and 10·5 g. of anisaldehyde in 20 c.c. of alcohol, which had previously been saturated with dry gaseous hydrochloric acid, was allowed to remain in a stoppered flask for

several days. The oily solid which had separated, together with a further quantity of this solid obtained by evaporating the solution, was dissolved in hot alcohol, from which it separated as colourless crystals melting at 158°C., identical with those mentioned above.

3. Equimolecular amounts of di-*p*-methoxyphenyl-methyltetrahydro-pyrone and anisaldehyde were dissolved in cold alcoholic hydrochloric acid, and the solution was let stand in a stoppered flask for a few days. The solution turned dark-red with separation of oily crystals. After recrystallisation from hot alcohol this substance melted at 158°C., and proved to be identical with that obtained in the last experiment. It gave on analysis the following results:—

0·1126 substance gave 0·3237 CO_2 and 0·0630 H_2O,
corresponding to C 78·4, H 6·2.
$C_{28}H_{26}O_4$ requires C 78·8, H 6·1.

This substance crystallises in colourless, rectangular prisms, which are sparingly soluble in hot alcohol and readily soluble in chloroform. Concentrated sulphuric acid dissolves the crystals forming an orange-coloured solution.

The formation of the substance from di-*p*-methoxyphenyl-methyltetrahydropyrone can be represented by the following equation:—

$$C_{20}H_{22}O_4 + (CH_3O)C_6H_4.CHO = C_{28}H_{26}O_4 + 2H_2O.$$

4. In an experiment similar to one described above (B 2), 6 g. of piperonal and 2·4 g. of anisylidene-methylethyl-ketone in 20 c.c. of ice-cold alcoholic hydrochloric acid was allowed to stand for a few days. The solid, which had separated, was then filtered and washed repeatedly with warm alcohol. When recrystallised from a mixture of chloroform and alcohol it melted at 195°C., and gave on analysis the following results:—

0·1871 substance gave 0·5055 CO_2 and 0·0827 H_2O,
corresponding to C 73·7, H 5·0.
$C_{28}H_{22}O_6$ requires C 74·0, H 4·8.

The compound consists of light yellow, platy crystals, which are sparingly soluble in hot alcohol, and readily soluble in chloroform. The crystals are coloured reddish-purple on contact with strong sulphuric acid, in which they dissolve, forming a dark-red solution. This substance is evidently analogous to the compound $C_{28}H_{26}O_4$ obtained from anisaldehyde and anisylidene-methylethyl-ketone.

Summary.

1. In the presence of dilute alkali piperonal and anisaldehyde condensed respectively with methylethyl-ketone to form piperonylidene- and anisylidene-methylethyl-ketone.

2. By the further action of anisaldehyde on anisylidene-methylethyl-ketone in the presence of alkali di-*p*-methoxyphenyl-methyltetrahydropyrone was formed.

3. In the presence of alcoholic hydrochloric acid methylethyl-ketone, anisylidene-methylethyl-ketone, and di-*p*-methoxyphenyl-methyltetrahydropyrone condensed with excess of anisaldehyde to form in each case the same substance, $C_{28}H_{26}O_4$. An analogous substance was obtained by the action of piperonal on anisylidene-methylethyl-ketone.

PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY

VOLUME XXXVI

SECTION C.—ARCHÆOLOGY, LINGUISTIC, AND LITERATURE.

DUBLIN: HODGES, FIGGIS, & CO.

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1921–1924

The Academy *desires it to be understood that they are not answerable for any opinion, representation of facts, or train of reasoning that may appear in any of the following Papers. The Authors of the several Essays are alone responsible for their contents.*

Dublin: Printed at the University Press by Ponsonby and Gibbs.

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SECTION C.

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p. 142, l. 5 ,, ,, .	*For* fig. 3 *read* fig. 6.
p. 221, l. 25, ...	*Delete* (3rd Baron Offaly).
p. 228, l. 23, ...	*For* Edw. IV. *read* Edw. III.
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PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY

PAPERS READ BEFORE THE ACADEMY

I.

A STUDY OF THE CHRONOLOGY OF BRONZE-AGE SCULPTURE IN IRELAND.

By M. L'ABBÉ BREUIL, Hon. M.R.I.A.,

AND

R. A. S. MACALISTER.

Read April 25. Published August 15, 1921.

Introductory Note.

During the Easter vacation of 1920 I had the privilege of conducting M. l'Abbé Henri Breuil, and Mr. Miles Burkitt, Lecturer on Prehistoric Archæology at Cambridge University, over a number of the bronze-age tumuli of Ireland which display ornamental sculpturing. Our itinerary included the carns of the Lochcrew Hills: Dowth and New Grange: Sess Kilgreen, Knockmany, and Clover Hill: as well as the very remarkable incised stone at Cloonfinloch, near Clonmacnois. We also visited the curious Christian "cup-and-ring" stones to be seen in the graveyards at Tully and at Rathmichael, near Dublin; and from Clover Hill we explored thoroughly the great dolmen-field at Carrowmore, in Co. Sligo. The most important omission from this list is the monument in the Deerpark of Castle Archdale, Co. Fermanagh: this structure is sadly dilapidated, and the sculpture upon its stones could not be examined without excavation.

M. Breuil's long experience in the study of the engravings and paintings on the cave walls of Southern France and of Spain enabled him to detect certain facts with regard to the superposition of styles and motives, to which attention had hardly, if at all, been previously directed. Analogous observations, in the caves just mentioned, have made it possible to determine the course and development of Palæolithic art; and the result of the examination now reported upon will be to put in the hands of Irish archæologists, for the first time, a test for the chronological study of the bronze-age art in this country.

At the kind suggestion of M. l'Abbé, this paper is presented under our joint names. But while it is possible that Mr. Burkitt and I contributed some details to the criticism of the monuments, as we discussed each in its turn on the spot, the credit for the results set forth in the following pages rests wholly with M. Breuil; and in translating his notes I have thought it only his due to allow him to speak in the first person. My own share in the work has been little more than to arrange and to conduct the tour of inspection, and to translate into English and arrange in literary form the notes which he sent me in a letter after his return to France. At his request they are now communicated to the Academy.—R. A. S. M.

I.—Observations upon Individual Monuments.

A.—*New Grange.*

Some of the sculpturings at New Grange show clear evidence of superposition, of two different styles of technique and of motive. Mr. Coffey's book (*New Grange and other Incised Monuments in Ireland*, Dublin, 1912) is a convenient *corpus* of photographs and other illustrations, in which the designs may be studied. References are made to that book, by page and figure, in the notes which follow.

1. On the stone (p. 29, fig. 5), the lozenges alternately incised and in relief are later than the pocked spirals; they are clearly modified in shape so as not to interfere with them.

2. On the stone with a triple spiral (p. 31, fig. 9) there are finely incised lines which have been left untouched when the surface of the stone was pocked preparatory to making the triple spiral. These are but faintly visible in the photograph.

3. The position of the stone (p. 32, fig. 10) shows that the pocked linear spirals, and other figures in the same technique upon this stone, are older than the building of the tumulus.

4. The same deduction follows from the position of the great roofing-stone of the right-hand burial-recess (p. 33, fig. 11; Plate VII).

5. In one of the three exposed stones of the outer kerb (p. 39, fig. 23; p. 75, fig. 58) the lozenges on the lower margin of the left-hand side have clearly been made after the spirals, which have been partly broken away to make room for them.[1]

[1] I am not convinced that the argument drawn from this stone can be maintained; to me the fracture seems to run into the right-hand compartment of the stone, where the ornamental device crosses it unbroken.—R. A. S. M.

6. In another of the exposed kerb-stones (p. 39, fig. 24; p. 75, fig. 59), the artist who formed the pocked triangles and lozenges on the left-hand side has been hampered by the spirals and outlined lozenges on the right, and has had to cramp his work to avoid them.

There are altogether four different styles of engraving used at New Grange; and the foregoing observations indicate that they succeed one another chronologically in the following order:—

I. *Incised lines.*—Only on p. 31, fig. 9.

II. *Pocked lines.*—Spirals, circles, zig-zags, arcs, and other geometrical figures. See the following stones: p. 29, figs. 4, 5 (lower part); p. 30, fig. 7; p. 31, figs. 8, 9 (lower part); p. 32, fig. 10; p. 33, figs. 11, 12; p. 36, fig. 19; p. 37, figs. 20, 21; p. 39, fig. 24 (right-hand side).

III. *Broad and deep lines, first pocked and then polished smooth.*—The kerb-stone exposed at the entrance is an example (Coffey, Plate III), as is also the greater part of p. 39, fig. 23.

IV. *Figures not merely outlined, but pocked over the whole surface.*—This produces the effect of a diaper of lozenges or triangles, alternately sunk and in relief. See p. 29, fig. 5 (upper part); p. 30, fig. 6; p. 33, figs. 13, 14, 15; p. 35, figs. 17, 18; p. 38, fig. 22; p. 39, fig. 23 (lower part of left-hand side).

B.—*Dowth.*

So far as I am able to judge, Dowth contains three groups of designs:—

I. *Incised lines*, rather rudely cut or scraped on the stone: p. 58, fig. 38; p. 59, fig. 39; and in Coffey's previous memoir,[1] Plate VI, No. 4. These figures are in some cases clearly worked over by a pocking technique resembling No. IV at New Grange.

II. *Pocked lines*, similar to those of No. II of New Grange, but with less elaborate devices. They bear close analogies to the designs at Lochcrew.

III. *Figures pocked all over* (at Dowth triangles only), leaving zig-zags in relief. Evidently corresponding to No. IV of New Grange.

C.—*Lochcrew.*

We spent one day only on the Lochcrew Hills; this was insufficient for a thorough critical examination of the wealth of designs which the monuments here display. An exhaustive memoir upon this great cemetery is much needed.

We were, however, able to detect undoubted traces of superposition. On the stone figured by Coffey (p. 83, fig. 64) there is a small pocked circle, cut

[1] *Transactions*, R.I.A., vol. XXX, p. 1.

into by a complicated concentric figure. I have insufficient materials for dividing the designs into incised and pocked; I can assert *incising* only in the case of the group of triangles on the top of the stone figured by Fergusson.[1] This, though incised, seems posterior to the rest of the engraving, since it was placed on a part of the stone left free from the pocked designs. In character it is analogous with Group IV of New Grange.

The greater part of the very varied series of figures at Lochcrew is to be associated with Series II of New Grange and Series II of Dowth. Some at least are shown by their position to have been engraved before the erection of the carns. In Carn *T* I discovered a most elaborately engraved slab, which can be seen only partially by peeping into the narrow crack between two adjacent roofing-stones. The pattern upon it, so far as it can be seen at all, is unique.[2]

Also in Carn *T* I noticed traces of colour upon one of the roofing-stones. This discovery is unique in Irish bronze-age art. The pattern consists of a series of lozenges in a whitish colour, traced on a ground of dirty yellowish-red ochre. Very likely the zig-zag was originally painted in some perishable vegetable colour, which has faded, leaving, so to speak, a *negative* of the original design.

It may be possible, with a more exhaustive exploration, to distinguish lightly pocked figures from others pocked more deeply, leading to Series III of New Grange.

D.—*Sess Kilgreen.*

The published illustration of this fine tumulus (p. 108, fig. 87) does not give an adequate idea of either its structure or its ornamentation. The latter is completely analogous to that of certain of the Lochcrew designs. Thus, there is a group found at both places, consisting of two groups of concentric circles, with a smaller imperfect group between them (an example is Lochcrew, Carn *U*, stone *B*[3]). There are also found two conjoined lozenges, comparable to a similar figure at Castle Archdale Deerpark, which I have not seen.[4] This latter monument is doubtless linked by its decoration to the

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[1] *Rude Stone Monuments*, p. 217; also figured in Conwell, *Tomb of Ollamh Fodhla*, p. 61, and *Journal*, Kilkenny Arch. Soc., New Series, vol. v, p. 384.

[2] This observation, also made at New Grange, suggests that the carns and the tumuli are secondary erections, set up in an ancient cemetery which originally consisted of graves marked with ornamentally sculptured stelae: and that these were appropriated by the builders of the tumuli, much as in later times Ogham pillars were utilized by the builders of souterrains. There is still one stone with pocked spiral ornament lying loose in a field near New Grange; it may be the sole survivor of the cemetery in its original form.—R. A. S. M.

[3] *Proceedings*, Soc. Antiq. Scot., vol. xxvii, p. 331, fig. 59.

[4] *Journal*, Roy. Hist. and Arch. Assoc. of Ireland, ser. IV, vol. v, p. 547.

same stage of evolution as the Sess Kilgreen stones. The same is true of the isolated stone in the field adjoining the Sess Kilgreen tumulus; this is possibly a little older than the tumulus stones, and nearer Series II of Dowth.

E.—*Knockmany.*

The figures on stone *A* (Coffey, p. 103, fig. 83) are, at least for the greater part, analogous to those of Series II of New Grange and of Dowth—probably towards the end of the period—and are thus closely linked with the majority of the Lochcrew designs. The small figures on stone *D* (p. 104, fig. 84) appear to belong to the same series; but the deeply cut curved figure in the middle seems to be added later. Its character suggests the influence of the style of La Tène.

F.—*Clover Hill.*

Here again there is an appearance of La Tène influence; in any case, this monument is probably the latest of the series.[1]

II.—AN ATTEMPT TO ESTABLISH A CHRONOLOGICAL SYSTEM.

The rock-scribings of Ireland may be divided into the following groups, and the nature of the monuments with which they are associated, as well as the evidence of superposition that has been set forth in the preceding pages, indicates their chronological sequence:—

A.—*Epoch of the True Dolmens.*

I saw no monuments of this period during my tour in Ireland except those of Carrowmore, Co. Sligo, and Glendruid, Co. Dublin. On the under side of the cover-stone of the dolmen called Listoghil, at Carrowmore, I detected a pattern of lozenges, outlined in very faintly traced lines; and another monument of the series has a device not unlike the Hissarlik masks or the faces on the Folkton chalk drums.

In *Proceedings*, R.I.A., there is described (vol. ix, p. 541) and figured a dolmen near Rathkenny, Co. Meath, bearing simple linear marks, crosses,

[1] It may be worth recording that in discussing the engravings on the spot we thought it possible that the device on the stone (p. 111, fig. 92) was intended to represent, or at least to suggest, a female figure; it has some analogies with the sculptured figures on the walls of the burial-places in the Marne region (see Déchelette, *Manuel d'archéologie*, i, 585). We likewise thought it probable that the central figure on stone *A* at Knockmany represents a human face.—R.A.S.M.

The field on the side of the road opposite to that containing the Clover Hill burial-chamber contains a large number of rough boulders, not artificially arranged, but tending to surround a mound on top of which is a small tumulus. On one of these boulders M. l'Abbé Breuil detected a group of concentric circles, pocked.—R.A.S.M.

circles, etc. Similar devices are to be seen on a rock-surface near "Calliagh Virra's house" at Monasterboice.[1] These figures have some likeness to the rock-scribings of the region of Étampes, near Paris, and to those of some of the rocks in Spain.

B.—*The Cloonfinloch Stone.*

This remarkable slab,[2] covered with incisions resembling the outlines of footmarks, cups, and conventionalized human figures, is undoubtedly akin to the Neolithic rock engravings and paintings of Spain, and is certainly Neolithic or early Aeneolithic.

C.—*The Tumulus Sculptures.* Series I.

The engravings in cut or scratched lines at Dowth, with a few at New Grange and at Lochcrew (?) in the same technique, are the oldest of the Tumulus series of sculptures. In no case do they interfere with other sculptures, but they themselves occasionally cause modification of later work. Note especially the stone at Dowth (p. 58, fig. 38), where the pocked area has undoubtedly been restrained to avoid interference with the circular figures in incised lines. The figure represents the pocked area as an unbroken surface, but it is really a diaper of triangles.

This series is, perhaps, contemporary with, in any case only a little later than, groups A and B.

C.—*The Tumulus Sculptures.* Series II.

This group includes the engravings in pocked lines at Dowth, New Grange, Lochcrew, Sess Kilgreen, Knockmany, and Castle Archdale. It is possible to subdivide the series either on a basis of technique (depth and regularity of the lines, presence or absence of polishing after pocking), or of design (relative elaboration of patterns, preference for particular motives; certain motives or designs appear alone on some of the monuments).

At Lochcrew and at New Grange many, if not all, of these designs were traced on the stones before the latter were used in the erection of the tumuli.

Towards the end of this series there is to be noticed a growth in the complexity of the spirals and concentric circles, with a concurrent diminution in the variety of individual symbols used.

I should associate with the end of this group many of the rock-sculptures containing channelled concentric circles (fig. 1, *d*). It is possible that in

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[1] *Journal*, Kilkenny Arch. Soc., new series, vol. v. p. 499.
[2] *Ibid.*, p. 354 ff.

certain cases at least this device may be derived from the conventionalized human figure of the Spanish type, as we find it on the Cloonfinloch stone, combined with concentric circles (fig. 1, *a–c*). The device on the stone at the "Gates of Glory," near Dingle (fig. 1, *e*), may be a connecting link; compare also the Scandinavian rock-sculpturing figured in *Journal*, Roy. Soc. Antiq. of Ireland, xxvii, p. 46 (fig. 1, *f–i*). This series of petroglyphs presents an extraordinary resemblance to those of Galicia in North Spain, and even to those of the Canary Islands.

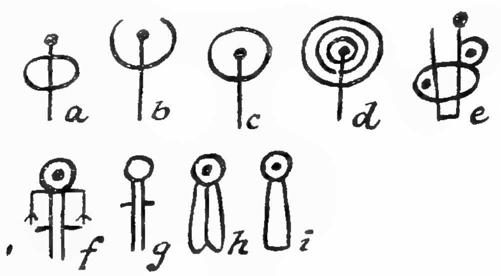

FIG. 1.

E.—*The Tumulus Sculptures.* Series III.

To this group belong the sculptures of New Grange, which consist of broad lines, having the effect of throwing into relief the surface intercepted between them. The kerbstone at the entrance to the passage is the best example (Coffey, Plate III).

F.—*The Tumulus Sculptures.* Series IV.

This group contains those figures in which the whole surface is pocked over: New Grange, Series IV; Dowth, Series III. We may compare the figure at the side of the stone at Carnwath,[1] which also seems to bear an older series, analogous to group D.

The quartered lozenge figure (p. 35, fig. 18), which belongs to this group, is strongly reminiscent of the well-known idols of Spain in dice-box shape.

G.—*The Tumulus Sculptures.* Series V.

That all the tumulus sculptures in the preceding groups are of the bronze age is shown, *inter alia*, by analogy with the decoration of the Folkton chalk drums, which includes nearly all the motives of ornament in the Irish work. There are, however, a few, as at Clover Hill and the central pattern of stone *D* at Knockmany, which seem to foreshadow the style of La Tène, and

[1] Anderson, *Scotland in Pagan Times, Stone and Bronze Ages*, p. 88.

thus to terminate the series. This analogy may, however, be illusory: decorations recalling the La Tène style, but not belonging to it, are found at several stages of European art-history (as, for instance, in the Scandinavian bronze age, and even in the Neolithic and Aeneolithic of the Danubian provinces). If we reject this La Tène analogy for the sculptures before us, they will take their place in group D above. It is not superfluous to note that a figure very similar to the device at Knockmany, here in question, exists among the older series at Carnwath.

A word or two may be added in conclusion as to the relation of Irish bronze-age art to the cognate arts of the Continent.

1. In Galicia and also in the Canary Islands there are to be found asymmetrical motives not unlike those in the last group, and very closely connected in style with petroglyphs containing concentric circles. We have already noted analogies between Spanish figures and some in the earlier groups. If a connexion between Ireland and Galicia should require stronger support, I would call attention to a remarkable lunula, found in a dolmen near Allariz.[1] It seems to be of a more advanced type than those of Ireland.

In this connexion I may say a word regarding the so-called "ship" devices of New Grange and of Dowth, as well as of Locmariaquer in Brittany. I am by no means convinced that this explanation is correct. There are in the rock-sculptures and paintings of Spain countless "pecteniform" figures of various forms and significations. Many of these symbols are difficult if not impossible to explain, but in no case can they be described as "ships." If the Irish or the Bretons had actually sculptured ships, they would surely have done so in greater numbers, as did their brethren in Scandinavia.

2. Attempts have often been made to draw analogies between the petroglyphs of Ireland and those of Scandinavia. In reality the differences far exceed the resemblances. The Irish sculptures are far more closely akin to those of Brittany or of Galicia than to those of Scandinavia.

3. Ingenious attempts have been made to derive Irish, along with the other North European, bronze-age art from Crete. That analogies have been established is unquestionable, but not a parentage. On this subject I support without reservation the remarks on the *mirage cretois*, to be found in *Proc.* R.I.A., vol. xxxiv, sect. C, p. 383 ff.

All these analogies are due to the fact that the artists of the different centres began with a common European stock of tradition, and on this basis they developed each group on its own lines. I might be tempted to exclude from this generalization the special case of the *Labyrinth*. But it is not a

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[1] Roman Barro Sivelo, *Antiguidades de Galicia*, 1875.

sound form of reasoning to compare petroglyphs in Northern Europe with the ornamentation of ceramics and of metal objects of a different centre of civilization, when no comparable specimens of the latter types of object have come to light in the north.

4. There is, however, one analogy which I cannot reject, namely, that between the Irish sculptured galleries and Gavrinis. I should even go so far as to call Gavrinis an Irish monument, in the same sense as the mounds of Armorica erected over the ship-burials of the northern pirates are called Scandinavian.

NOTE ADDED IN PRESS.

Since the above paper was presented to the Academy, Mr. Burkitt has published in his volume entitled *Prehistory* (Cambridge University Press), plate XL, three photographs of engravings at Sess Kilgreen.

II.

PRINTING IN CORK IN THE FIRST QUARTER OF THE EIGHTEENTH CENTURY (1701-1725).

By E. R. McC. DIX.

Read May 9. Published August 15, 1921.

In April, 1912, I had the pleasure of laying before the Academy a paper on "Printing in Cork in the Seventeenth Century," with a list of all recorded printing there in that century. I have not since obtained any additions to that list, but it has occurred to me to continue the subject a little further and to show how, slowly, but surely, the printing press was developed in Cork in the succeeding twenty-five years, and to contribute a similar list for such period which will be a suitable "Supplement" to my former paper; and such accordingly my present contribution purports to be.

The list, to a large extent, speaks for itself, but a few observations upon it may be useful.

First, then, so far as researches have gone, with the doubtful exception of the first appearing of *The Cork Newsletter* in 1707 or 1708, there is no extant item of Cork printing prior to 1714. Then we find there a printer, George Bennett, and a specimen of his press issued that year, namely, a single issue of a little periodical called *The Idler*, No. 1. We do not know if it even reached a second number. It was not, correctly speaking, a newspaper. It might, perhaps, be more correctly designated a news-sheet or letter, but the first actual Cork newspaper was the one already alluded to, *The Cork Newsletter*, and which, I think, certainly appeared in 1715 or 1716, if not at the earlier date above suggested. When George Bennett *first* came to Cork as a printer we do not yet know, and some of the extant pieces of Cork printing are undated, and can only be conjecturally ascribed to certain years, though such conjectures are probably accurate enough. In 1716 we find the name of *John Redwood* coupled with that of *George Bennett* as a Cork bookseller; and some seven years later Redwood is given as the *printer* of a book or two. In the year 1716, or at end of 1715, also appeared a newspaper, or rather news-letter, called *The Free-Holder*, of which one copy is extant. This was apparently the second newspaper, news-sheet, or newsletter printed in Cork. To the next year, 1717, is attributed *The Cork Intelligence*, the third newsletter in Cork; but the authority for it is only the Council Book of the Corporation, no copy being extant. Having the unquestionable fact, however, of a printer being in Cork, namely, George Bennett, since 1714, there are no grounds to deny that he was most probably the printer of much other matter there, and of anonymous work, or of pieces only known from titles in old sale catalogues. When on perusing the following list we reach the year 1721, we begin to see more solid and extended development of the printing press in Cork. We find also another printer in that year at work there, namely, Samuel Terry, in addition to George Bennett; and if an opening existed for two printers, we must conclude that much of the output of their presses was of a business or commercial character, and has perished. In 1722 a third printer appears, Andrew Welsh. It is possible he was printing in Cork at an earlier date, as conjecturally given under 1715. I might here add that Terry also printed in Limerick in the years 1722–1725.

If we consider the character of the output of the Cork presses from 1721 to 1725, inclusive, we find it comprised religious works (one in French), sermons, almanacs, a play, and miscellaneous works, including some of a local character.

To Mr. James Buckley's laborious and minute study or examination of Caulfield's "Council Books of Cork" I am particularly indebted in the preparation of this list. If there exist similar Corporation records of other of our cities and towns, I am sure they would prove sources of information on the subject of local printing and printers.

It is lamentable to think that not a copy of *The Cork Newsletter* is extant; and this is the more strange as it ran to at least 824 numbers, according to Windele. Perhaps some copies or issues may still be discovered in some private library or collection.

Note.—I might here add, referring to my papers of printing in the cities of Waterford and Kilkenny in the seventeenth century, that no record of the revival of printing of any sort there during the first quarter of the eighteenth century at present exists, so that the City of Cork has a superior record in this respect; but so has Belfast, as shown by the late Mr. M. Anderson's work on early Belfast printing, which steadily developed also.

LIST OF BOOKS, &c., PRINTED IN CORK, 1705–1725.

ABBREVIATIONS.

[Windele = History of Cork. Madden = Irish Periodical Literature. Caulfield = Council Book of the Corporation of Cork. Tuckey = Cork Remembrancer. Bib. Lind. = Library of Earl of Crawford and Balcarres. J. B. = James Buckley.]

1704.—"That the Chamberlain pay unto the Mayor 4li. 19s. by him paid for the 'Public News' sent him by Mr. De-laafa for three quarters of a year, and so continue till further order." [*Vide* Council Book of the Corporation of Cork (1876). Edited by Caulfield.]

N.B.:—This News was possibly printed, but it is very doubtful where. There are, it may be mentioned, a few records of the Corporation having paid small sums in *subsequent* years for London News.—[J. B.]

1707 [or **1708** ?].—The Cork News Letter. See N.B. under date 1723.

1714.—The Idler. By Anonimous Nobody, Esq., No. 1. Feby. 1st, 1714, Tuesday. (*George Bennett*). s.sh. Folio. 12½ ins. 2 pp. in double columns.—[Bibliotheca Lindesiana. Wigan.]

[**1715** ?].—The Freeholder's Answer to the Pretender's Declaration (*Andrew Welsh* and *Thomas Cotton*. "Sold by John Redwood.") Folio. 2 pp. 2 columns. Roman letter.—[Bibliotheca Lindesiana, Cata.—Eng. Broadsides, No. 1153.]

1715 [or **1716** ?].—The Cork News Letter. See N.B. under date 1723.

1716.—NOTE:—"George Bennett" and "John Redwood" were "Booksellers in Cork" in this year. [*Vide* Imprint on Sermon by Revd. Mr. Davies, printed in Dublin in 1716.]

1716.—The Freeholder. A newspaper. 4to, single sheet. [*Vide* Windele's Cork, Caulfield, and Madden's Irish Periodical Literature, vol. ii, p. 167.]

1716.—The Free-Holder. May 31st. No. xxiv. (*George Bennett.*) Sm. 4to. 4 numbered pages. [S. O. Casaide.]

NOTE.—If this Journal appeared weekly, it must have started about 21st December, 1715.

1717.—The Cork Intelligence. A newspaper. [*Vide* Council Book of the Corporation of Cork, p. 397.] [J. B.]

1717.—N.B.—In this year the Trustees of the Cork Charity Schools ordered to be printed an Abstract of the State of the Schools, annexed to a Charity Sermon by the Dean of Cork, preached the 11th of August, 1717, and published by him. (Query:—Printed in Cork ?) [*Vide*—"Pietas Corcagiensis" (1721), p. 52.]

1718.—A Collection of such Places in Holy Scripture, as either expressly or by good consequence condemn the Principal errors of Popery. 4to. [*Vide* John O'Daly's Sale Catalogue (Bibliotheca Hibernica). No. 44 (1875).]

1719.—A Tutor to Arithmetic, Being an examination and exercise, Thro' all the Common Rules of that useful Science, &c. By "J. B.," Teacher of Mathematics in Corke. (Printed for the Author by *G. Bennett.*) 8vo [10], 3–148 pp. [University Library, Cambridge, /Hib. 8.719, 3.]

1719.—N.B.—Caulfield mentions a report, printed in 1719, of Schools. Query :—Where ?—[J.B.]

[**1719** ?].—The Speech of Judge Powis at . . . sentence on Parson Bisse . . . at Wells Assizes for . . . Sermon at St. George's Church near Bristol . . . 1 leaf. Fol. "Corke Printed." [University Library, Cambridge. /Acton b. 25, 393 [20].]

N.B.—No printer is given. The Speech is dated 22nd December, 1718.

[**1720** ?].—Elegy on the Unfortunate tho' much Lamented Death of James Cotter, Esq., who was executed at Cork on the 7th of May, 1720, for Ravishing Elizabeth Squib, a Quaker. A Broadside (S.sh.) printed on one side, with a rude woodcut on each side of the page—one of a soldier on guard, the other of a suspended skeleton.

N.B.—No date, place of printing, or printer's name is given, but it was *most probably* printed in Cork, as the custom of printing street songs about condemned criminals has survived in the City to this day.—(J.B.)

[**1720**].—Another ballad, similarly printed. Like observation.

N.B.—These ballads are pasted to the end leaves of a MS. volume of Irish poems. [*Vide* Quaritch's Catalogue, No. 196 (1900), No. 3182.]

1721.—Pietas Corcagiensis, or, a View of the Green-coat Hospital; And other Charitable Foundations, In the Parish of St. Mary, Shandon, Corke, shewing the several steps that have been taken in Erecting and supporting these Charities. (*Samuel Terry.*) 4to; with plates. 94 pp. + 1 leaf postscript. [National Library, /Vol. 60 (Pamphlets); Brit. Mus.—2 copies. Robert Day; M. Dorey, Dublin; Royal Irish Academy, /H.T.; King's Inns; University Library, Cambridge, Hib. 7, 745, 26; Marsh's Library, Dublin (Cashel Loan Collection).]

1721.—The Beauty of Holiness in the Common Prayer; As set forth in Four Sermons Preach'd at the Rolls Chapel. The Rev. Thos. Bisse, D.D., Preacher of the Rolls. 8th Edition. (Reprinted at Cork, by *Samuel Terry*, for John Redwood. Bookseller, near the Exchange.) 8vo., cut down, viii + 144 pp. Folding plate between pp. 76 and 77. Folds in fours. [National Library, Dix Collection, 2 copies.]

1721.—The Club in a Diologue between father and son. James Puckle. (*Samuel Terry*) in Cock Pit Lane for John Redwood, Bookseller near the Exchange, 12mo. 96 pp. [British Museum (4377. a.)]

1721.—King George's Title Asserted. In a Sermon Preach'd at Cloynpriest, In the Diocesse of Cloyne; On the First Day of August, 1721, The Revd. Arthur d'Huvers, LL.B., Rector, etc. (*George Bennett.*) 4to IV. + 16 pp. Folds in twos. [Trinity College, Dublin.]

[**1721** ?].—An Answer to a book, intitl'd, Reasons offer'd for erecting a Bank in Ireland. In a letter to H. Maxwell, Esq., Hercules Rowley, M.P. (Re-printed *by* and for *George Bennett*, and are to be sold at his Shop opposite Broad Lane.) 8vo. 26 pp. [British Museum, /8227, aaa, 33.]

N.B.—The Dublin edition of above was printed in **1721.**

1722.—Undeniable Reasons for suspending the Habeas Corpus Act and securing Traytors, etc. Dated 10*th Novr.*, 1722. (*George Bennett.*) Broadside

(S.sh.) printed on both sides. [*Vide* Colonel Grant's Collection of Broadsides, now with Messrs. Pickering and Chatto, London; and University Library, Cambridge, Hib. i, 679, 1[8].]

1722.—The Defence of the Whole Society of Cool-Combers of the City and Liberties of the City of Corke, Upon their late Turn-out with their advice to their masters the Clothiers of the same. (No printer's name is given.) Broadside (s.sh.) printed on both sides. [*Vide* Col. Grant's Collection of Broadsides, now with Messrs. Pickering and Chatto, London; and University Library, Cambridge, Hib. i. 679, 1[9].]

1722.—The Speech at Large, which the Bishop of Salisbury Made to His Majesty. Relating to the Horrid Conspiracy lately Carried on by Several Persons in England against his Majesty's Sacred Person, &c., &c. (*Andrew Welsh.*) Single sheet, Fol. 2 columns. Roman Letter. [Bibliotheca Lindesiana, Cata. Eng. Broadsides, No. 1221.]

[**1722**?].—An Abstract of the several Publick Charities, given by Edward Colston, Esq., In his Life Time. (*Samuel Terry*, Printer in Cork and Limerick.) 12mo. 8 pp. [The Dublin Municipal Library.]

N.B.—No date is given, but Edward Colston died in October, 1721.

1723 [**1722**?]. An Almanack; or, Diary Astronomical, etc., for the year of Our Lord 1723. John Knapp. (*Andrew Welsh.*) 12mo. 40 pp. + 4 leaves. [National Library. Imperfect.]

1723.—An Exact and Entire Abstract of the whole Tryal of Christopher Layer as it is publish't by the Celebrated Author, Mr. Abel Boyer, &c. (*John Redwood.*) 12mo. 63 pp. + 1 p. (blank). [Maynooth Library.] In vol. of Pamphlets in MSS. Room.]

1723.—Conscious Lovers. A Comedy, etc. Sir Richard Steele. 12mo. 4 leaves (title, etc.) + 77 pp. + 3 pp. (epilogue, &c.). "Corke, Printed, and Sold by J. Redwood in Castle Street." [Nat. Lib. Dix Collection.]

[**1723**?].—The Blunderful Blunder of Blunders, Being an Answer to the Wonderful Wonder of Wonders [of Dean Swift]. (*George Bennett.*) 4to. 4 pp. [British Museum, 11631, bb. 5.]

1723.—The Spiritual Week, Consisting of Rules for the Conduct of Life, with Meditations and Prayers for Every Day. To which are added Particular Offices for Lent and other Times of Humiliation and Fasting; For the Sick; and for the Holy Communion. (*John Redwood*, in Castle Street.) 12mo. iv + 136 pp. Has "advertisement" at end. [British Museum. 4468, a. 41; Nat. Lib. Dix. Imperfect.]

N.B.—On the back of the title-page of the Spiritual Week, etc., is the following advertisement:—"Lately printed and sold by the Publisher Hereof; The Beauty of Holiness in the Common Prayer, Being an Explanation and a Vindication thereof: as set forth in Four Sermons by Tho. Bisse, D.D., As also A Chronological Table, shewing the Lateness and Rise of several erroneous Popish Doctrines, pr. 4d." This advertisement is copied here, as these two books were evidently printed in Cork. At "1721," above, an eighth edition of the first item appears printed by *Terry* for Redwood, and this may be the edition referred to in the advertisement, though the use of the term "lately" in this latter strongly suggests a further edition, not improbable by any means, as but a small number of copies were then comprised in an edition.

[**1723** ?].—The Great Duty of Frequenting the Christian Sacrifice, And the Nature of the Preparation Required: With Suitable Devotions. Partly Collected from the Ancient Liturgies. To which are perfixed (*sic*) Instructions for Confirmation. 8th edition. (Reprinted in Cork by *John Redwood*, in Castle Street.) 12mo. 4 leaves + 239 pp. + 2 leaves (contents and subscribers). [National Library, Dix Collection.]

N.B.—At the back of the title-page are advertised as "lately printed": (1) The Beauty of Holiness, etc. (Bisse); (2) The Spiritual Week, etc.; (3) A Protestant's Resolution, showing the Reasons why he will not be a Papist.

1723 (to **1725**).—The Cork News Letter. (*George Bennett.*) Sm. folio. Double columns. [Vide Windele's Cork; Madden, vol. ii, p. 167; and Tuckey.]

N.B.—The number of this News Letter that is described by Windele is given by him as "828." Assuming that this number is not a misprint, it may be taken with certainty that this paper was not a daily paper; thus, if it were only issued weekly, it must have first appeared in 1707 or 1708. If, however, the paper was issued twice weekly, which is probable, then it was first issued in 1715 or 1716. Even if thrice weekly, which is hardly likely, it must have commenced in 1717. *Caulfield* states that this paper appeared *about 1716.*

1724 [**1723** ?].—An Almanac: or Diary Astronomical, Meteorological, Astrological. For the Year of Our Lord, 1724, It being Leap-Year, Containing the Solar-Ingresses, Eclipses of the Luminaries, Rising and Setting of the Sun, for the City of Cork, &c., &c. John Knapp, Watch and Clockmaker. Printed and sold by *Andrew Welsh*, in Castle Street. 12mo. 44 pp. [The Dublin Municipal Library; National Library, Dix; and N. Massey.]

1725.—Les Veritez & Les Devoirs De La Religion Chretienne Tirez Des Livres Du V. et Du N. Testament Exprimez Dans les Termes Mêmes De l'Ecriture Ste. avec vn abrége de l'histoire Ste. du V. Test., Depuis Adam, jusqu'a J. Christ. & vn Discours préliminaire sur l'Inspiration de l'Ecriture Ste. By M. Laval. Imprime a Cork chez *Andrew Welsh*, MDCCXXV. Collation: Title-page and verso blank, and dedication (1st September, 1724), 3 leaves; preface, liii pp. (verso of last p. blank); text, 264 pp., and 3 leaves of index. The Abridgment of the Testament is separately paged, i.e., 4 leaves and 149 pp.; Table, 12 pp. and 1 p. blank; Tables Chronologiques, etc., 27 leaves. [British Museum /854, i. 8.; the late Canon Rd. Travers Smith, Dublin; University Library, Cambridge, Hib. 7.725,4; Magee College, Derry ($7^{10}/16 \times 5^{11}/16$).]

1725.—A Sermon, preach'd at Christ's Church, in the City of Corke, upon Michaelmas Day, before the Worshipful Mayor and Corporation of that City, Being an Anniversary day of Thanksgiving observed for the Surrender of the City of Corke to the Arms of the Great King William of Ever-glorious Memory in the late Happy Revolution, &c. The Revd. Boyle Davies, M.A. (*George Bennett.*) 4to. 12 pp. $8 \times 5\frac{3}{4}$.

1725.—Inquiry into the plan and pretensions of Mr. Sheridan. Sermon preached at Corke on the Boyne Anniversary. [*Vide* Sale Catalogue of M. W. Rooney, February, 1876, p. 16, No. 478.]

III.

A FRESH AUTHORITY FOR THE SYNOD OF KELLS, 1152.

By Rev. H. J. LAWLOR, D.D.

Read January 9. Published February 2, 1922.

The Synod of Kells is of much importance for the historian who desires to trace the development of diocesan episcopacy in Ireland. But of its proceedings our knowledge is not great. The principal authority is the Book of Clonenagh, as quoted by Keating.[1] But Keating's extracts, though they give us precise dates, and a list of those who took part in the Synod, tell us no more of its acts than that it condemned simony and usury, and commanded the payment of tithes; and that the President, Cardinal Paparo, bestowed palls on the four archbishops. The Four Masters, if indeed the Synod which they record to have been held by Paparo *at Drogheda* in 1152 is really the Synod of Kells, state that it enjoined tithes, and prohibited concubinage, the demand of fees for the administration of certain sacraments, and the sale of church property; but they say not a word about the palls, the giving of which other authorities regard as its most important business.[2] That the Synod did more than can be ascertained from these two sources is made clear by a letter from Pope Honorius III to Henry of London, Archbishop of Dublin, dated 6th October, 1216.[3] It states that Paparo constituted the dioceses of Ireland, and determined their boundaries, and in particular gave Henry a large portion of the diocese of Glendalough, at the same time providing for the future union of the rest of it with Dublin. Moreover, in the acts of a Synod, held by Simon Rochfort, Bishop of Meath, at Newtown, near Trim, in 1216, an ordinance of Paparo at the Synod of Kells is recited, to the effect that as the bishops of the weaker sees died off, their dioceses should be converted into rural deaneries.[4] It is obvious that the Synod of Kells took measures to suppress sees, and fixed the limits of dioceses.

These facts are, I believe, all that we can learn about the doings of the Synod of Kells from what may be called the primary authorities hitherto known to us. But Sir James Ware had in his hands a list of the sees of Ireland as they were divided among the four provinces by Paparo. He says that it was preserved in the Codex Censuum of Cencius the Chamberlain. On it is based the greater part of chapter xvi of his *Antiquities of Ireland*.[5]

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[1] *History of Ireland*, ed. Comyn and Dinneen, vol. iii, p. 312 ff.

[2] John of Hexham in *Symeonis Monachi Dunelmensis Opera Omnia*, ed. Arnold (R.S.), i. 326; *Historia Pontificalis* in *M. H. G.*, xx. 539 f.

[3] *Crede Mihi*, ed. Gilbert, p. 11.

[4] Wilkins, *Concilia*, i. 547.

[5] Jacobi Waraei, *De Hibernia et Antiquitatibus ejus Disquisitiones*, ed. sec., London, 1658, pp. 83–87. Translated in Harris, *Ware's Works, Ant.*, p. 285 f.

Now, Mr. E. J. Gwynn lately examined ms. 92 of the Library of the School of Medicine at Montpellier. The main contents of this manuscript are Geoffrey Monmouth's History of the Kings of Britain, and Bede's Ecclesiastical History. They are written by the same hand, which, according to the Catalogue of the manuscripts of the Library, is of the twelfth century.[1] On the page which contains the *explicit* of Geoffrey's work is a list of Irish sees. Mr. Gwynn tells me that it is written in a hand larger than that of the rest of the ms., but apparently of the same date. Supposing that it might be of use to me, he most kindly made a careful copy of it, which he placed in my hands on his return home. The copy was not long in my possession when I turned to Ware, and convinced myself that it was very closely related to the document which he used for his disquisition "On the ancient disposition of the bishoprics of Ireland." Some months elapsed before I could examine Ware's source. The *Liber Censuum* was compiled by Cencius the Chamberlain, afterwards Pope Honorius III, in 1192. Its purpose was to set out a list of the bishoprics and religious establishments from which the Pope claimed revenue. Its publication was begun by M. Paul Fabre in 1889, and after his death the work was continued by Monseigneur L. Duchesne. It has not yet been completed. The list of Irish bishoprics is in the second fasciculus (1901).[2] Now, Cencius based his work on a *Provinciale*—i.e., a list of bishoprics grouped in provinces—which had been drawn up before his labours began. Duchesne gives us a specimen of such documents: it is the *Provinciale* of Albinus, Cardinal Bishop of Albano, which may be dated 1188–9.[3] Cencius seems to have used a yet earlier *Provinciale*, from which that of Albinus was transcribed. It was probably compiled between 1164 and 1167.[4] It is obvious to anyone who compares the documents that the list which Mr. Gwynn has given us has a much more intimate relation to the *Provinciale* of Albinus than to the *Liber Censuum*. The *Provinciale* and the Montpellier list are, in fact, practically identical, save for a number of clerical errors on one side or the other. But these errors are important. The Montpellier ms. sometimes gives the place-names more correctly than the edited list: frequently the latter is more accurate than the former. It is clear, therefore, that neither is copied from the other. They are descendants of a common exemplar. This exemplar must have been written, at the latest, ten or fifteen years after the Synod of Kells.

[1] *Catalogue des Manuscrits des Bibliothèques Publiques des Départements*, vol. i (1849), p. 320.

[2] *Le Liber Censuum de l'Église Romaine, publié avec une préface et un commentaire*, Paris, 1889–, vol. i, p. 232 ff. The work of Cencius is contained in the Vatican ms. 8486. Ware does not follow his authority with scrupulous accuracy.

[3] *Op. cit.*, ii. 85 ff., from the Vatican ms. Ottob. Lat. 3057. The list of Irish bishoprics begins on p. 101.

[4] R. L. Poole, *The Papal Chancery*, 1915, p. 193 f.

The Montpellier list runs as follows :—

¶ In hibernia sunt *prouincie* iiij[or].

¶ Temp*ore* Domini Eugenii *pape* iij facta est diuisio toci*us* hiber*nie* i*n* iiij[or] metropolos (*sic*) *per* ioha*nne*m paparo *presbyterum* card*inalem* tit*uli* Sa*ncti* laure*ncii* i*n* da[m]aso apostolice [s]edis legatum modo[1]

¶ Metropolitanus armachie primas tocius hibernie. hos habet sufraganeos sub se.
Ep*iscopu*m conue*r*ens*em*.
Ep*iscopu*m de dunda lehglas.[2]
Ep*iscopu*m lugundunens*em*.[3]
Ep*iscopu*m de clunirand.[4]
Ep*iscopu*m de conannas.[5]
Ep*iscopu*m de arcdahad.[6]
Ep*iscopu*m de Rathboth.[7]
Ep*iscopu*m de Rathlurig.[8]
Ep*iscopu*m de damliagg.[9]
Ep*iscopu*m de darnth.[10]

¶ Metropolitanus dublinensis hos habet suffraganeos sub se.
Ep*iscopu*m de clendalacha.[11]
Ep*iscopu*m de ferna.[12]
col. 2] Ep*iscopu*m / de camnig.[13]
Ep*iscopu*m de lethglen.[14]
Ep*iscopu*m de celldara.[15]

¶ Metropolitanus cassellennensis[16] hos habet suffraganeos sub se.
Ep*iscopu*m de celdalna.[17]
Ep*iscopu*m de lulineo.[18]
Ep*iscopu*m de insula gathai.[19]
Ep*iscopu*m de celliunabrach.[20]
Ep*iscopu*m de ymlech.[21]
Ep*iscopu*m de roscree.[22]
Ep*iscopu*m de Watifordida.[23]
Ep*iscopu*m de lismor.[24]
Ep*iscopu*m de cluanuama.[25]
Ep*iscopu*m de corchaia.[26]
Ep*iscopu*m de Rosailithir.[27]
Ep*iscopu*m de arfordt.[28]

Due aut*em* ecclesie. sunt sub eodem archiepiscopo que dicunt se habere debere ep*iscopo*s quor*um* nomina sunt haec. Ardimor[29] et mu*n*garath.[30]

¶ Metropolitanus. Tuatuensis[31] hos suff*raganeos* habet. sub se.
Ep*iscopu*m de mageo.[32]
Ep*iscopu*m cellaaid.[33]
Ep*iscopu*m de rosconconmon.[34]
Ep*iscopu*m de culuanfat.[35]
Ep*iscopu*m de aicbal.[36]
Ep*iscopu*m de conairi.[37]
Ep*iscopu*m de celmunduach.[38]

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[1] *l.* hoc modo.

[2] *l.* Dún dá Lethglas, now Down. Fabre imagines that Dún dá Lethglas was Dundalk, from which the see was soon translated to Downpatrick!

[3] Adj. of Lugbad, now Louth. [4] Cluain iráird, now Clonard.

[5] *l.* Cenannas, now Kells, Co. Meath. [6] *l.* Ardachad, now Ardagh.

[7] Ráith Both, now Raphoe. [8] Ráith Lúraig, now Maghera, Co. Derry.

[9] Dam-Liag, now Duleek, Co. Meath.

[10] Apparently a corruption of Dairiu, dat. of Daire, now Derry. See below, p. 19 f.

[11] *l.* Glenn dá locho, now Glendalough. [12] Now Ferns.

[13] *l.* Cell Cainnig, now Kilkenny. According to Fabre, Cainnig, or, as he prints it, Cairuc, was one of the two sees of Ossory which preceded Kilkenny.

[14] Now Leighlin. [15] Now Kildare.

[16] *l.* Casselensis. [17] Cell da Lúa, now Killaloe.

[18] A corruption of Luimnech (Luimneċ), now Limerick.

[19] Inis cathaig, now Scattery, an island in the Shannon, near Kilrush.

[20] *l.* Cell Finnabrach, now Kilfenora. [21] Imlech, now Emly.

[22] Now Roscrea. [23] Waterford.

[24] Now Lismore. [25] Cluain úama, now Cloyne. [26] Corcach, now Cork.

[27] Now Ross. [28] Árd fert, now Ardfert. [29] Ard mór, now Ardmore.

[30] Mungairit, now Mungret, near Limerick. [31] Tuamensis.

[32] Mag n-eo, now Mayo. [33] *l.* Cell alaid, now Killala. [34] *l.* Roscommon.

[35] *l.* Cluain ferta, now Clonfert.

[36] This name is uncertain. It may be read *alcbal* or *aicbai*.

[37] See below, p. 20. [38] *l.* Cell mic Duaich, now Kilmacduagh.

It will be observed that no mention is made of the place of origin of the ordinance of Paparo concerning the ecclesiastical provinces and the bishoprics of Ireland; and, as to its date, we are only told that it was put forth while Eugenius III was Pope. But no one who is familiar with the documents on which our knowledge of the Synod of Kells depends can doubt that the ordinance of Paparo was issued at that assembly.

How, then, did this list come to rest at Montpellier? I may venture a guess which seems to me not improbable. The nucleus of the Montpellier collection is described in the Catalogue as "Fonds de Bouhier," which comprises a large number of MSS. gathered from many quarters. Of the first 150 MSS. described in the Catalogue, no less than sixty are referred to it. The majority of the others whose origin is known (about sixty in all) came from Burgundy; especially from Clairvaux (fifteen) and Troyes, which is about thirty-five miles from it (seventeen). Now the Synod of Kells was the final result of the labours of St. Malachy of Armagh. He was on terms of affectionate intimacy with St. Bernard of Clairvaux, who stood beside him in his last hours, and wrote his life. St. Bernard, and no doubt many of his community, were well aware of his scheme for the organization of the Church of Ireland. Paparo also seems to have been a friend of St. Bernard. At all events, in a short letter written in the year of the Synod of Kells, and intended for the ear of the Pope, he goes out of his way to eulogize him, contrasting his conduct with that of another legate who had been sent to Germany.[1] We may infer that he followed Paparo's movements with enthusiasm. Indeed, we can hardly imagine that, in any place outside the British Isles and Rome, this record would have been of interest, save at Clairvaux. I suggest that it was transcribed there from Paparo's manuscript of the acts of the Synod,[2] and that it was subsequently transferred, with other Clairvaux MSS., to Montpellier.

The list, as I have hinted, is full of errors in the place-names; but they are not more numerous than might be expected by a student of the documents of the Papal Chancery. Attention may be called to two which are more serious than the rest. Among the suffragans of Armagh, we have the Bishop of Rath Luraig and the Bishop of Darnth (Derry). These are in fact the same person. At this period the see of the Diocese of Cenél Eoghain

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[1] S. Bernardi, *Epist.* 290 (Migne, *PL.* clxxxii. 496).

[2] It is true that on this hypothesis we should not expect to find the words "tempore domini Eugenius papae" in the heading of the list, both in Albinus and in the Montpellier copy. They seem to imply that Eugenius was not the reigning Pope. He died on 8th July, 1553, and St. Bernard on 20th August, 1553, nearly a year and a half after the Synod. But the objection does not seem serious.

was at Rath Luraig; but the bishops were nevertheless often styled bishops of Derry.[1]

Again, among the suffragans of the Archbishop of Tuam we find the Bishop of Aicbal (?)[2] and the Bishop of Conairi. The former name is certainly a corruption of Achad, which appears in the lists of Albinus and Cencius. But, if so, we are at once struck with the fact that Achad Conairi (Conaire) is the Irish spelling of the name of the diocese which we call Achonry. Someone has obviously again made two dioceses out of one. The words "episcopum de" before Conairi should therefore be deleted, though, from the agreement of the other lists with ours, we must infer that they stood in the original record. Ware's bold equation of Conairi (or, as he prints it, Cinani) with Clonmacnoise (Cluanensis)[3] is impossible.

This conclusion invites us to further speculation. If we are right, Clonmacnoise is not mentioned in our document.[4] But there can be little doubt that the Diocese of Clonmacnoise was already constituted; and in fact its Bishop, Muirchertach Ua Mail Uidhir, was present at the Synod. So also was Tuathal Ua Connachtaigh, Bishop of Ui Briuin (later known as the Diocese of Kilmore)[5]; and the obits of Aedh Ua Finn, Bishop of Breifne (the same district), in 1136, and Muirchertaich Ua Mail Moicheirge, Bishop of Ui Briuin, in 1149, are recorded in the Annals of Tigernach. But this bishopric also is absent from our list. Are these omissions due to the blunders of a scribe? We might think so, but for a remarkable piece of evidence to the contrary. The chronicler known as Henry of Peterborough gives us a list of the bishops who did fealty to Henry II in 1171. It seems to include the whole of the Irish episcopate; but neither the Bishop of Ui Briuin nor the Bishop of Clonmacnoise is mentioned. It is, therefore, probable that these two bishoprics were suppressed—so far as an ordinance of Paparo could achieve such a result—in 1152. Yet both of them remain; Clonmacnoise, it is true, in name only, to this day.

Some dioceses in the list which no longer exist deserve attention. They are Kells, Duleek, Inis Cathaigh, Roscrea, and Mayo. Kells was not recognized at the Synod of Rathbreasail in 1110, though it seems to have been in

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[1] See *Irish Church Quarterly*, x (1917), p. 226 ff. The see seems to have been translated from Derry to Rath Luraig (Maghera) between 1137 and 1150. It remained in the latter place up to the end of the thirteenth century.

[2] See above, p. 18, note 36.

[3] Fabre also, more dogmatically than Ware, identifies Conairi with Clonmacnoise, giving no reason for his opinion.

[4] So Ware, with reference to the *Liber Censuum*, p. 85; but he changes his mind on p. 87.

[5] Keating, iii. 316.

existence in that year. It appears in the list of Benedict of Peterborough, but it was incorporated with Clonard about 1213.[1] Duleek was one of the two dioceses of Meath in the Rathbreasail Acts.[2] It was incorporated with Clonard between 1152 and 1191[3]—probably, indeed, between 1152 and 1171, since it has no place in Benedict's list. Inis Cathaigh does not appear in the Rathbreasail Acts, nor in Benedict. I have found only one bishop of that see between 1119 and 1360—namely, Aedh Ua Beacain, who died in 1188.[4] For a short time, however, after 1360 it had a precarious existence. A bishop named Thomas was provided for it in that year; but he was opposed by the neighbouring bishops, and the Pope ordered inquiry to be made whether Inis Cathaigh was a cathedral or a parochial church.[5] John was provided in 1402,[6] and Richard in or before 1414.[7] In 1447 John Greny was provided, as the successor of a deceased bishop named Denis, for "Insulan. in provincia Cassellensi,"[8] which is probably Inis Cathaigh. If so, he is the last known bishop of the see. It is now in the Parish of Kilrush, Diocese of Killaloe. Apart from our document, I can find no evidence of a Diocese of Roscrea.

The Diocese of Mayo appears here for the first time. It is also in Benedict's list. In the immediately following period only two bishops of that diocese are known: Gilla Isa Ua Mailin, †1184-5, and Ceile Ua Dubthaigh, †1210.[9] Under Innocent III, Mayo was adjudged a parochial church under Tuam by the Papal Legate, Cardinal John, in 1201, and this decision was confirmed by subsequent Popes.[10] But the diocese was revived about 1400, and from 1428 to 1572 we have a fairly complete succession of bishops.[11] The last bishop, Eugenius MacBrehon, was provided in 1541. He was in office on 7th February, 1572, when he was fined for not appearing before the High Commission Court.[12] He died before 12th February, 1574.

Ware makes no reference to the note that the churches of Ardmore and Mungret claimed that they ought to have bishops. It is, in fact, omitted in the *Liber Censuum*, though it appears in the *Provinciale* of Albinus. Mungret is only three miles from Limerick; and it is not likely that its demand was that it should be made the centre of a diocese apart from Limerick. Possibly

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[1] See my *St. Bernard's Life of St. Malachy of Armagh*, 1920, p. xxviii, note. The mention of the Bishop of Kells in our list confirms the argument of that note.

[2] Keating, iii, 302. [3] *Life of St. Malachy*, p. l. [4] Four Masters.

[5] A Theiner, *Vetera Monumenta Hibernorum et Scotorum*, pp. 316, 318, 324.

[6] *Cal. of Papal Letters*, v. 499, 503. [7] *Ibid.* vi. 513.

[8] Eubel, *Hierarchia Catholica*, ii. 170, 301.

[9] *Annals of Ulster*; *Annals of Loch Cé.*

[10] Theiner, p. 4 (cp. Four Masters, 1201); *Cal. of Pap. Lett.*, i. 190.

[11] Eubel, *op. cit.*

[12] *Register of High Commission Court* in Public Record Office, Dublin, ff. 34v, 36v, 40v, 46, 47v, 50.

the Irish of the district desired that St. Mary's Church, a Danish foundation, and without ancient ecclesiastical tradition, should be ousted from its position as the Cathedral Church in favour of Mungret, founded by St. Nessan, a disciple of St. Patrick.[1] The claim was at any rate fruitless. The Annals apparently name no bishops of Mungret after 1152.

Similarly in the claim of Ardmore we may see evidence of a quarrel for precedence between the two saints of the Diocese of Lismore—Carthach or Mochuta, of Lismore, and Declan, of Ardmore.[2] In this case, however, the demand may have been for the formation of a new diocese to be carved out of Lismore. In spite of Paparo's apparently adverse decision, there was in fact for a short time a Diocese of Ardmore. Its bishop, according to Benedict, did fealty to Henry II. He was probably that Eugenius, Bishop of Ardmore, who with his presumed rival, Christian, Bishop of Lismore and Papal Legate, witnessed a charter of Diarmait MacCarthy between 1172 and 1179.[3] The see was in existence in 1210;[4] but we have no later mention of it.

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[1] *Tripartite Life of St. Patrick*, ed. Stokes, p. 204.

[2] For their lives, see P. Power's edition in vol. xvi of the Irish Texts Society.

[3] For the text of the charter, see C. A. Webster, *Diocese of Cork*, 1920, p. 375. The date is fixed by the fact that Christian's successor was in office in 1179, while the predecessor of another episcopal witness (Gregory of Cork) died in 1172.

[4] Migne, *PL*. ccxvi. 234 (Epist. 48 of Innocent III).

IV.

CROMM CRUAICH OF MAGH SLEACHT.

By JOHN P. DALTON.

Plate I.

[Read June 27, 1921. Published February 28, 1922.]

In his Catalogue of the Irish Manuscripts preserved in the Library of Trinity College, Dublin, Dr. John O'Donovan defined Magh Sleacht as "that level part of the barony of Tullyhaw (in the county of Cavan) in which the island of Breaghwee, now Mogue's Island, the church of Templeport, and the little village of Ballymagauran are situated."[1] That the town of Magauran, or of Mac Samradhain, was in Magh Sleacht is shown by an entry in the Irish Annals for 1459.[2] That Inis Breaghmhuighe was in Magh Sleacht is proved by the older Irish Lives of St. Moaedhog, the saint's birthplace being named in them "Inis brecmuige for Mag Slect."[3] That O'Donovan was right in identifying Inis Breaghmhuighe with the islet of Templeport Lake, just facing Templeport Church—*Tempall an Phuirt*, or "The Church of the Bank"[4]—has recently been demonstrated by records which in his time were hidden away in the Roman archives.[5]

In restricting Mágh Sleacht within the limits of Tullyhaw barony O'Donovan, moreover, was in agreement with Colgan, who wrote in his "Vita de S. Dallano Martyre": "Natus est in Connaciae regione Ultoniae contermina, quam prisci Masraige et Cathraige Sleacht, moderni vero Teallach Eathach nuncupant."[6] *Teallach Eachdaich*, which has been angli-

[1] "Manuscript Catalogue" (T. C. D.), p. 159.

[2] See "Annals of Ulster," edited by MacCarthy, vol. iii, p. 199.

[3] MS. 23, O 41, R.I.A., p. 242; H 2. 6, T.C.D., pp. 33, 34.

[4] See "Annals of Four Masters," A.D. 1496 (O'Donovan's edition).

[5] See "De Annatis Hiberniae" (published by the Maynooth Record Society), pp. 231, 234, and 237. *Vide infra*, p. 39.

[6] "Acta Sanctorum Hiberniae," p. 203. Colgan professes to have taken this from the "Acts of the Synod of Druimm Ceta." The ancient preface to the "Amra Choluim Chilli" ("L. na h-Uidhri," pp. 5, 6) gives the same information ("Dallan Forgaill do Masraigi i Maige Slect"). O'Beirne Crowe ("Amhra C. Cille," p. 9), and Hennessy ("Book of Fenagh," p. 89) misconstrue this text when they make St. Dallan not merely a native of Masraighe Sleacht, but one "of the Masraighe of Magh Sleacht."

cized Tullaghagh, or Tullyhaw, represented the tribe-land of the descendants of Eochaidh—a Breifni sept of whom in later centuries the Mac Samhradhans, or Magaurans, were hereditary chiefs.[1] Their lords paramount were the O'Ruaircs, kings of West Breifni, East Breifni having been concurrently swayed by the cognate family of Ua-Raghallagh, or the O'Reillys. Each and all of these tribes belonged to the Ui-Briuin race of Connaught, a ruling stock who, tracing their ancestry to Brian, son of Eochaidh Muighmeadhoin, had branched into numerous septs, and achieved supremacy throughout Breifni, probably within a century of the introduction of Christianity.

Breifni, or Sen-Breifni[2]—an area of wide extent, for it stretched from Donegal Bay to the north-east corner of Co. Meath—thus came to be known by the synonymous designations of Ui-Briuin, Breifni, and "The Two Breifnis." Its outlines are permanently graved on our ecclesiastical maps, the present diocese of Kilmore being territorially co-extensive with ancient Breifni. Among the *obits* recorded in Irish Annals are those of a bishop "of Breifni, from Drumcliff to Kells," in 1355, and of "the bishop of the two Breifnis" in 1464.[3] In 1258 the hostages of "all the Ui-Briuin from Kells to Drumcliff" were given to Aedh O'Conor, King of Connaught.[4] These entries will sufficiently demonstrate the geographical identity of Kilmore Diocese with the united Breifni kingdoms.

In the Annals, again, deaths of bishops of Conmaicne are registered six times in succession during the thirteenth and fourteenth centuries.[5] The ecclesiastical Conmaicne remains unaltered as the diocese of Ardagh, which had within it two rural rectories—that is, parochial population-groups unconnected with monasteries or termon lands—named respectively Muintir Anghaile and Muintir Eoluis.[6] The same names designated the two affiliated groups of tribes which, together, composed the Clann Fearguis of this region—reputed descendants of Fergus Mac Roy—and occupied the territory of Conmaicne.[7] The boundary between Leitrim and Longford counties cuts the diocese of Ardagh transversely, just along the line which separated Muintir Anghaile on the east side from Muintir Eoluis on the west.[8] Muintir Eoluis thus corresponded territorially to the Leitrim portion of Ardagh

[1] "Irish Topographical Poems" (edited by O'Donovan), p. 55.

[2] So called in the "Dindseanchas of Mag Luirg" (Todd Lecture Series, R.I.A., vol. x, p. 397).

[3] "Annals of Ulster." See also *sub annis* 1314 and 1421.

[4] "Annals of Lough Ce," vol. i, p. 429.

[5] "Annals of Ulster," 1224, 1230 *bis*, 1237, 1289, 1322, 1343.

[6] See "De Annatis Hiberniae," p. 163 (*sub anno* 1458).

[7] See "Irish Top. Poems," pp. 57, 58.

[8] For references see Hogan's "Onom. Goed.," pp. 546, 548.

Diocese, the area owned by the associated Conmaicne septs, who traced their descent from an eponymous Eoluis.[1] Ethnographically Muintir Eoluis denoted the Conmaicne occupiers of Magh Rein; and in our native records Magh Rein, Conmaicne Magh Rein, and Muintir Eoluis apply as interchangeable terms to the tribe-lands of this people.[2]

For centuries the Conmaicne chiefs rendered tribute to the O'Ruairc kings of Breifni, and acknowledged them for suzerains. The Annals thus describe these earlier O'Ruaircs as "kings of Breifni and Conmaicne."[3] Political amalgamation is apt to obscure territorial boundaries; and, just as O'Flaherty included Anghaile within Magh Rein, so have some undiscriminating documents extended Breifni over Muintir Eoluis.[4] But as to one central fact there is entire agreement in all the earlier texts: Magh Rein comprehended Muintir Eoluis, that is, the region owned by the Mag Rannalls (or family of Reynolds) and their correlative septs.[5] As this region coincided with the portion of Co. Leitrim that lies east of Lough Allen,[6] Magh Sleacht at one side was wholly bounded by Magh Rein.

While the precise limits of Breifni and of Magh Rein, in certain directions, may not be free from ambiguity, no confusion whatever exists as to the geographical relations of Magh Rein and Magh Sleacht. They lay side by side, coterminous, but mutually exclusive, their line of separation being traced by the boundary between the baronies of Carrigallen and Tullyhaw, which runs south-east from the slopes of Slieve-Anierin. On the Leitrim side of this line stretched Magh Rein; bordering it on the Cavan side lay Magh Sleacht.

But the junction of the dioceses, Ardagh and Kilmore, is not collinear with the same boundary, for two Conmaicne districts got severed from Ardagh and incorporated with Kilmore. Their ancient names were Cinel-Luachain and Magh Angaidhe; their present ecclesiastical, or parochial,

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1 "Book of Fenagh," p. 7.

2 While the Annals equate Muintir Eoluis and Conmaicne Magh Rein, it should be noted that O'Flaherty ("Ogygia," p. 275) and the "Book of St. Caillin" (p. 385 *et seq.*) extend Magh Rein or Rein to Anghaile (Annaly).

3 See "Annals of Lough Ce," *sub annis* 1087, 1122, 1172, 1256.

4 E.g., Perrott's "Indenture of Composition" (see Hardiman's "Iar-Connaught," p. 347). In a letter from Queen Elizabeth to Lord Deputy Saintleger, on the other hand, Breny (Breifni) is limited to the "Countie of Cavan." See "Calendar of Pat. & Cl. Rolls" (Morrin's), vol. ii, p. 439. Anglo-Irish records cannot be relied on for the boundaries of ancient districts.

5 For fuller references on the ancient localities here named consult Hogan's "Onom. Goed."

6 "Irish Top. Poems," pp. 57–59 and notes.

names are Oughteragh and Drumreilly.[1] In early times the O'Ruairc kings chose Tuaim Seanchaidh, at the north side of Magh Angaidhe, for their principal seat; and, judging by the number of "O'Ruairc castles" which subsequently arose in the neighbourhood,[2] this Magh must have been appropriated for the use, as demesne land, of the O'Ruairc royal family and its principal officers of state.

Cinel Luachain, primarily the name of a Conmaicne sept,[3] whose chiefs were the MacDorchaidhs, got politically fused as a *tuath* with O'Ruairc's division of Ui-Briuin Breifni, and thereby segregated from the Mag Rannall chiefry, to which it originally belonged. After the thirteenth century the Annalists cease to distinguish the O'Ruaircs as kings of Breifni and Conmaicne, showing that the O'Ruairc suzerainty over Conmaicne had then lapsed[4]; and in the fourteenth century the dominion of O'Ruairc embraced eight petty kingdoms, of which the sub-kingdom of MacDorchaidh made one.[5] Thenceforth Cinel-Luachain and Magh Angaidhe formed part of West Breifni, the corresponding ecclesiastical divisions of Oughteragh and Drumreilly becoming merged in the diocese of Kilmore. But the districts were, and are, still part and parcel of the original Conmaicne Magh Rein; and their absorption into the Ui-Briuin governmental area of church and state organization cannot obliterate, though it may obscure,[6] the ancient boundary-line separating Magh Rein and Magh Sleacht.

At the dawn of our recorded history Magh Sleacht belonged to the Masraighe or Tuath Masraighe, one of the rent-paying tribes of ancient Ireland.[7] These Masraighe must have occupied Magh Sleacht in St. Patrick's time, for in 464 A.D. they were still strong and bold enough to make a marauding dash into Meath.[8] In the following century they were ousted, or

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[1] This is proved by several entries in "De Annatis Hiberniae" (see pp. 230, 232, and 238). O'Donovan ("Four Masters," 1403 A.D., and "Top. Poems," note 267) correctly identified Cinel-Luachain.

[2] See M'Parlan's "Statistical Survey of Co. Leitrim," p. 90 *et seq.*

[3] See "Book of Fenagh," p. 389.

[4] The O'Ruaircs sometimes strove to reassert their sway over Magh Rein (see, e.g., "Ann. L. Ce," vol. ii, p. 57); and they were so strongly settled there in Queen Elizabeth's time that Co. Leitrim was then commonly called "O'Royrk's (or Rowerk's) Country" in State papers. See, e.g., Perrott's "Indenture" in Hardiman's "Iar-Connaught," p. 346, and Morrin's "Calendar," vol. ii, p. 522. So was Clandeboy an "O'Neill's Country," but that did not make it part of ancient Tir-Eoghan.

[5] "Irish Top. Poems," pp. 55–57.

[6] That it is liable to do so is evidenced by Dr. Healy's erroneous description of Magh Sleacht ("Life of St. Patrick," p. 183).

[7] "Book of Ballymote," folio 140.

[8] "Four Masters," *sub anno*; also "Book of Fenagh," p. 89.

reduced to servitude, by the Ui-Briuin, who had then extended their supremacy over the Conmaicne Magh Rein. The Book of St. Caillin, or of Fenagh, in its existing form, was evidently compiled before Ui-Briuin dominance had been shaken in Magh Rein,[1] for its rhapsodies are everywhere charged with glorification of the O'Ruaircs. The writer, or writers, based their fiction, that the Conmaicne were first brought to Magh Rein as feudatories of the Ui-Briuin, on a forged unification of Aedh Finn, son of Fergna or Brian,[2] with Aedh Dubh of the Attacotic Glasraighe,[3] from whom the Conmaicne had wrested Cairbre Gabhra. Incredible, indeed, is the story that the Ui-Briuin would have vacated the vast plain that stretches from Lough Allen east to Lough Sheelin to make room for a migrant colony of the Conmaicne Dunmor.[4]

But if the versifiers of St. Caillin's book cannot be relied on for history, they may be trusted for an exhaustive inventory of the dues, tributes, and immunities of their patron's richly endowed foundation at Fenagh.[5] These they enumerate for Magh Rein in minutest detail; yet, though the Masraighe were admittedly in possession of Magh Sleacht in St. Caillin's time,[6] and had then received the rudiments of Christianity, nowhere is tribute or contribution claimed from their territory. The Conmaicne tradition recalled the Masraighe only as a hostile and hated race, distinct by blood and location from the proud breed of Magh Rein; and, according to the same record, the Ui-Briuin had attained supremacy over the Conmaicne before they subjugated the Masraighe. But when the Masraighe were reduced they disappeared, as a separate people, from the soil. The Conmaicne, on the other hand, always preserved their tribal existence, never sinking lower than the tributary status.

At what date the Masraighe were actually extirpated I need not here inquire. Their *tuath* was appropriated by the Teallach Eachdhaich sept of Ui-Briuin, and thenceforward Magh Sleacht invariably appears as part of the Teallach-Eachdhaich patrimony. Before the break up of the old tribal regime by the settlement of Ulster, in 1610, all Breifni, "from Kells to

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[1] The editors assign its compilation to a date "about or previous to A.D. 1300" (Introduction, p. vi).

[2] This *Fergna* stands five generations in direct descent below Brian, son of Eochaidh Muighmeadhoin (*op. cit.*, p. 113).

[3] *Op. cit.*, pp. 82, 118, 130, 136. The miraculous "whitening" of Aedh Dubh is said to have been effected at his baptism by St. Caillin.

[4] *Op. cit.*, pp. 175 *et seq.*

[5] See Introduction to volume, p. 9.

[6] *Op. cit.*, pp. 140, 141.

Drumcliff,"[1] belonged to Connaught. Under the new order Breifni O'Reilly was formed into an Ulster shire; but not by itself, for Teallach Donnchaidh (Tullyhunco) and Teallach Eachdhaich (Tullyhaw) were taken from Breifni O'Ruairc and united with it to constitute the County Cavan.[2] The other *tuaths* of Breifni O'Ruairc remained with Connaught as part of the County Leitrim.

The partitioning of ancient Breifni between two provinces, coupled with the antecedent division of Magh Rein between the dioceses of Ardagh and Kilmore, has introduced much complexity into inquiries concerned with the early topography of the march districts. Colgan, therefore, who lived out of Ireland, and wrote not long after the administrative reorganization of the provinces, may well be excused for placing Magh Sleacht, or, as he names it, *Masraighe et Cathraige Sleacht,* " in Connaciae regione Ultoniae contermina."[3] O'Flaherty, whose authority on questions of western topography will command respect, rectified Colgan's mistake by locating Magh Sleacht of Breifni "in Comitatu Cavan ad Connactiantum spectante, sed nunc ad Ultoniam."[4]

Thus tested at every side O'Donovan's delimitation of Magh Sleacht is seen to emerge unshaken. His definition " the level part of the barony of Tullyhaw," however, needs qualification, for no portion of that barony could strictly be described as level. A large rhomboidal area on the south-east side of Tullyhaw, though presenting everywhere crumpled and twisted elevations of surface, appears low-lying in contrast with the towering Slieve Russell, along its northern margin, and the long ranges of Slieve Anierin which dominate it from the west. Templeport Lake occupies a central position in this tract; and near its perimeter, some two miles to the south-east of Templeport, lies the hamlet of Ballymagauran. Both would serve pretty closely as points for tracing a diagonal of the rhombus in question; while the line so drawn would run, near the Ballymagauran end, along the base of a hill which is locally known as Darraugh. The crest of this hill is crowned by an elliptically shaped rath, whose major axis points directly south. The rath commands beautiful prospects in every direction, but the most picturesque view opens to the south, where the panorama is adorned by a series of lakes that stretch away to right and left out of range of sight. Darraugh stands medially over the circuit of this water system, and looks straight down, along a gentle slope, on its midmost basin underneath.

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[1] The " Book of Fenagh " (p. 80) extends Ui-Briuin " from Ath Droichit to Sligech " (Drogheda to Sligo).

[2] See Harris's " Hibernica," pp. 153-6 ; and Hill's " Plantation of Ulster," p. 204.

[3] " AA. SS. Hib.," p. 203.

[4] " Ogygia," p. 196.

East of Ballymagauran the lake-formation divides Cavan from Leitrim, and ultimately drains out through the Woodford river, which flows north by Ballyconnell to Lough Erne. The Blackwater river, descending from Slieve Anierin and discharging its water supply close by Ballymagauran, is the principal feeder of the system. Conspicuously marked on two sides by high mountain ramparts, the contour of Magh Sleacht is completed farther round by the rivers just named and their intermediate band of lakes. Inside those boundaries lay the choicest part of Teallach Eachdhaich—the Magauran's country—the seat in olden times of the Sen-Tuatha Masraighe, or Masraighe Sleacht. The physical landmarks which have been traced do not define mathematically the bounds of Magh Sleacht, but they supply the guiding lines for its delimitation, and nowhere swerve appreciably from the actual frontiers.

The Tripartite Life of St. Patrick, in a much-quoted passage, relates:—"Thereafter Patrick went over the water to Mag Slecht, a place in which was the chief idol of Ireland, namely Cenn Cruaich, covered with gold and silver, and twelve other idols covered with brass about him. When Patrick saw the idol from the water named Guth-ard (i.e., he uplifted his voice); and when he drew nigh to the idol he raised up his hand to put Jesu's staff upon it, and reached it not, but . . . . its right side, for to the south was its face, namely, to Tara."[1] The Tripartite is silent as to the Saint's previous movements after he had left Granard; but the Memoir of Tirechan partially supplies the *lacuna* by informing us that Patrick passed through Magh Rein, where he ordained Bruscus to the ministry and founded a church.[2] The chief object of this paper is to discover the site of the idol Cenn Cruaich; and the more important data for the solution of the problem have now been collected.

The positions of Magh Rein and of Magh Sleacht being known, I have first to search for the water expanses along their common boundary; for over water the Saint's advance was continued when he had quitted Magh Rein. One glance at the maps of Co. Cavan and Co. Leitrim will show that Magh Sleacht is cut off from Magh Rein by water envelopments only at the south-east corner, the corner where Darraugh hill rises gradually from the brink of Ballymagauran Lake. Looking north from the Magh Rein, or Newtowngore, side of the lake, the eye is instantly arrested by the graceful outlines of Darraugh, as well as by the venerable aspect of the quaint rath-frontlet. No other feature at all comparable in distinction is visible in its environment; nor in the outstretched background of the lakes, for its entire length, is a second

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[1] "Rolls Edition," vol. i, p. 93.

[2] "Book of Armagh," edited by Rev. John Gwynn, D.D., folio 11, col. 1.

detail exhibited which would challenge more than momentary attention. From Darraugh rath, on an inclement evening of December, 1919, I surveyed scrutinisingly the country on every side—a country strewn with monumental symbols of long-vanished races; and before I had gazed for many minutes the conviction flashed on me that, if the story of Crom Cruaich were not a myth, I was standing on the ground where his worship had been celebrated. Here was Magh Sleacht; there in front lay Magh Rein; water rolled between, but was it "the water named Guth-Ard"?

The lake system I have described seems, at first sight, to stop at Ballymagauran; but, on closer examination, it is seen to penetrate thence into the County Leitrim, well on towards Ballinamore. The largest and loveliest of its branches, bending into many sinuous folds, and bordered by sylvan headlands, shelters beyond Woodford demesne. This is Lake Garadice, a water-sheet which, though a member of the same lake series, does not touch Magh Sleacht, being enfolded all round by Magh Rein; but it comes close up towards Magh Sleacht, and ends in a bay within quite easy view of Darraugh. Looking out from the hill-top, I could see the pale light of a dying winter's day reflected from different coils of its surface.

In the Ordnance maps the name of this lake is printed "Garadice." As to the phonetic correspondence of Garad and Guth-Ard, nobody will be likely long to doubt; for in the native pronunciation of Guth-Ard the aspirated dental was ignored, while a short vowel sound was interpolated between the final consonants.[1] Guth-Ard was thus pronounced Gu(th)-Ar(a)d, or Gōrad.[2] Samuel Lewis wrote the lake-name in the form Gorradise,[3] a spelling which closely reproduces the Irish original as it was heard in local speech. James M'Parlan, at an earlier date, wrote "Garradise,"[4] an exactly identical form if the first vowel be given its Irish, as distinguished from the English, sound. Elsewhere Lewis mentions "Garradise Lough, a considerable sheet of water, on the shore of which is Garradice, the seat of W. C. Percy, Esq.";[5] and in doing so he shows, I think, that the "Garadice" of our Ordnance maps was borrowed from the name-form chosen by the Percy family for their delightfully situated residence on the lake's western shore.

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[1] The Irish peasantry retain this practice when pronouncing words like barn [bar(u)n], Cork [Cor(u)k]. Compare Lickerrig (from *leac-dherg*), Scullabogue (from *Scolb-og*), etc.

[2] The phonological equivalence of Gorad and Gu-Arad is shown by the inherited pronunciation of such names as Ua-Ruairc (O'Rorke), Ua-Nuallain (O'Nolan). The Latinized form *Ororicus* (see Giraldus Cambrensis, *Expugnatio Hiberniae*) is an exact parallel for Gorad.

[3] "Topographical Dictionary," p. 520.

[4] "Stat. Survey of Co. Leitrim" (1802), p. 111. The variant "Paradise," which appears at pp. 22 and 53 of this work, is obviously a typographical error.

[5] *Op. cit.*, p. 109.

Garadise, or Goradise, Lake lies within the parish of Drumreilly, or, to use phonetic spelling, Drumriley. On the Down Survey map of Carrigallen Barony this name appears as Drumreally.[1] In ecclesiastical records of the fifteenth century the parish was styled Drumerbelaid,[2] an obvious corruption of the Irish compound *Druim-air-bhelaigh*, meaning "the ridge of the eastern road." The seventeenth-century antecedent of Drumreilly having been Drumreally, it is not unreasonable to suppose that Goradise may have emerged, in like manner, from Gorad-(d)eas. Thus would "Garadice," the name which is now exclusively used, be a disguised form of Guthard-dheas, and as such mean simply "southern Guthard."

Local usage supplies analogies in abundance for this inference. The district of Magh Angaidhe, to which I have already referred, bounds Lake Goradise on the Newtowngore side. In O'Donovan's time this region was known to its inhabitants as "The Moy."[3] Ua-Raghallaigh, the family name of East Breifni's chieftains, was, and is, pronounced O'Reilly. The county name Mayo, representing *Magh-Eo*, or *Magh-Eo na Saxan*,[4] is sounded throughout Leitrim as Moy-ō, or Mȳ-ō. To anybody acquainted with the speech-forms now prevalent in Breifni it will at once be evident that, if the name Guthard-dheas has escaped extinction, it could have survived only as *Gorad-doise* (or *dise*).[5] But the question is not solely dependent on linguistic reasoning. Though the Down surveyors did not chart Lake Goradise, at the southern side of the vacant space corresponding to it on their maps they entered "Garteoise";[6] and the position in which they marked this word indicates that, in Petty's time, the lake spread farther than it now does to the south-east.

The name Guthard-dheas implies that at one time the lake was mated to a Guthard-thuaid or Goradoo. The physical geography of the locality shows clearly that the junction of these two Guthard lakes was close to the moat of Tuam Seanchaidh, or Toomonaghan, a little behind the point where the Woodford Canal now enters Ballymagauran Lake. Guathard-thuaid, or North Guthard, thus corresponded to the three continuous water basins at present differentiated as Ballymagauran, Derrycasson, and Coologe lakes; but proofs could easily be adduced to demonstrate that its area in early times was

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[1] Sheet 118.

[2] "De Annat. Hib.," p. 239; also "Droimergelaid," at p. 238. Comp. "Seven Bishops of Druim-airbhealaigh" ("Martyr. of Donegal," p. 17).

[3] See "Four Masters," A.D. 1424, note (q).

[4] *Op. cit.*, A.D. 1476.

[5] Compare also Rathwire = Rath Guaire, Carrickmines = Carraicmeadhon, etc. (Hogan's "Onom. Goed.")

[6] Sheet 118.

much more extensive. Guthard-dheas stretched, in a nearly opposite direction, far to the west and south of Tuaim Seanchaidh, filling up the ravine through which Woodford Canal has been constructed.

Garadise and Ballymagauran lakes are no longer in immediate contact, though their water supply is unified by an intervening canal. They lie, in fact, fully half a mile apart; but their separation has been effected by the disappearance of a considerable lake which, two centuries since, occupied the hollow space between. In the Down Survey map this depression, amply water-charged throughout, appears as an integral part of "Lough Finvoy."[1] Petty's contorted Finvoy was known in mediæval Ireland as Loch Finnmaighe,[2] "the lake of the white plain," which plain was evidently Magh Anghaidhe. O'Donovan equated Lough Finvoy with Garadise Lough,[3] but in doing so he gave insufficient heed to times, and to the varying significance of geographical names. Garadise, as I have shown, survived as a distinct name in the seventeenth century, limited in its application to the terminal basin of the lake-system at its southern end. Between this shrunken Lake Garadise and Lough Dromkirk (now Ballymagauran Lake) came Lough Finvoy.

The name Finvoy has disappeared, and all the water south of Ballinacur Bridge, where the modern county road from Ballinamore to Newtowngore crosses the system, has become Lake Garadise. The tortuous defile to the north, winding among limestone slopes and terraces, and sometimes opening to a goodly width, has been well-nigh desiccated by the sinking of the Woodford Canal, though the spacious water-loops surviving near both ends still mark it out as a rescued lake-bottom.[4] This area formed a continuation of Lake Finvoy, and united the whole series of lakes from end to end into an unbroken sequence. The name Finnmaighe may be assumed to have come into distinctive use in connexion with the royal residence of the O'Ruaircs in Magh Angaidhe, just by the lake shore[5]; and there can be little doubt that the earliest name of the uninterrupted water-tract lying south of Tuam Seanchaidh was Garadise, or Guthard-dheas.[6]

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[1] Sheet 118.

[2] See "Ann. L. Ce," A.D. 1418.

[3] "Four Masters," A.D. 1387, note (w).

[4] This tract was still under shallow water in 1802, when it was known to M'Parlan as "Newtowngore Lake" ("Stat. Survey of Co. Leitrim," p. 22).

[5] See, e.g., "Four Masters," 1386 and 1418 A.D.

[6] It is possible that the names Guthard (used for the water-formation in its entirety) and Finnmaighe (applied to the narrower water-tract guarding Tuam Seanchaidh) may have co-existed.

In early times, then, Guthard was a vast, continuous water-sheet, consisting of two far-reaching branches, which met near Tuam Seanchaidh. The old moat stood sentinel beside the narrowest crossing of Guthard, and thus commanded the approaches to Magh Sleacht from eastern Magh Rein. A study of the 200-feet contour lines traced on the six-inch Ordnance maps, together with the peaty hollows and alluvial pockets laid down on the Geological Survey maps, will show that Magh Angaidhe went out towards Tuam Seanchaidh, through the present Woodford demesne, in a nearly insulated promontory, much indented by creeks along the south side. But Tuam Seanchaidh was always approachable from the east by dry land, resting on a solid limestone foundation, and shrinking to an isthmus where Newtowngore village now stands.

A direct line from Granard to Tuam Seanchaidh passes close by three Tobar Patraics, all of which are marked on the inch Ordnance sheets. Two of them lie a few miles south of Garrigallen village, while the third is just inside the Longford border, nearly midway between Leggah and Ballinamuck. Though no particulars are on record as to the Saint's journey, it may be assumed, I think, that these wells were important halting stations along his missionary march. It is most likely, indeed, that on setting out from Tara on that eventful occasion St. Patrick had Magh Sleacht in view as his chief destination, the destruction of Crom Cruaich's worship being doubtless the main object of his expedition. Not less certain is it that a direct road led all the way from Tara to Guthard, for the High-King Laegaire is stated to have habitually worshipped at Magh Sleacht, accompanied by the magnates of Tara.[1] With this track the sanctified wells surviving between Carrigallen and Granard would likewise have been closely in line. Geographical considerations point distinctly to the probability that Tuam Seanchaidh was the port of embarkation for the southern adorers of Crom Cruaich in their pilgrimages to Magh Sleacht; but, independently of this inference, the conclusion has strong recommendations that it was from Tuam Seanchaidh St. Patrick crossed when he sailed over "the water named Guthard."

The parenthetical phrase—"(i. gabtha a guth)"—inserted in the Tripartite paragraph is, doubtless, an interpolation supplied by some early copyist, who surmised that the origin of the name Guthard dated from St. Patrick's memorable voyage. Guth-Ard unquestionably means "loud voice"; but the attribution of the name to the Saint's uplifting of his voice on the occasion seems to me not alone intrinsically improbable, but quite out of place in a description which keeps so strikingly close to recognizable facts.

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[1] See "Vita Trip.," p. 93. Also Colgan's "Trias Thaumaturga," pp. 25 and 42.

The Magh Sleacht idol was an object of national veneration. "Brave Gaels used to worship it," "He was their god," proclaims the Dinnsenchus ode of the Book of Leinster.[1] Votaries flocked from far and near to prostrate before Crom,[2] the men of Meath and of Leath-Mogha coming, like Patrick, over the water name Guthard. But all alike,

> "They beat their palms, they pounded their bodies,
> Wailing to the demon who enslaved them,
> They shed falling showers of tears."[3]

The outbreaking of a mournful chant was evidently an accompaniment of the ceremonies, and the pilgrim-hosts sailing over Guthard doubtless commenced their lamentations the moment Crom's dreaded figure was sighted on the hill-top before them. At all events, the congregated Gaels made the lake shores resound with their cries of supplication and self-reproach during each recurrent festival; and the name Guthard was much more likely to have originated from this acoustic phenomenon than from the single act of voice-raising in which the Saint's indignation found vent.

Before quitting Magh Rein Patrick ordained Bruscus to the priesthood and placed him in charge of a church. The station assigned to Presbyter Bruscus, or Brosc, seems to have been near an island—"Insula generis Cothirbi"—which, during his lifetime, became the hermitage of a holy recluse.[4] The name Cothirbi, borne by the island's earlier owners, discovers them, I suspect, to have been the same people as Colgan's "Cathraige[5] Sleacht." Possibly these Cathraige were the custodians of Crom's shrine, and the wardens of its water defences in front. As such they would have garrisoned Tuam Seanchaidh, then a fortified mound, and subsequently a residential seat of Breifni's dynasts; while the islands of Guthard would naturally have been reserved to their protecting charge. The ancient church of the Moy, at Newtowngore,[6] possibly marks the spot where Bruscus first opened his mission; while the retreat of his hermit-neighbour may have been Church Island, or Inishmore, inside Garadise Lake.[7]

Viewed from Magh Rein, in St. Patrick's time, the aspect of Darraugh hill was very different from its present appearance. The rath was there,

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[1] See "Voyage of Bran," p. 304.

[2] See, e.g., "Vita Trip.," i, p. 219, and "Irish Lives from Book of Lismore," p. 161.

[3] "Voyage of Bran," *loc. cit.*

[4] *Supra*, p. 29, "Vita Trip.," vol. ii, p. 311.

[5] If *b* in Cothirbi were replaced by *g*, the names would be identical; and this *b* may quite easily have been a copyist's error.

[6] See Lewis's "Top. Dict.," vol. ii, p. 438.

[7] No such closeness of correspondence to the record as these places derive from the proximity and antiquity of their ruined churches is elsewhere visible along the entire route.

but so was the oak-wood (*doire*),[1] enfolding it like a sacred vestment at the back and sides.[2] The hill-summit, standing 382 feet above the sea-level, is to-day some 208 feet higher than the lake-surface underneath. At that time the difference of levels between lake and hill-top probably did not exceed 180 feet. The depressions marked on the Ordnance map by 200-feet contour lines lay under water in early and mediæval times. One of those lines zig-zags for more than a mile north from Derrycasson Lake, winding at its extremity around Camagh Lough, a short distance north-east of the rath. It marks the course of a valley which hooks inward towards Kilnavart; and on the Down Survey map it is replaced by a long, sickle-shaped fiord that penetrates right up under the knoll surmounted by Kilnavart rath and church. Camagh Lough[3] is, in fact, but a pot-hole which, preserved from obliteration by its greater depth, remained behind when this projection of the lake receded southwards.

The contour lines, when studied in conjunction with our earliest maps, likewise show that, west of Darraugh, a branch of Guthard curved round to Porturlan.[4] From the south, therefore, Crom Cruaich's hill looked a promontory, broad-faced before and tight-laced with water for the greater part of its girth. Its neck sloped down through Porturlan to Kilnavart, over ground whose venerableness in pagan Ireland is still attested by the number and variety of its prehistoric monuments.[5] The isolation of Darraugh, unbroken save by its secluded avenue of approach from behind, was no doubt the determining feature that led to its appropriation for the service of a national worship.

Such was the hillock, adorned by Crom Cruaich's shrine for head-gear, which St. Patrick saw immediately north of Guthard when he reached Tuam Seanchaidh. Embarking there, at the neck where North and South Guthard met, he had but a mile of water to cross in his voyage to Magh Sleacht. From the lake shore opposite another half a mile of easy ascent

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[1] The Ordnance maps name the townland Derryragh. The spelling used in this paper (Darraugh) is designed to convey the local pronunciation.

[2] For the importance of the oak in druidical practices see Frazer's "Golden Bough," vol. ii, chap. xx.

[3] As bearing on the older, or correct, pronunciation of Garadise, I may mention that Camagh is pronounced in the locality as if it were spelt *Commagh.*

[4] The older name Portnerilinchy (see "Inquisitiones Ultoniae," 10 Carol. I) would indicate this fact. I take the etymology to be *Port-na-h-Urlaidhe-h-Innsi*, i.e., "the slaughter-bank of the island."

[5] My inquiries in the district elicited that, some two or three generations since, this ridge of Magh Sleacht was literally paved with pillar-stones, dolmens, and stone-circles. The 6-inch maps show that a considerable number of them still survive.

brought him straight to the portals of Crom Cruaich's celebrated sanctuary. The Tripartite tells us that, in the journey up, the Saint's brooch fell from his mantle, and was covered by heather. Though the soil is of good quality resting on a wholesome limestone foundation, wide patches of heather tenaciously persist to-day among the pasture fields sloping down along Darraugh's southern face.

The rath of Darraugh is elliptical in outline, and so constructed that its longer axis appeared to me to point due north and south. The enclosure has an area of, approximately, an acre and a quarter, statute measure. The vallum, a clay fence, is well preserved; but it is single, and, being unsupported by fosse or other artificial protection, its strength would have been very inadequate for defensive purposes. All the extant characters would associate the initial, or golden, age of this remarkable rath with religious, not with residential, functions. If its interior was the shrine of Crom Cruaich, the famous idol, we may presume, would have been erected on the axial line, perhaps near the frontal apse. In this position the awesome image would have fulfilled geometrically the condition specified in the Tripartite—a significant condition in its bearings on Crom's worship—"to the south was its face."

Looking down from Darraugh, the eye will not fail to rest on a quadrangular common skirting the road to Porturlan, a short distance north of Ballymagauran. Still clothed in its primeval heath, and intersected by a narrow causeway which has every appearance of being a genuine relic of antiquity, this neglected plot is the "fair green" of Ballymagauran, where from time immemorial fairs have been held in May and in November. A roadway extending east from Ballymagauran, along the water's edge, similarly served for a racecourse, from remotest ages until the annual race meetings were discontinued during the recent world-war. These institutions, so vividly reminiscent of the era of assemblies, would of themselves create a presumption that Darraugh and its environs were once a focal centre of the national life, a popular rendezvous of more than local celebrity.

Viewed from Ballymagauran, Darraugh stretches back towards Porturlan as an elongated ridge, or rick-shaped elevation. From the fair green, or old assembly ground, its aspect is that of a veritable *cruach*. Seen from other directions, Darraugh looks plump and smoothly rounded, assuming an air of reposeful dignity, which increasing distance but enhances, as the observer gazes back in his departing journey through Magh Sleacht.

Refraining from speculation on St. Patrick's doings in the sacred enclosure, when the mighty Crom and his attendant sub-gods were demolished,[1] I proceed to the next stage of this great missionary operation. The Tripartite Life relates :—

"He founded a church in that stead, namely, Domnach Maighe Sleacht, and left herein Mabran (whose cognomen is) Barbarus Patricii, a relative of his and a prophet. And there is Patrick's well, wherein he baptized many."[2]

St. Patrick's Well is still to be seen in the second field to the east of St. Mogue's Roman Catholic Church at Kilnavart, and but a short distance in from the road leading thence to Ballyconnell. Its site is marked "Tober Patrick" on the Ordnance maps; and the well, now a muddy pool, can easily be located by the aid of a solitary ash tree which towers above it. St. Patrick's personal association with this well retains its hold in local tradition with a vitality that, I believe, could now be matched in very few parts of Ireland by an inherited remembrance of the apostle. Everybody in the neighbourhood will repeat, in the same simple words, and with as absolute faith in their verity as if he were relating an incident which happened before his own eyes, that "St. Patrick went on his knees from the well to the chapel." The present parish priest of Templeport, who resides at Kilnavart, has kindly supplied me with some interesting notes on the district, from which I extract the following :—

"I can find no tradition about the patron of the church. There is a tradition that St. Patrick was at the holy well, which is distant only two fields from the chapel, and that he moved over on his knees from the well to the site of the present chapel, and on this site founded a church. The churchyard is still used for interments. The site of the old thatched chapel is the site on which the present church is built. There is no trace of the old chapel site. It was very small, and stood within the present chapel."[3]

Father Brady, I may mention, had no theories to propound on any topic; nor did he appear to be cognisant of the importance of Kilnavart in pagan and Patrician history. The particulars which I quote from him are in exactest agreement with the results of my own subsequent inquiries around Ballymagauran and Kilnavart. But, having been much impressed by Father Brady's complete detachment from bias, and by his scrupulous regard for accuracy of statement, I prefer to give information of such great evidential value in his precise words, in order to strengthen the guarantees of its reliability.

The chapel which St. Patrick founded near the holy well was the Domnach Maighe Sleacht of the Tripartite record; and, if tradition does not

[1] I pass over this topic to eschew prolixity; for, having reflected on all the evidence, I find myself in disagreement with Professor Bury's suggestions ("Life of St. Patrick," p. 125), and I should feel constrained to controvert them.

[2] "Trip. Life," edited by W. Stokes, vol. i, p. 93.

[3] Letter of Very Rev. Terence Brady, P.P., dated 19th January, 1920.

mislead, that Domnach stood on the site now occupied by Kilnavart Roman Catholic Church. The church occupies a position which, I would venture to say, is quite unique, for it is built inside a strong, deeply fossed rath, and I doubt whether all Ireland could produce another example of the like collocation. The interior of a rath would surely not have been chosen for a church site either in modern or in mediæval times. Neither would such a choice have been made in the earliest period of Christianity except for some very exceptional and compelling reason.[1]

The humble chapel mentioned by Father Brady stood among the ruins of a much earlier edifice, of whose origin all memory has long been lost. Lewis in 1837 thus referred to it: "At Kilnavart are also the remains of an ancient monastery, of which there are no particulars on record, with an extensive burial-place still in use."[2] This rath-enclosed burial-place, the present chapel yard, is still regularly used for interments by the local population; and I found, when inspecting it, that some of the older tombstone inscriptions give the townland name as Kilfert.[3] Among the lands demised to Sir Garrott, or Gerald, Moore of Mellifont, on 6th March, 1605-6, were the termon "of Kilfeart, 2 pulls, the like of Templeport, 4 pulls."[4] The Bishop of Kilmore lodged claims on these termons; and an Inquisition taken at Cavan on the 20th September, 1609, upheld his suit, finding that he was seized in fee "out of the termon land of Templeport, conteyning six pooles, ten shillings and two-third partes of a beefe per annum; and out of the other polles of termon land adjoyninge to the chapple of Kilfert, in the parish of Templeport, twelve pence per annum."[5]

The earlier church of Kilfert, or Kilnavart, is thus proved to have been a religious foundation of recognized standing, supported by two pulls, or polls,[6] of termon land. On the Down Survey map of Templeport Parish those two polls, adjoining the chapel, are seen to be the contiguous townlands of Kilfert and Cownaren,[7] measuring respectively about eighty-four and

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[1] Though I have seen other churches and church remains similarly situated, in no instance have I discerned traces of a fosse or outer rampart. At Kildallon, about five miles from Kilnavart, a little fort encloses the site of St. Dallan's early church, now a cemetery; while the present Episcopalian church, at the opposite side of the road, is surrounded by a small elliptical fort.

[2] "Top. Dict.," vol. ii, p. 613 (Art. "Templeport").

[3] The form "Kilferten" also occurs.

[4] Erck's "Enrolments of the Patent Rolls of Chancery," p. 233.

[5] "Ulster Inquisitions," App. vii.

[6] This land-measure seems to have varied from half to three-quarters of a plough-land. For different estimates of it see Dr. Reeves, Proc. R I.A., vol. vii, p. 477; Harris's "Hibernica," Pt. I, p. 117; Erck, *op. cit.*, pp. 226 and 232.

[7] These polls are now represented by Kilnavart and Cloneary townlands, in extent

sixty-three acres. That those two polls of endowment land should have been attached to the obscure chapel of Kilfert is surely a fact of profoundest significance.

In the maps of the escheated counties of Ireland, published by Colonel Sir Henry James, F.R.S., in 1861, the same church is named "Kilfart"; and its complete structure is shown, with a cross overhead, denoting that it was used for worship in 1609.[1] About a century and a half after St. Patrick's time, St. Moaedhog founded on his native island, just one mile below Kilnavart, a church which became the principal ecclesiastical centre of Magh Sleacht. In the late fourteenth, or early fifteenth, century[2] this church was replaced by the "church of the bank" (*Teampul-an-phuirt*,[3] or Templeport), built just opposite on the mainland. Templeport has ever since been, and remains to-day, the parochial church for the greater part of Tullyhaw, as recognized under State establishments. But the Kilfert, or Kilnavart, church, there cannot be the slightest doubt, was the oldest religious foundation of Magh Sleacht. Had it not existed before St. Moaedhog's church, why should it ever have been built? Is it likely that St. Moaedhog's successors, who, like himself, guarded most jealously their abbatial dues and possessions,[4] would have permitted a minor church to be set up beside their termon and endowed with a considerable tract of land? Is it likely, moreover, that any chief of Teallach-Eachdhaich would have been allowed to set apart a goodly area of the tribe-land for the support of such a church, even if the episcopal authority had sanctioned its erection? All that is known of ecclesiastical government and procedure compels us to answer in the negative. The Kilfert chapel must have been older than the island church of St. Moaedhog; and, that being so, it can have been none other than the Domnach Maighe Sleacht which St. Patrick founded after his demolition of the idol. That primitive church having been eclipsed by the adjacent monastery of St. Moaedhog, its early history got enshrouded in darkness; but sufficient is known to make it fit, as a closing link, into the chain of evidence that, with unfailing consistency, establishes the location of Crom Cruaich's long-hidden shrine.

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about 330 acres. Only arable land was measured. Cloneary stretches close to Templeport Church.

[1] Map No. 25 (Tullyhaw Barony).

[2] I deduce this approximate date from the entry marked F. 118, at p. 231, of "De Annatis Hiberniae."

[3] See O'Donovan's "Four Masters," A.D. 1496.

[4] This is clearly demonstrated by the Irish "Life of Moaedhog," already cited (*supra*, p. 23).

Colgan's "Tertia Vita"[1] has a short notice of St. Patrick's visit to Magh Sleacht. The "Quarta Vita,"[2] too, relates the incidents of the occasion, and with greater detail. The writers, as well as the so-called "Evinus,"[3] who composed the "Tripartite Life," were dependent for their materials on common sources, the chief of which was undoubtedly the Memoir of Tirechan. Yet the Memoir, as it has reached us, connects St. Patrick with Magh Sleacht only by one scanty allusion. As the authors of the three several "Lives" cannot be supposed to have independently invented the same story, it must be inferred that the original manuscript of Tirechan described the famous visitation, but that, from motives which are easy to understand, some early monk-transcriber excised, or omitted, the Magh Sleacht passages.[4]

Fortunately the objectionable matter was not cut out quite clean; and the short sentence that escaped deletion is of great present value. It says: "Mittens autem Patricius methbrain ad fossam Slecht barbarum Patricii propinquum qui dicebat mirabilia in Deo vera."[5] The Latin *fossa* in place-names, such as that here given, means a rath[6]; and the equivalence is recognized by Bury, who translates "fossam Sleacht" as Rath Slecht.[7] Where are we to look for this Rath Slecht? Not surely on top of Darraugh Hill, for the rath there shows no sign of having ever been a fortified rampart. Next to the ceremonial enclosure on Darraugh, the largest fort of Magh Slecht laid down in the earlier Ordnance maps is the double-ringed rath surrounding the old chapel and churchyard of Kilnavart.[8] I can see no reason for doubting that this was the identical *fossa Slecht* to which Patrick despatched Methbrain. This relation of the saint, born somewhere outside the Roman dominions, had for his commission, as explained in the Tripartite Life, the pastoral charge of Domnach Maighe Slecht, that is, of the church which Patrick founded "in that stead."

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[1] "Trias Thaumaturga," p. 25.

[2] *Ibid.*, p. 42.

[3] *Ibid.*, p. 117.

[4] "There is reason to suppose that an account of the visit has fallen out of Tirechan's text" (Bury's "Life of St. Patrick," p. 306). Professor Bury discusses the matter fully in Proc. R.I.A., vol. xxiv, Sect. C, pt. 3 ("Itinerary of Patrick in Connaught"), pp. 154–6.

[5] "Book of Armagh" (edited by Dr. Gwynn), folio 11, p. 21.

[6] Hogan's "Onom. Goedel.," p. 430.

[7] "Itinerary of Patrick in Connaught" (Proc. R.I.A., vol. xxiv), p. 155.

[8] This double rath is shown on the earliest Ordnance maps, and it stood intact until the building of the modern church in 1864. The rath fences were then demolished, for about a third of their circumference, along the front, or road side; the arc being replaced by a low stone wall, with a central iron gate. In from the road the ancient circumvallation remains *in situ*.

The church erected inside Rath Sleacht would have served no practical purpose if the Masraighe had not been converted in sufficient numbers to supply a congregation. The six-inch Ordnance maps locate a Tober Patraic, or St. Patrick's Well, in the townland of Brackley, at the north side of Brackley Lake. They place another in the townland of Ballaleenan, near a bend of the Blackwater River, not far south of Lake Bunerky. A third, not marked on the Ordnance maps, I have seen myself near the roadside in Crimlin[1] townland, Co. Leitrim, about two miles south of the Cavan border. Taking these wells to be extant vestiges of the Saint's route, the information they convey is, I think, highly important. It tells that, after founding his church at Rath Sleacht, St. Patrick made a full circuit of the Magh of Adorations, preaching to its inhabitants as he advanced, and administering baptism at suitable stations.

The wells, moreover, reconcile the Magh Sleacht passages of Tirechan and the Tripartite Life, clearing up a difficulty that has withstood the best essays in exegesis.[2] The note of Tirechan reads:

"Mittens autem Patricius Methbrain ad fossam Slecht . . . "; and in connexion with it three topographical entities have to be kept distinct in idea, viz., Darraugh Fort, where Crom Cruaich was worshipped; Rath Sleacht, a mile away, where St. Patrick built his church; Magh Sleacht, the considerable district of country which the saint perambulated in a missionary tour before departing for Magh Ai. The church in Rath Sleacht was to have Methbrain for minister, and it was intended to serve the needs of the Magh Sleacht population. Surely Methbrain accompanied his bishop and master during the days, or weeks, that were spent in Christianising the people who were to be committed to his charge. St. Patrick first entered Magh Sleacht from Magh Rein, when he sailed thither from Tuam Seanchaidh over the water named Guthard. At a subsequent date he entered Magh Rein from Magh Sleacht as he passed south from Bellaleenan to Crimlin, crossing the frontier, most probably, somewhere near Derrada townland, over a ford of the Blackwater. It was from there the sending of Methbrain back to his church at Rath Sleacht was performed, the sending chronicled by the veracious Tirechan. The sentence which tells of it evidently ended up Tirechan's account of St. Patrick's doings at Magh Sleacht; and by some happy accident it remained behind when all the rest of the narrative bearing on Magh Sleacht was expunged.

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[1] *Crimlin* is the local pronunciation, but in the Ordnance maps the name is printed Cromlin. It was there O'Donovan searched for the site of Crom Cruaich.

[2] See, e.g., Bury's "Itinerary of Patrick in Connaught," p. 155.

The Tripartite shows us St. Patrick only during the interval between his approach to Darraugh from the lake side and his erection of the church at Kilnavart. Tirechan shows the Saint only at the moment when he was about to quit Magh Sleacht some five or six miles north-west of Guthard water. There is, therefore, no discrepancy whatever between the two passages. Patrick sent his relative, Methbrain, to Rath Sleacht; but, if he did, the commission was given near the confines of Magh Sleacht, at the close of his own mission, which is virtually equivalent to saying, in the words of the Tripartite, that "he left therein Mabran."

I take Kilnavart to be the modern form of *Cell-na-fheart*, meaning the church of the grave or burial monument. There are several such monuments in the neighbourhood; but the largest and most remarkable cromlech is situated in a field quite close to the church. This monument, no doubt, marks the burial-place of some particularly distinguished personage—druid, or chieftain, or combination of the two—in prehistoric times.[1] The number of forts on every side proves that Magh Sleacht was then thickly populated.

The *fossa Slecht*, or Rath of Magh Sleacht, may have been the residence of the Masraighe chieftain; but, if this chieftain was not likewise the actual guardian of Crom Cruaich's station on Darraugh hill, I consider it more probable that Rath Sleacht served to house the dignitary, or fraternity, who had custody of Crom's temple, and presided at his worship. Druids, Magi, or whatever their proper title may have been, there were surely some sacerdotal functionaries at Magh Sleacht, dedicated to the service of Crom Cruaich and his subordinate gods. This body may have consisted of a community, or *consortium*,[2] of the Cathraighe, whom Colgan associates with the primitive Masraighe as an occupying folk-group of Magh Sleacht. As custodians of the elliptical shrine overlooking Guthard, and ministers of its ritual, they had to be provided with dwellings and sustenance befitting their dignity. Not improbably they held in trust all the precincts and approaches of the sacred retreat; but where are we to search for their own habitation? The site that will most readily and naturally present itself is the strong rath at Kilnavart—the debris, as I take it to be, of Tirechan's *fossa Slecht*.

The material wants of this *collegium* would have been supplied by an ample provision of land in the immediate vicinity, adjacent to, but not

[1] The dolmen in question is surrounded by a small ring-fort. The tenant-occupier (Mr. Murray) informed me that the interior was dug up many years since by searchers for treasure-trove, when a stone cist containing ashes and human bones was exposed. A tall pillar-stone stands just outside the fort, and another inside, at the end of the grave.

[2] On the subject of druidical *consortia*, or *collegia*, see "La Religion des Gaulois," par A. Bertrand, leçons xix and xx.

encroaching on, the sanctuary grounds. The completion of St. Patrick's mission at Magh Sleacht demanded, not alone the subversion of Crom and his religion, but likewise the expulsion of his priesthood and the appropriation of their freehold to Christian uses. Herein, I suspect, lies the explanation of the origin of those polls of termon land which, as has been seen, were still unsecularized and unsevered from Kilfert church at the beginning of the seventeenth century.

Named Mabran in the Tripartite, and Methbrain in Tirechan's Memoir, the priest who was left in charge of the infant church at Magh Sleacht more probably had for his real name Niabrain, or Niethbrain.[1] What subsequently became of him we know not. It is possible that his mission encountered many obstacles in the pagan obduracy and the hereditary practices of the Sen Tuatha. But the Domnach Maighe Sleacht held its ground, I think, as the chief, if not sole, tribal church of the district until the Masraighe became subjects of the Ui-Briuin. The racial principle operated too strongly in ancient Ireland to allow the proud descendants of Fergna to recognize a Masraighe foundation as their metropolitan church in Teallach Eachdhaich; and they gave their allegiance instead to the church which St. Moaedhog founded in his native Inis Breaghmuighe, a mile below Kilfert.

St. Moaedhog's father was of the race of Colla Uais, but his mother was of Ui-Briuin extraction.[2] By the Ui-Briuin he has ever been held in veneration as the greatest of Breifni's evangelizers, and one of the foremost of Ireland's missionary apostles. The Ui-Briuin turned away from Kilfert, and enriched their own Saint's church in Templeport Lake with liberal donations of the tribal territory. But the old church of *fossa Slecht,* though reduced to minor importance, evidently ceased not to operate as a temple of Christian worship. Most likely it was relegated to the broken Masraighe population, and allowed, by an act of grace, thenceforth to serve, separately or mainly, their religious needs.[3] The derisive allusion which seems to lurk in its name, Kilfert ("church of the grave"), would, on this hypothesis, become perfectly intelligible.

On the 27th May, 1836, John O'Donovan wrote from Cavan: "If I
dubh
discover the idol Crom Cruach on the plain of Moy Slecht, I shall deem

[1] Bury, Proc. R.I.A., vol. xxiv, p. 155; and Index to "Book of Armagh," pp. 491–2.

[2] See "Martyrology of Donegal," p. xxxiii.

[3] Though St. Mogue's cemetery is only a mile distant, and serves as burial-ground for a large district of country, Father Brady tells me that, in the sixteen years of his pastoral charge, he has never known anybody from around Kilnavart to be interred in the island. The original rivalry of the churches seems to have descended to the churchyards.

myself compensated for all my exertions, and not an idoler."[1] O'Donovan had not then ascertained the true position of Magh Sleacht, and, influenced by Lanigan and Beauford, he associated the "plain of genuflections" with County Leitrim. Surmising that Cromlin, or Crimlin, a townland in Oughteragh parish, might have derived its name from the idol,[2] he made a careful examination of its "crooked glen." At that time the Tripartite Life was known only through Colgan's Latin paraphrase in the "Septima Vita,"; and O'Donovan had to rely for his marks of identification on two passages, viz. (*a*), "Cum enim Patricius existens juxta fluvium Gath-ard appellatum, videret cominus idolum . . . ," and (*b*) "In ista regiuncula Patricius exstruxit Ecclesiam, vulgo Domnach Mor, Basilicam magnam nuncupatam; eique praefecit Mauranum, cognomento Barbanum, alias Banbanum, cognatum suum."[3]

The misleading expression, "fluvium Gath-ard appellatum," would probably have sufficed in those days to defeat the keenest explorer, though his search had been prosecuted inside Magh Sleacht. While the failure of our most eminent topographer may, therefore, be regretted, it in no wise reflects on his diligence or acumen. Writing from Mohill on the 24th June, O'Donovan thus reported the result of his quest: "Now, though one should think there are sufficient data here to discover the spot where Crom stood, still I cannot discover any place that will agree with it. I cannot find a church called Donaghmore, nor a river called Gathard. The only features remaining to support my conjecture are the river which destroyed the chapel,[4] and the well dedicated to St. Patrick,[5] both which, joined with the name Cromlin and with their contiguity to Fenagh, would with some visionary minds amount to demonstration."[6]

On the 9th December 1836, O'Donovan thus wrote from "21 Great Charles Street":—"In looking over the 'Life of St. Dallan,' of Kildallan, near Killyshandra, I find that Magh Sleacht, where the idol of Crom Cruach stood, was the ancient name of the barony of Teallach Eathach (Tullyhaw), in the county of Cavan. This shows that I searched for Crom in the wrong place,

[1] "Ord. Survey Letters" (Cavan and Leitrim).

[2] This notion was by no means fanciful. N. O'Kearney similarly took "Crum Linn" to be "the lake of Crom" ("Trans. Ossianic Society," vol. i, p. 105).

[3] Colgan's "Trias Thaumaturga," p. 134.

[4] At least two very old men of the neighbourhood still remember the occurrence here mentioned—the damming up of the river in the gorge above the road, the bursting of the bridge by the unloosened reservoir, and the sudden flooding of the little chapel below it, one Sunday while Mass was being celebrated.

[5] St. Patrick's Well at Crimlin was not destroyed. It is carefully preserved by the respectable blacksmith (Patrick Gormley) near whose forge it is situated.

[6] "Ord. Surv. Letters" (Cavan and Leitrim).

being misled by Lanigan, who was misled by Seward, who was blinded by Beauford." Two or three years later O'Donovan, being then engaged in preparing a catalogue of the Irish Manuscripts in the Library of Trinity College, noted, in his description of Manuscript H 2. 6—that is, the Irish "Life of St. Mogue of Ferns"—"I searched the two Brefneys for the situation of Magh Sleacht, on which stood the chief pagan Irish idol, Crom Cruach, but have failed, being misled by Lanigan, who had been misled by Seward, who had been blinded by the impostor Beauford, who placed this plain in the county of Leitrim."[1] Some ten years subsequently O'Donovan published his monumental edition of the "Four Masters"; and four times successively, in his notes to those massive volumes, he defines the district, substantially in the same terms, as the low-lying portion of Tullyhaw Barony, in which Ballymagauran is situated.

In a note printed in "The Journal of the Kilkenny Archæological Society"[2] O'Donovan wrote, a few years before his death:—"The place at which this idol stood has not yet been identified. It stood near the river Gathard, in the plain of Magh Sleacht, in the barony of Tullyhaw, and county of Cavan, somewhere in the neighbourhood of the village of Ballymagauran." This was probably O'Donovan's latest published reference to the subject, and it is utterly at variance with his supposed abandonment of Tullyhaw as the area of search for Magh Sleacht.[3] So far as his literary remains indicate, O'Donovan never deviated from the conviction that the true site of Crom Cruaich lay in the neighbourhood of Ballymagauran; and since his death, in 1861, two generations of scholars have, with but a very few dissentients, testified their faith in his topographical insight by unquestioningly adopting that judgment.[4]

Since O'Donovan's time two investigators, and—so far as I know—two only, have made personal search for the site occupied by Crom Cruaich. One was the Rev. Canon John O'Hanlon, the learned author of the "Lives of the Irish Saints," and the other was the Most Rev. John Healy, D.D., Archbishop

[1] The reference here is to William Beauford's "Map of Antient Ireland during the Middle Ages," inserted in Vallancey's "Collectanea de Rebus Hibernicis" (vol. iii, p. 252). The map places "Magh Sleucht" under Conmaicne, and west of Granard—that is, partly in Co. Longford; but in the topographical glossary which follows the place is said to be situated near Fenagh (*ibid.*, p. 388). Colonel Wood-Martin, still more fatally blinded by the map, locates the idol "in the plain of *Mag Slecht*, near Granard" ("Traces of the Elder Faiths," vol. ii, p. 208).

[2] Vol. i (New Series), 1856-7; note at p. 216.

[3] Hyde's "Lit. Hist.," p. 84.

[4] W. Stokes, for example ("Rev. Celt.," xvi, p. 36); D'Arbois de Jubainville ("Irish Myth. Cycle," p. 60); Bury ("St. Patrick," p. 306); Hogan ("Onom. Goed.," p. 530); Joyce ("Social History," i, p. 276); E. Gwynn ("Metr. Dinds.," Part III, p. 550).

of Tuam, author of a very interesting and readable "Life of St. Patrick. Both approached their task under the prepossession of a firmly conceived theory, namely, that Crom was venerated somewhere near Fenagh, in County Leitrim; and both appear to have confined their explorations to Fenagh and its neighbourhood. I do not know whether either thought it worth while to go near Ballymagauran. Each in turn—Canon O'Hanlon first, Dr. Healy some twenty years later—fixed on Edentinny, a low limestone ridge nearly midway between Ballinamore and Fenagh, as the goal of his quest, believing it to be so beyond reasonable possibility of doubt. Though I should much like to examine the arguments on which their agreed solution of the question was made to rest, it must suffice for me here to mention that the "water named Guthard," from which St. Patrick saw the idol, is supposed by Canon O'Hanlon to have been "Lough Gowna, or the upper course of the Erne";[1] while Dr. Healy extends it thus through the heart of Conmaicne Magh Rein: "The water here referred to seems to be the chain of small lakes stretching from Drumshambo Lough to Gulladoo Lough, on the borders of County Cavan. There are eleven or twelve of them in all."[2] For the Domnach Maighe Sleacht the same author was reduced to the strait of requisitioning "the parish church of Oughteragh" or of Ballinamore.[3]

Canon O'Hanlon, moreover, while confessing his inability to locate the "Masraige et Cathraige Sleacht" of Colgan,[4] does not hesitate to reject O'Donovan's reasoned identification of Magh Sleacht.[5] Dr. Healy accepts that identification, but, on the strength of "an entry in the 'Annals of the Four Masters,' under date A.D. 1256," he makes Magh Sleacht include the greater part of the parish of Oughteragh, in County Leitrim.[6] The entry in question relates to the battle of Magh Sleacht, the site of which had been supposed by O'Donovan to lie somewhere between the extremity of the Bartonny wing of Slieve Anierin and the village of Ballinamore.[7] But O'Donovan had, apparently, not consulted the full descriptions of this engagement given in the "Annals of Lough Ce" and in the "Annals of Connaught." The battle was fought "on bealach na beithige, at the *head* of Sliabh an Iaraind,"[8] "on the brink of Ath lerg,"[9] "between Ath na Beithige and Bel in Bhealaigh."[10]

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[1] "Lives of the Irish Saints," vol. iii, p. 580.

[2] "Life of St. Patrick," p. 182. He might have added that they lie far apart, and cover a range of more than twenty miles.

[3] *Ibid.*, p. 188.

[4] "Lives of the Irish Saints," vol. i, p. 498.

[5] *Op. cit.*, vol. iii, p. 581.

[6] "Life of St. Patrick," pp. 183, 184.

[7] Note to "Four Masters," *sub anno* 1256.

[8] "Ann. Ulst."

[9] "Ann. L. Cé" and MS. 23 E, 7, R.I.A., p. 911.

[10] *Ibid.*

These data will readily demonstrate that the fighting took place on the Magh Sleacht side of Bellavally[1] gap, the summit of the gorge separating Slieve Anierin from Cuilcagh, close to the shallow which bore the name "Red Ford"; or, in other words, that the contest was decided in the little townland of Legnaderk[2] (*Lug-n-atha-dheirg* = the mountain hollow of the red ford), which stretches from the descending stream to the base of Benbrack mountain.[3]

I take Cromm Cruaich to mean *Cromm of the Rick*, and to represent the name which Crom Dubh's figure bore at Magh Sleacht.[4] The idol's super-eminent position on the hill-top adequately explains, I think, the name Cenn Cruaich, given to it by the Tripartite, i.e., "Head, or Lord, of the Sacred Rick."[5] Jocelyn styled the object Ceancroithi[6] or Ceancroithe,[7] a form which appears to be resolvable into Cean Cruai(ch)dia—*latine* Ceancroidhi—and to mean "the hill-head god."[8] All the indications deducible from textual description, when coordinated with the local features, suggest that Crom looked forward from the conspicuous station on the hill-brow where terminates the axial line of the rath behind. "To the south was its face," says the Tripartite narrative, "namely, to Tara."

Having shown that Darraugh and Kilnavart answer in every particular to the evidential tokens, I would submit that I have vindicated the trustworthiness of those much-arraigned texts that rescue from oblivion the memory of Crom Cruaich. It behoves me now to see whether, by their aid, the mystery of Crom's personal identity may likewise be penetrated. The documents imply that he must have occupied a station of unquestioned

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[1] The word is printed in this form on the Ordnance maps, but the local pronunciation corresponds to the spelling *Bel-bally*.

[2] It is marked on the earliest issue of the six-inch Ordnance sheets (No. 6 for Cavan); and the name (Legnaderk) was included in the Census lists down to 1901, though it was omitted in 1911.

[3] Hogan's identification is:—"Aghadark tl. nr. and s. of Ballymagauran" ("Onom. Goed.," p. 530). Aghadark townland (*Achad-na-d-torc* = the hog's field) runs into Ballinamore at the west end, and is not less than ten miles from Bellavally.

[4] This does not imply that his worship seats elsewhere were not likewise Cruachs.

[5] While conceding to Professor Rhys that *Pennocrucium* (Penkridge)—a place-name of the British Cornavii—may be an etymological equivalent of *Cenn Cruaich* ("Hib. Lectures," p. 203), I fail to see how it can be accepted for anything more. The word "Cenn" or "Head" is used in a variety of applications; and it has not been shown that there was ever an idol at this Roman station.

[6] Messingham's "Florilegium," p. 26.

[7] Colgan's "Tr. Thaum.," p. 47.

[8] The "Third Life" of Colgan names the idol "*Cennerbhe* ("Tr. Thaum.," p. 25), presumably a corruption. Dr. J. H. Todd surmises, quite reasonably, "that this word is wrongly transcribed, and that it is really the same as Jocelin's *Ceancroithi*" ("St. Patrick, Apostle of Ireland," p. 128).

supremacy in the old Irish pantheon. Of all its inmates, he alone can produce from our ancient literature specific credentials of divinity. Every succeeding wave of invaders brought, no doubt, its own chosen celestials to our shore; but, each and all, they failed to dethrone Crom, and his empire tottered only when the Gospel message was sounded at Magh Sleacht. "Until Patrick's advent he was the god of every folk that colonized Ireland."[1]

The versified Dinnsenchus, as rendered by Kuno Meyer, attests:—

> "He was their God,
> The withered Crom with many mists,
> The people whom he shook over every host,
> The everlasting kingdom they shall not have."[2]

In a note to this stanza the translator suggests "harbour" as a possible alternative for the word "host" of the third line. In the Irish original the term used is *cuan*; and for *cuan* Edward O'Reilly gives the following meanings:—(*a*) deceit; (*b*) a bay, haven; (*c*) a field; (*d*) a troop, multitude.[3] If O'Reilly's authority is not challenged, all these meanings should, on their merits, be equally eligible for selection; and as (*c*) alone would succeed in yielding clearly intelligible language, I shall substitute it for "host" in the English version. I shall also write "faded Crom" for "withered Crom" (Irish, *Cromm Crin*) in the second line, on the warranty of O'Reilly, who translates *crine* as "rottenness, withering, fading."

The second couplet of the same stanza appears to me to be remarkably suggestive of a well-known sentence of St. Patrick's Confession: "Omnes qui adorant eum (*id est* solem) in poenam miseri male devenient."[4] The correspondence of the thoughts conveyed by the two texts creates, at all events, a strong presumption that the poet, when inditing this verse, had St. Patrick's pronouncement prominently in mind. In other words, the writer must be suspected of merely repeating in his own poetic style the plagiarized judgment that all the field-dwellers who quailed superstitiously under the darkened sun had forfeited thereby the hope of eternal salvation.[5]

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[1] "Rennes Dindsenchas," "Revue Celtique," xvi, p. 36.

[2] "Voyage of Bran," ii, p. 304.

[3] "Irish-English Dictionary," *sub voce*.

[4] "The Latin Writings of St. Patrick," by N. J. D. White, D.D. (Proc. R. I. A. vol. xxv, Sec. C, p. 252).

[5] The likelihood that the Dinnsenchus-maker was well acquainted with St. Patrick's Confession is further corroborated by the lines attesting the existence of idol-worship in pre-Patrician Ireland:

> "There was worshipping of stones
> Until the coming of good Patrick of Macha."

Compare "nisi idula et immunda usque nunc semper coluerunt" (White's "Latin Writings of St. Patrick," p. 248).

Taking Crom then to stand for the "Sun," and making the other alterations indicated, the lines emerge from obscurity, and plainly read :—

> "He was their god,
> The faded Sun-Deity with many mists,
> The people whom he shook over every field,
> The everlasting kingdom they shall not have."

On this interpretation Crom would take rank as a genuine solar divinity. But the sun in his dazzling brilliance and majesty Crom Crin, on the Dinnsenchus testimony, cannot pretend to be. At best he can aspire but to the rôle of a faded sun, shorn of his beams by many gathering mists; and, in addition to the crux thus presented, how are we to explain "The people whom he shook over every field (or bay)"?

The sun himself may help us in these difficulties if we study his behaviour towards our nether globe. The least scientific eye will not have failed to note that the sun functions doubly. In his sublime moods he dispenses the life-sustaining energies of light and heat. But his temper being unstable, he sometimes darkens the heavens with ominous vapour masses, while the thunder-spirit then takes possession of the blackened atmosphere, and stalks in unrestrained fury over the quaking earth. The sun, the hidden thunder-sprite, the thunder-god in action, being thus correlated, is it likely that the concept of their unity in trinity never took shape inside the minds of the keen-witted Gaels? The faded sun-god of the Dinnsenchus verse is clearly a synonym, a typification, of the power which shook the people "over every field"—a people doomed to perdition because of their spiritual bondage—and that power, I think, was the Cloud-Gatherer and Thunder-Wielder, Crom.

Let me now probe this theory at the mythological side. Roderick O'Flaherty, who had ampler opportunities of studying the phenomena of pagan survivals in Ireland than can ever again be enjoyed, informs us that Crom Dubh was an *alias* for Crom Cruaich, and that Crom's festival, held on the last Sunday of July, was commonly observed throughout the country as Domnach Crom Duibh.[1] Yet O'Flaherty failed to trace this observance to its ultimate source, for he took it to be a commemoration of the destruction of idolatry which St. Patrick had achieved at Magh Sleacht.[2] Objecting that "the coincidence of the day with the ancient pagan festival destroys this hypothesis," Dr. Todd very justly remarks "that Sundays were not dedicated to saints."[3]

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[1] "Ogygia," pp. 191–9. In an Irish poem of 28 stanzas, bound up with the "O. S. L.," Mayo (vol. ii, pp. 272–6), Crom introduces himself as "Crom Dubh Cruaich."

[2] *Ibid.*

[3] "Life of St. Patrick," p. 129.

If the Domnach Crom Dubh celebration had been instituted in honour of St. Patrick, it would have been associated everywhere with his name, and reserved exclusively for his veneration, taking its place among our annual festivals as a second Patrick's Day. Such, indeed, was the special purpose of the pattern, or station, held on the last Sunday of July at Kilnavart. A generation or two ago large numbers of people regularly assembled there on every recurring Domnach Crom Dubh;[1] and I am informed that, until recent years, some pious folk kept up the traditional practice of moving on their knees, after the Saint's example, and reciting prayers along the connecting pathway between the well (Tobar Patraic) and the rath (Fossa Slecht).

But holy wells abound in Ireland, dedicated to various other saints as well as to the national apostle; and many of them even yet are the scenes of Domnach Crom Dubh assemblies. Six miles west of Athlone, in the Co. Roscommon, is the village of Brideswell, so called from a St. Bridget's Well, around which its humble habitations cluster. I was there in the last week of July, 1920, and I learned that a local pattern held in honour of St. Bridget still brings a considerable concourse to the place on Crom Dubh's Sunday.[2] Near Lahinch, in the parish of Kilmanaheen, in West Clare, stands another St. Bridget's Well, which is much regarded by the native population. The patron saint is regularly venerated there on her festival day, the 1st February; but at the beginning of the last century the well derived additional fame from the size of its gatherings on the last Sunday of July. The devotions and the amusements special to the occasion were fortunately placed on record by a careful observer,[3] who incidentally mentioned that the day "is called Garlic Sunday,[4] but for what reason is not known."

A projecting stone in an old church wall at Cloghane, in Co. Kerry, rudely shaped into a human head and countenance, was believed, in the middle of the last century, to represent the features of Crom Dubh.[5] At the same village, Mr. Hitchcock tells us, "a pattern is still held, in honour of

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[1] Father Brady writes me: "There was a station at the well to which crowds of people came about sixty years ago. The station has discontinued. It took place on the *last Sunday of July*. Some old individuals in the locality still make the station on the las Sunday of July."

[2] Lewis ("Top. Dict.," p. 224) states that this "patron," once of great celebrity, was suppressed by the R. C. clergy. The "suppression" can have proved only partially effective.

[3] Rev. James Kenny, LL.D., Archdeacon of Kilfenora, in Shaw Mason's "Parochial Survey of Ireland" (1814), vol. i, p. 494. Mr. Nutt mistakenly refers this celebration to Kilmainham in Meath ("Voyage of Bran," p. 214).

[4] As to "Garlic" Sunday (*recte* Garland Sunday), *vide infra*, pp. 51, 56.

[5] "Gleanings from Country Churchyards," by R. Hitchcock (in "Trans. of Kilkenny Archæological Society," vol. ii, p. 126).

Crom Dubh and St. Brendan, on the last Sunday of July, which is commonly called 'Dounach Crom Dubh'"[1]

At Kilcummin, in North Mayo, where tradition still cherishes the well used by St. Patrick for baptizing his converts in the district, "not a year has passed since then without the people holding a station at the well on the anniversary of that day, and that day is the last Sunday of the seventh month. And in that place the Irish speakers call the month 'Mi na Lughnas,' and the Sunday 'Domhnach Chruim Duibh'; and the English speakers call the Sunday 'Garland Sunday.'[2] And not a year from then until now but there has been a pattern at Kilcummin, where the same well is. 'Tobar Chuimin' they call it, for its name was changed in St. Cuimin's time, because of the many miracles he worked there; and he is buried in Kilcummin, within a perch of the well . . . There is a pattern the same Sunday at the well called St. Bridget's, just close to Kilbride, and not far from Doonbristy."[3]

In the "Descriptive Catalogue of the Book of Fermoy," published by J. H. Todd, D.D.,[4] one of the fragments is thus introduced: "This is the reason why Crom Dubh Sunday was so called." The explanation given is that on the same day, as was related by a demon to St. Cainnech of Roscrea, Crom died; that the evil powers, whom he had well served, naturally clutched at his lifeless body, with intent to carry off his spirit; but that "suddenly St. Patrick, with a host of saints and angels, appeared, who assailed us with fiery darts, one of which struck me in the leg, and has left me lame for ever. It seems that Crom Dubh's charities and good works were more than a balance for his sins; so the saints took possession of his soul, and put us to flight."[5]

This legend simply conveys by means of Christian symbol the well-remembered facts that St. Patrick with his legion of saints and angels had invaded Crom Dubh's citadels at Magh Sleacht and elsewhere; that the aged deity Crom then forfeited his heathen existence; that the evil spirit of paganism—the lingering regard for idol-worship—still struggled hard to resist destruction; that the same spirit was quickly maimed, and Crom Dubh's instrumental influence rescued from its grasp, by the new-risen church of Patrick's founding. Thenceforth the saints had possession of Crom's

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[1] "Trans. of Kilkenny Archæological Society," vol. ii (1852-3), p. 130.

[2] I infer from this that the name "Garland Sunday," incorrectly given by Dr. Kenny as "Garlic Sunday" (*supra*, p. 50), was used only by the Anglo-Irish.

[3] "Lub na Cailligh," edited by Joseph Lloyd, M.R.I.A. (Gill & Son, 1910), pp. 39, 40.

[4] Proc. R.I.A., vol. i, pt. i, p. 30.

[5] *Ibid.* See also "O. S. Letters," Co. Mayo, vol. ii, p. 269.

soul; and his quondam friends, the demons, were doomed to perpetual banishment.

The demons having been routed, Crom became thereafter the friend, the associate, and the helper of those saints who had rescued his soul from its appointed doom. In the beautiful figure which thus accounts for the origin of the name Domnach Crom Dubh, we see exhibited the *raison d'être* of the same Domnach institution, and obtain a graphic illustration of the mode in which Ireland's ecclesiastical mind reacted on its *damnosa haereditas* of paganism during the era of its endeavour to organize our early church.

In Tirmany and in Corcomroe, as has been shown, Crom was placed under the protection of St. Bridget. In Corcaguiney his guardian was St. Brendan the Mariner. In Tirawley he enjoyed the friendship of St. Cuimin. At Magh Sleacht he was joined in devoted companionship with St. Patrick. The common term of all these combinations being the ubiquitous Crom Dubh, the conclusion is fully warranted that to him the annual festival had been sacred before saints ever came on the scene to share its distinctions under the reformed dispensation. The commemorations having resisted suppression, the church compounded with popular sentiment by placing them under religious patronage. Both as a name and an institution Domnach Crom Dubh luminously exemplifies the treatment applied by Irish ecclesiasticism to such pagan survivals as, holding out against anathematisation, maintained their place in popular regard.

The conclusion here reached can be set on an absolutely impregnable basis. While Crom Dubh, or Crom Cruaich, was associated throughout Ireland with saints, and honoured as their conciliated subordinate, he ceased not in many quarters to reign as the sole hero of the Lugnasad celebrations. His independent anniversaries, no doubt, became more and more isolated; and very few of them survived down to recent generations. In one region, however, the process of effacement has been arrested by counter agencies; and, most remarkably, that region is the continuous barrier of mountains that shields Magh Sleacht on the western side.[1] In Magh Sleacht itself the last Sunday of July still attracts a large gathering every year to St. Patrick's Well at Bellaleenan.[2] North of Cuilcagh, the bold steep of Benaughlin (Beneachlabhra) guards the pass leading from Fermanagh into Tullyhaw;

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[1] In this branch of my inquiry I have received valuable help from Mr. R. Vincent Walker, of Clones, who has made a special study of the place-names, customs, and traditions of every district of Co. Cavan.

[2] I owe this information to Mr. Walker; and I learn from him also that Kinawley was, a generation or two since, the scene of another big "Domhnach Sunday" assembly.

and under its precipices some thousands of people still assemble annually to celebrate the last Sunday of summer, or of July.[1]

Half way up to Bellavally, along the county road leading from Bawnboy to Glengevlin, a formidable protuberance of limestone rock rises just by the roadside. Commonly known as the "Black Rocks," this crag-mass is sometimes named "Maguire's chair,"[2] and its fame is widespread even yet as a "Domnach Sunday" station, to which people resort, not alone from the neighbourhood, but from distant parts of the surrounding country.

Inside the Bartonny ridge of Slieve Anierin there is a place called Scarahoo (Scairbh thuadh ?), well up along the chasm of a mountain torrent.[3] There is another curious spot called Pollty, or Polltyhalla, some five or six miles farther west towards Drumshambo, right under the highest point of Slieve Anierin. I have spoken to several people, young and old, who have frequently attended one or both of the festivities held at these remote trysting grounds on Domnach Sunday, or the last Sunday of July. At Pollty one of the pastimes consisted in throwing stones into a fathomless hole, or fissure, through which a mountain rill descends among the rocks, to reappear at a lower level about a mile farther down. The object, or origin, of this performance, my informants did not know; but I could not help recalling, as a possible clue to its explanation, a story I had heard in Ballymagauran, that the demon Crom when vanquished had cast himself into the earth, making a deep hole in his descent.[4] The hole-idea was invoked even in the mode of paying the musicians. Everybody who participated in the dancing threw his contribution at the end of the bout into a hole appointed for the collection.[5]

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[1] There are many dolmens and ancient monuments around, from Knockninny on the east to the "Marble Arches" on the west.

[2] It was this name, I presume, that misled Coote into foolishly locating the coronation seat of the Fermanagh chieftains on top of Cuilcagh ("Statistical Survey of Co. Cavan," p. 25).

[3] I have heard the name variously pronounced as *Scarhoo*, *Scarahoo*, and *Skerahoo*.

[4] The local tradition, as I heard it summed up by old Pat Prior of Ballymagauran, now in his hundredth year, runs thus: "When Crom Cruaich was killed by St. Patrick he flung himself into the earth behind Ballymagauran, making a deep hole in the ground, and he is there buried." Mr. Walker, of Clones, has sent me some verses of an old folk-ballad, which he heard recited in Co. Cavan, and which, after vaunting that Magauran's "tribal ground" in Tullyhaw was once the centre of a nation's faith, relates:

> "So quickly did the Tullyhagh come into Christian birth,
> That legends tell, Crom Cruaich fell and vanished in the earth."

[5] I have fully authenticated all these, and some other, "Domhnach" stations, having visited the places and conversed with many—including some members of the teaching profession—who were present at one or more of the anniversary meetings.

The Domnach Sunday carnivals, at the end of July, are decaying; the numbers who frequent them are diminishing, and getting restricted to the juvenile population; the race of blind minstrels has died out, and music is now rarely heard on the occasions; but all round Slieve Anierin, nevertheless, the fête, or gala-gathering, is still kept up, an organic institution of the social life, a recurrent function of the hereditary customs, throughout a large district of country.[1] The assembly stations hide, in a continuous line, within the long chain of mountains that overlook Magh Sleacht from the west, in retreats or at elevations difficult of access. From Darraugh fort the full extent of this range, to both its extremities, can be surveyed at ease, its course throughout being clearly discernible. So far as I could ascertain, the meetings held at Benaughlin and at Bellaleenan on the last Sunday of July have now no particular name. But at Pollty, Scarahoo, and Cuilcagh (Black Rocks) the occasion is styled Domnach Sunday.[2]

Did St. Patrick hear of these celebrations when he demolished Crom's famous shrine? His route through Magh Sleacht and Magh Rein supplies the strongest reason to believe that he did. After leaving *fossa Slecht,* he made a full circuit of both Maghs, keeping close all the time beside the mountain bases, and baptizing his converts at intervals of about half a dozen miles. There is a Patrick's Well near Pottore, in front of the glen leading into Scarahoo. There is another near Liscarbin, not far from the Aghacashel entrance to Pollty. The Saint, I think, beleaguered Crom not alone on Magh Sleacht, but likewise in his lurking-places among the mountains. The number of these stations within such a limited area is most remarkable. It shows that every inhabited quarter along the lower ground dedicated a mountain temple of its own to the great deity. The opening verse of the Dinnsenchus poem—"Sund nobid idal ard co n-immud fich"—has been translated, not very intelligibly, into "Here used to be a high idol with many fights."[3] I find *fich* rendered by Zeuss as *municipium, pagus* or *vicus*;[4] that is, cantonment or minor population-group. In view of the facts which I have just outlined, this rendering appears to me to bring out, with striking effect, the bard's intended meaning.

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[1] "L'homme abandonne moins volontiers ses ceremonies que ses dogmes." Camille Jullian, "Histoire de la Gaule," i, 143.

[2] I have not heard of such observances in Leinster, though "The Maas" (Lammas) is still celebrated in South Wexford. Domnach Sunday patterns are most numerous around Lough Allen, from Kiltoghert, near Carrick-on-Shannon, to Kinawley, near Lough Erne. Mr. Walker tells me that the curious custom of runaway matches, well known at Tailltu, was long kept up in connexion with these occasions at Cuilcagh.

[3] "Voyage of Bran," pp. 301 and 304.

[4] "Grammatica Celtica," pp. 21 and 53.

It is manifest, therefore, that the god who had been so exalted in distinction by Gaels and pre-Gaels did not, after his discomfiture by St. Patrick, wholly forfeit the goodwill of his subjects throughout Ireland. Rather, while abdicating his empire over their spiritual natures, he retained in goodly measure the homage of their minds and hearts. As the centuries passed by his familiar figure and functions faded from the national recollection. Forgotten he was not;[1] but, deprived of his transcendental attributes, and confined to the terrestrial universe, he shrank into euhemerized likenesses of his original self. In West Mayo he got so thoroughly humanized that even O'Donovan failed to recognize in him the deposed deity, and unsuspectingly took him to be, as was there believed, "a chieftain in Umhall, who had been a powerful opponent of St. Patrick, but was converted by St. Patrick on this day."[2] In doubt as to this identification, Todd goes near to provoking a smile by objecting that O'Donovan "gives no authority for the existence of any such person" as Crom Dubh.[3]

In that rare retreat of hoary legend, the environment of Lough Gur in County Limerick, the Ronadh Crom Dubh, or staff of Black Crom, is a leading feature of the existing stone circle; while the "tradition of harvest offerings, lingering in the folk-lore of that locality, identifies Crom as the little black man who first brought wheat into Ireland."[4] Cromwell Hill in the same county was apparently one of his shrines, for an ivy-covered rock of conical shape, rising from its southern side, is still called Caislean Crom.[5] Not improbably the war-cry of the FitzGeralds, "Crom-aboo," made the same old deity's name resound on many a battlefield; for there is reason to believe that Croom on the Maigue took its name from a stone emblem of Crom, now lying neglected beside the river.[6]

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[1] Thus N. O'Kearney, a competent authority on the customs of the Irish peasantry, knew that the Friday, Saturday, and Sunday immediately succeeding *La Lugnasa* "were called *Aoine, Satharn, agus Domnach Aine agus Chroim Duibh*"; these days being sacred to Aine, in conjunction with Crom, a universally acknowledged deity of the Pagan Irish (Trans. Kilk. Arch. Soc., ii, 35); and that "Crom's festival was celebrated by the husbandmen . . . in gratitude for having brought the fruits of the earth to perfection" (Ossianic Society's Publications, vol. i, p. 105).

[2] "Four Masters," anno 1117. For the Umhall "chieftain," *vide* poem cited *supra*, p. 49, note 1, and *infra*, p. 64, note 1.

[3] "Life of St. Patrick," p. 129.

[4] Journ. of Limerick F. Club, iii, 56 (Paper by Mr. P. J. Lynch, M.R.I.A.).

[5] *Ibid.*, p. 54.

[6] *Ibid.*, p. 56. A like suggestion would apply to Crom Castle, the Earl of Erne's beautiful seat, a few miles north-east of Slieve Russell. For an amusing development of Crom's euhemerization, see a note of E. O'Curry, at p. 270 of "O. S. L.," Mayo, vol. ii.

At Askeaton, in the same county, "Crom Dubh, St. Patrick's servant," lived in tradition as the intercessor on behalf of the Sidhfir, or "Good People," with his potent master St. Patrick. He took their message to the Saint "on the last Sunday in July, and ever since that day (for the first Sunday in August it sometimes is) is called in Ireland Crom Dubh's Sunday."[1] It would seem from this that the first Sunday of autumn served in some localities for Crom Dubh's festival, as an alternative date to the last Sunday of summer. Particularizing the day as Lammas Sunday, or the first Sunday of August, Professor Brian O'Looney designates it by the twin names, *Domnach Lunasa* and *Domnach Crom Dubh*; and in a valuable account of the day's programme at an actual celebration near Mount Callan, in County Clare,[2] he informs us that the occasion was called "Garland Sunday" by the English-speaking inhabitants of the district, "from the practice of strewing garlands of flowers on the festive mound on this day, as homage to Crom Dubh." The festive mound bore the significant name *Altoir na Greine* (altar of the Sun); the assembly ground was *Buaile na Greine* (fold, or stead, of the Sun); and the festive assemblage was *Comthineol Chruim Duibh* (the congregation of Crom Dubh). The clergy and elders of the neighbouring parishes having "admonished the people to abandon the custom of going to Mount Callan," the annual meetings at *Buaile na Greine* were discontinued during the Professor's youth.[3]

Black Crom's Sunday, by reason of its universal recognition, stood out so prominently in the national calendar that the "Four Masters" used it as their date-mark when recording a murderous attack by Aedh O'Ruairc and the Ui-Briuin, made in 1117 A.D., on the bishop and people of Kells. "The name," wrote O'Donovan, "is to this day applied by the Irish to 'Garland Sunday,' or the last Sunday in summer."[4] Summarizing this entry of the "Four Masters," Colgan ridiculously dates the occurrence as "the feast of St. Cromdubh";[5] and for his "ludicrous error" of canonising Crom he is duly censured by Lanigan, who accepts unreservedly O'Flaherty's explanation of the origin of Domnach Crom Dubh.[6]

Lugnas, or Lugnasad, the favourite feast of the Celts, was celebrated not alone throughout Erin and Gaelic Alba, but probably all over Britain and

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[1] David FitzGerald, in "Revue Celtique," vol. iv, p. 175.

[2] This communication is incorporated in a paper on "Sun-Worship at Mount Callan," read before the Royal Irish Academy in 1873 by Sir S. Ferguson.

[3] Proc. R. I. A., vol. i, ser. ii, No. xi, pp. 267–9. The large patterns at Rath Sleacht (Kilnavart) were discontinued under circumstances similar to those here described.

[4] Note to "Four Masters," A.D. 1117.

[5] "*In festo S. Cromdubii,*" "Trias Thaumaturga," p. 508.

[6] "Ecclesiastical History of Ireland," vol. iv, p. 56.

Gaul as well. It was the "fair of Lug,"[1] for it commemorated Lug, the sun-god, whose chief citadel in western Europe appears to have been Lug-dunum, or Lyons, in France.[2] Gaelic legend turned Lug into a Tuatha-De-Danaan king, Lughaidh Lamhfadha, the same who first instituted the fair at Tailltu, or Teltown, in honour of his foster-mother, the Firbolg queen so named.[3] If the cultured Gallo-Romans did not convert Lug into Augustus Cæsar they, at all events, held a festival of great celebrity at Lugdunum, and on the anniversary of the Lugnasad, in honour of the deified Augustus.[4] Among the religious commemorations of pagan Ireland, the most popular of all was the *La Lugnasad,* held on the first day of August, for the reason that it was the occasion of joy and of thanksgiving, evoked by the ripening of the fruits of the earth. The fields, which had been fructified by summer sunshine, were then becoming golden with the rich gifts of harvest; and the hearts of men were elated by the arrival of that season on which promise of abundance always attends. It was then, too, Crom Cruaich annually dispensed his blessings over the land, in repayment of the heavy tribute that had been laid on his shrine.

> "Milk and corn
> They would ask from him speedily
> In return for one-third of their healthy issue:
> Great was the horror and the scare of him."[5]

The carnivals of Lugnasad have, almost everywhere, disappeared, though the day that was gladdened by their rejoicings is in many places well remembered under the appropriate name of Garland Sunday. But in one primitive region these festivities are not yet defunct. Though steadily decaying, they survive within Magh Sleacht and along the whole extent of its mountainous environs.

Thus was Crom Dubh, after his decline, still reverentially cherished throughout Ireland, folk-tale co-operating with Christian legend in perpetuating his name, by reserving to him a two-fold rôle and a double sphere of influence. The common folk did not readily surrender their belief that he who had brought wheat into Ireland might still be a potent force in fertilizing their grain crops, and in blessing with increase their store of milk

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[1] *Lugnasad* = *Lug* and *Nasad,* "i.e. a festival or game of Lugh Mac Ethne or Ethlenn." The fair was opened *in gach bliadhain in thoidecht lugnasad,* which implies that it also preceded and followed Lammas day. (See "Cormac's Glossary," p. 99.)

[2] "Hibbert Lectures," pp. 419–21.

[3] O'Mahony's "Keating," pp. 142, 143.

[4] An altar was dedicated there to Augustus in 10 B.C. (Suetonius "De XII Caesaribus," v. cap. 2). Consult also Rhys, *op. cit.*, pp. 420–21.

[5] "Voyage of Bran," p. 304.

and butter. Though Crom had been dethroned for nearly a millennium and a half, though he had been united in companionship with saints and placed by Colgan on the saints' calendar, the lineaments of him that had got stamped on the national mind in his Olympian days still persisted until our own century in leaving traces among the imagery of the people.

In the golden period of Crom's power Ireland knew nothing of Christian institutions, and would have rendered no acknowledgment to the Lord's Day. With St. Patrick came a change, and the policy was inaugurated of diverting pagan observances to the service of the Church. Lug was ejected, for his influence had waned; while Crom was acknowledged as the true hero of the occasion. Complete deposition not being easy to achieve, the Church deheathenized the old potentate, and, placing his festival under religious auspices, allowed him, as the attendant of saints, still to participate in its honours. Among remote folk-groups, to whom the faith but slowly penetrated, Crom reigned on, as before, in undiminished majesty; and when such regions were finally reformed their Domnach Crom Dubh celebrations, though inevitably purified, in many cases escaped appropriation by saints. Obsolescent as a name, Lugnasad as an event was transferred from its own initial day, usually—as at Magh Sleacht—to the Sunday before, but in many localities likewise to the Sunday following, or the first Sunday of August. The people of each district, I would suppose, made their own choice of Sunday, and probably in some instances adopted, as each occasion came round, the Sunday nearest to the original date.[1]

The older ceremonies of Crom and of Lug having synchronized, the question arises: Would the Gaels have so ordered their religious proceedings that two rival deities should be obliged to participate in a common, undifferentiated anniversary? The possibility that they might have done so cannot be entertained; and its rejection leads at once to the result that under the dissimilarity of names lurks a virtual sameness of the entities which they clothe. The personages are really but one, a single primal divinity, conceived as such in the parental womb of Aryan theology, and as such begotten there by the generating idea. The names, having been evolved by divergent stocks of Aryan wanderers, were eventually brought into collision when the worshippers of Lug crossed from Gaul to Erin, and, with superior war-appliances, overthrew the followers of Crom. Compelled to forfeit their lands, the beaten race held fast by their religion. On their altars still reigned the aboriginal solar divinity, not in his alien guise as Lug, but as their own unmetamorphosed Crom. In process of time the names got sundered in

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[1] In cases known to me this arrangement was adopted for patterns that had been changed from the Patron Saint's day to the proximate Sunday.

their application, to distinguish the deity as he manifested himself in two separate, yet co-ordinate, sets of activities. Lug was distinctively the sun-god of the ruling Gaels, personifying the sun in his luminous splendour.[1] Crom was a sun-god likewise; but the sun which he typified showed a face turning black with anger, and wrathful eyebrows boding havoc to men.

In Ireland Crom was undoubtedly the older deity; and until Lug came hither, probably with the race that afterwards shed lustre on Emania,[2] Crom was undisputed lord of the sky and the air.[3] It is not at all unlikely that the punishment inflicted on the myth-hero Tigernmas at Magh Sleacht[4] was brought on himself by an ill-advised effort to assimilate the rites of the native divinity Crom to the exotic worship of the imported Lug. But Crom Cruaich prevailed over Tigernmas; and until Patrick's time he was worshipped by every folk that had settled in Ireland. He was obliged, it is true, to divide his empire with Lug, reserving as his own domain the exclusive realm of the thunder bolts; yet there is ample reason to believe that the *Sen Tuatha* never assented to this partial deposition. The depression in rank helped to make Crom morose, fitful, vindictive. Trusted by none, feared by all, with heartless cruelty he exacted the dearest tribute which the Gaels had to bestow, at one time being placated only by hecatombs of their healthy offspring. His demands were, nevertheless, conceded by all, from the High-King down; and Laegaire himself, sceptic though he apparently was, had not the courage to renounce his religious obligations to Crom at Magh Sleacht. But the demands of Crom's officiators having been wrung from his superstitious fears, rather than freely rendered by his faith, it was not so unnatural that Crom's overthrow by St. Patrick should have received his royal approval.

The attitude of King Laegaire in rejecting Christianity, while sanctioning St. Patrick's mission, has not hitherto been elucidated by the Saint's biographers. The seeming paradox, I think, will cease to perplex when it is remembered that the religions to be suppressed were, in the main, racial

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[1] This Celtic word is evidently identical with the root of the Greek λευκαίνω and Latin *luc-eo.*

[2] The Irian kings were buried beside Lug's famous shrine at Tailltiu (see *Senchas na releg*, in Petrie's "Round Towers," p. 101).

[3] The conquering Hellenes, similarly, suffered the priests of some vanquished states to retain the gloomy rites of their pre-Hellenic god Kronos—the deity to whom, as to the Semitic Baal or Moloch, royal offspring were once sacrificed (see Frazer's "Golden Bough," vol. ix, p. 354). The old Irish Crom presents more than one striking resemblance to the old Greek Kronos; but while Kronos was knit to Zeus in closest family relationship, Crom was never reconciled to Lug.

[4] See "Four Masters," B.C. 3656.

inheritances of the older, subject populations. The chief divinity of the Sen Tuatha had no place among the accredited Penates of Milesian rulers; and it is, furthermore, not improbable that the governing Gaels, having outgrown their primitive beliefs, retained of their own ritual observances only the empty forms. They could not have been expected to view with unqualified favour the religious stations of Crom; for the assemblies, being widely diffused through the land, might readily become centres of political disaffection.

As thunder-god Crom retained the most formidable of his ancient prerogatives, dominion over fire. But this power he would no longer use for beneficent purposes. He kept the awful weapon concealed until his temper got roused; and then, with loud rumblings and roarings, he flashed it recklessly forth, to the dismay of the nations. Small wonder that the tribesfolk, whom "he shook over every field," strove with all their might to propitiate such a ruthless and irascible despot. Like every Aryan race, the Gaels trembled in awe of their malignant thunder-god. In the Homeric theogony Zeus, the cloud-gatherer, sate supreme over all. The Latins had their Jupiter, the Teutons had their Thor, the Gauls had their Taranis, for autocratic disposer of meteorological events.[1] The same Taranis, with a rapacity which likened him to the Scythian Diana and to the Hibernian Crom Cruaich, demanded the punctual immolation of human victims on his altars.[2] Taranis extended his sway into Britain, where he reigned as Taran,[3] and is thought to have had his idol worshipped under a resembling name.[4] Can it be believed that the throne of the thunder-god was left vacant in the palace of our Gaelic immortals? Is it not more likely that the occupant of that throne held aloof, disdaining to commingle with an adventitious body of celestials who, jealous of his monarchic prerogatives, had striven vainly to usurp his sceptre?

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[1] For a full enumeration see Frazer's "Magic Art," vol. ii, pp. 356–75.

[2] "Et quibus immitis placatur sanguine diro, . . .
. . . .
Et Taranis Scythicae non mitior Dianae."
(Lucan's "Pharsalia," i, 444–7.)

[3] "Taranis seems to have been worshipped by the Britons under titles derived from words for fire and thunder, as "Summer-god who brought the rain and sunshine, and dispensed the fruits of the earth" (Elton's "Origins of English History," p. 256).

[4] "Etirun, the Idol of the Britons," see "Dinnsenchus of Temhair," in Petrie's "Tara Hill" (Trans. R.I.A., vol. xviii, pt. ii, p. 130). As to Etirun, or Etherun ("Metr. Dind.," Todd L. Ser., vol. viii, p. 11), it should be noted that Prof. Rhys makes Taranis a goddess ("Orig. and Gr. of Celtic Religion," pp. 70–2,—being, I fear, the sole representative of this view—while Professor Macalister holds (Proc. R.I.A., xxxiv, Sect. C, nos. 10, 11, pp. 298, 9) that Etherun is the EDDARRNONN of Pictish monuments, and will not easily equate with Taran.

Some[1] have impugned the credit of the Dinnsenchus poem because it affirms that the tribute rendered to Crom by his votaries included the sacrifice of "their piteous, wretched offspring," even to the extent of "one-third of their healthy issue." [2] But *a priori* considerations will not suffice for rejecting the obnoxious stanzas of the document, even in such a worthy cause as that of clearing the reputation of our heathen ancestors from an odious stigma. Questions of this kind had better be avoided if they are not tried by strict methods of historical inquiry;[3] and, indeed, in the present instance sentimental scepticism can but lead to the *reductio ad absurdum* that the early colonizers of Ireland had fled hither in protest against the sacrificial observances which, on Cæsar's testimony, we know prevailed in their own cradle-lands of Gaul.

Even when the horrible rite had been discontinued,[4] the worship of Crom must have been a most dismal function, an ordeal which imposed the severest strain on the physical endurance of his devotees. "They all prostrated themselves before him," says the Rennes Dindsenchas, "so that the tops of their foreheads, and the gristle of their noses, and the caps of their knees, and the ends of their elbows broke, and the three-fourths of the men of Erin perished at these prostrations."[5]

Following the prose versions of the Dinnsenchus, both Colgan[6] and O'Flaherty,[7] in their Latinized rendering, "Campus Adorationis," refer the etymology of the name *Magh Sleacht* to those prone congregations of suppliants. Though their derivation, having been approved by O'Donovan,[8] is now universally accepted, it must be admitted nevertheless that Charles O'Conor's interpretation of Magh Sleacht as *Campus Stragis,* or *Campus Excidii,* is by no means in conflict with the metrical, or original, Dinnsenchus:[9]—

"To him noble Gaels would prostrate themselves,
From the worship of him, with many manslaughters, the plain is called Mag Slecht."

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[1] Dr. Joyce, e.g., "Soc. Hist.," i, 281-4.

[2] "Voyage of Bran," ii, 394. See also "Rev. Celt.," xvi, p. 36.

[3] "That human sacrifices were commonly offered by the ancestors of the civilized races of North Europe, Celts, Teutons, and Slavs, is certain" (Frazer's "Golden Bough," vol. iv., p. 214.)

[4] The practice could hardly have survived the enlightened reign of Cormac Mac Airt, if it had not ceased before that date. No Dinnsenchus tract affirms the continuance of human sacrifice here until St. Patrick's time.

[5] "Revue Celtique," vol. xvi, pp. 35, 36.

[6] "Tr. Thaum.," p. 133.

[7] "Ogygia," p. 196. The "Four Masters" (*anno* 3656 B.C.) and Keating (Dineen's Edition, ii, 123) render the words similarly.

[8] O'Donovan would make the name mean "plain of genuflexions" ("F.M." *loc. cit.*). "Plain of prostrations" seems to be a closer translation.

[9] It might appeal also to the name *Porturlan,* standing for a townland right under Crom's hillock (*vide supra,* p. 35).

Much learning has been expended in efforts to discover the mysterious Crom by subjecting his compound name to philological dissection. The interpretations of the word *Crom* that are most in favour oscillate between (*a*) "a maggot" or "serpent" and (*b*) "a crooked or bent thing"; while, as regards *Cruaich,* opinion is equally divided between the significations (*c*) "bloody" and (*d*) "mound." Every combination which these meanings yield has been put forward by scholars of eminence as the solution of Crom's identity.[1] Some would, indeed, suggest that the name was of no particular import; that, in all probability, it denoted nothing more than a neglected heap of stones at Magh Sleacht.[2]

A hypothesis evolved, in the first instance, from linguistic speculation, if it is to be carried beyond the conjectural stage, must be compared with such evidential tokens as are discoverable among the traditions of Crom that survive in records and in living legends. With a view to bringing the trial processes to a speedy end, I shall range together the theories just noticed, and confront them with a single folk-tale, which was taken down verbally, not many years since, in the native speech, from an old resident of Tirawley, and was subsequently published by Mr. J. H. Lloyd under the title "Sgeala ar Naomh Padhraic's ar Chrom Dubh."[3] But before doing so let me admit from the glossaries just another verbal meaning which has hitherto, unjustly, been almost overlooked or ignored. *Cruim* is an archaic word, but we know, on ample authority, that it existed in old Irish, and signified *thunder*.[4]

The story I propose to introduce reads as if it had been composed, of set purpose, by George Meredith or Rudyard Kipling, or some other master of the allegoric art, to euhemerize Black Crom and the vagarious perversity of his works and pomps. The scene of the drama is the headland between the bays of Killala and Bunatrahir, in the County Mayo. The same ground was anciently occupied by the wood of Fochlad, the wood whence St. Patrick in a dream heard the "voice of the Irish" calling him back to walk amongst

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1 Thus O'Curry ("MS. Mat.," p. 632) adopts the combination (*a*) (*c*).
Borlase ("Dolmens of Ireland," ii, 472) ,, ,, (*a*) (*d*).
De Jubainville ("Ir. Myth. Cyc.," pp. 60–61) ,, ,, (*b*) (*c*).
Rhys ("Orig. and Gr. of Celt. Rel.," p. 201) ,, ,, (*b*) (*d*).
Professor Henderson propounds the novel view that Crom may be "cognate with the Teutonic *hrum*," which means "soot" ("Survivals of Belief," p. 204).

2 Wood-Martin ("Traces of the Elder Faiths," ii, 208); MacBain ("Celt. Myth. and Rel.," p. 201). Dr. W. Stokes took Crom to be a mere earth-god ("Rev. Celt.," xvi, 35).

3 "Lub na Caillighe," published by *Connradh na Gaedhilge* (1910), pp. 33–40. See also "Gadelica," vol. i, pp. 172, 173.

4 See "Archiv für Celtische Lexicographie," Band III, Heft I, p. 535, where Kuno Meyer quotes from O'Clery's Focloir "Cruim i. toirneach." The lexicographers O'Brien and O'Reilly also give *cruim* = thunder.

them as before. Crom's residence was Dun Briste, or Doonbristy (the broken fort), then joined to the mainland, but now a rock-islet in the sea, outside Downpatrick Head.[1] The characters are: Crom Dubh himself; his two sons, Teideach and Clonnach; and his two mastiff hounds, Coinn Iothair and Saidhthe Suaraighe. The editor presents the tale as he received it; and though he can hardly have failed to perceive its profound mythological import, he makes no allusion whatever thereto. He does not even suggest the latent significance of any one of the foregoing names. Who Crom Dubh is I shall leave an open question for the present. Teideach, whose retreat was Pollatheidigh,[2] is the cavernous wind-gust in humanized form. Clonnach is taken to be a variant, or derivative, of *Clonn,* meaning a pillar, or a chimney-piece.[3] As the brother, in flesh and blood, of Teideach, Clonnach, if not a verbal freak, must therefore represent the columned cloud-formations that so often rise unexpectedly from the sea. *Coinn Iothair* (= Cu Iothair) is explained as "Hound of Rage," and *Saidhthe Suaraighe* as "Bitch of Wretchedness." Thus Crom Dubh's dogs become Rage and Affliction, while his sons reveal themselves as the Storm-Blast and the Pillared, Fire-Enclosing Clouds. With this preface I shall give, in translation, just a few passages from the tale, and allow them to explain themselves:—

"Before St. Patrick came to Ireland, the leader of the Pagans, whose name was Crom Dubh, lived in the north of County Mayo."

"He had a big fire kindled on top of the cliff, into which he threw everybody who escaped the dogs."

"Crom Dubh, his sons, and his dogs were noted far and near for their wickedness; and the people were so affrighted by his name, and not his name alone, that they would bury their faces in their breasts when it was mentioned; and if they heard his dogs barking they would hide under the ground to protect themselves from Crom Dubh and his mastiffs."

"Crom Dubh would send his sons and his dogs before him to announce that he was coming to collect his yearly rent." "It is how Crom Dubh came after them in a sort of sliding car."

"Crom Dubh and his company had the old authority, and the people had to endure his tyranny for many years; and every year their lot got worse, without hope of getting better, as they did not know God."

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[1] For a description of this pyramidal rock-mass, and of the corresponding indenture in the headland cliff close by, see M'Parlan's "Statistical Survey of Co. Mayo," p. 151; O'Donovan's "Ordnance Letters," Co. Mayo, pp. 279 *et seq.*; and, particularly, a paper by Mr. T. J. Westropp in Jour. R.S.A.I. for 1912, pp. 101–112.

[2] *Recte* Poll a t-Seididh (the blowing-hole), "the name of a sea-cave that is honeycombed in under Glennlosser," "Lub na Caillighe," pp. 77–79.

[3] *Ibid.*, p. 75.

"For that reason they had nobody in whom to trust, except Crom Dubh; for they thought that, bad though he was, he brought them *light of day, darkness of night*, and *change of seasons*."[1]

St. Patrick proceeded to Crom's dwelling-place; and, as he approached, Saidhthe Suaraighe gave a loud bark, while Crom and Teidheac urged him against the Saint. "With that Teidheac put his right finger in his mouth and whistled for Coinn Iothair, who was hunting with Clonnach on the top of Gleann Lasaire. She wasn't while you would be saying 'rainy day' in coming, when she heard the sound of the whistle."

"The two dogs made for St. Patrick, flames of fire issuing from their mouths, and a blue poisonous light shining in their eyes."

St. Patrick described a circle around them with his crozier, commanding

"A lock on your claws, a lock on your teeth";[2]

while "a fermented froth came from their mouths, and their hair stood erect like harrow-pins."

"When Clonnach saw the misfortune that had befallen his father he was so frightened of St. Patrick that he commenced to burn the mountain, and to set that whole side of the country on fire." Hence the name Gleann Lasaire, or Glenlosser (blazing glen).

"The people gathered everywhere in crowds paying honour to St. Patrick; and they felt very sorry when Crom Dubh was no more." Then the Saint baptized them all at a well close by.[3]

If Crom Dubh be interpreted as the Thunder-god,[4] this folk-romance becomes instinct with true poetry—the poetry whose aliment is supplied by direct observation of nature.[5] So, likewise, will the obscurest lines of the

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[1] Compare the following lines, which I translate from stanza 5 of the poem already cited (*supra*, pp. 49 and 55):—

Loquitur Crom:—

"'Tis I, alas! black Crom of the Rick,
Who was brought low in Umhall.
If the spell of the Evil One has fled from the Rick,
Has not the spell parted from the Sun (or Eye? Irish súl)?"

Much more of this poem might deservedly be put in evidence.

[2] "Glas ar d'iongain, glas ar d'fhiacail." In a supposed "St. Patrick's prayer against cross dogs," which Mr. Walker copied down, close to Magh Sleacht, the self-same words are used: Glas ar d'ionga as ar d'fhiacail."

[3] For further extracts *vide supra*, p. 51.

[4] Sylvester O'Halloran ("Introd. to the Hist. and Antiqs. of Ireland," p. 34) formulated this hypothesis, on the strength of "Cruim's being obsolete Irish for Thunder"; but he developed the theory no farther.

[5] The "chimney-piece" (Clonnach) figure seems to me to be particularly apt and beautiful, as imaging the columnar cloud-erections that get piled up from the sea, and

Dinnsenchus rhapsodist grow poetic; and what more expressive name could have been given the disowned deity than Crom Dubh? This, there can be no doubt, was his universal name throughout Ireland. As such he was specially reverenced near the higher mountain massifs,[1] because it was around their craggy sides his roar was most appalling; and it was over their summits his flame-discharges shot their most lurid glare. With the ruling breeds of the Gael his worship was not in fashion. They had their newer gods, who had accompanied them from Gaul, and helped them to victory and conquest. Neither was Crom in favour among the race whom these later Gaels had humbled in battle, driving them from their homes and demolishing their shrines. In pagan times there were diversities of religion in Ireland, just as there are to-day. So likewise was there active antagonism of races. The subjugated peoples appear but little in history, for neither historically nor socially was the life of those unregarded rent-payers deemed worthy of notice by their governing superiors.

The humbler folk-units stood apart from the usurping Gaels, sundered from them by baseness of blood, by political status, by hostility of agrarian interests. The *literati* of the Gaels confined their relations to the deeds of the Gaelic aristocracy, disdaining the plebeian tribes as too mean for admission to chant or record. They treated pre-Gaelic institutions and religions with the contemptuous indifference which Christian hagiologists and calendarists have observed towards the common paganism of all.[2] For this reason Crom Dubh is unadvertised in early Irish literature, and his name has been saved from perishing only by the preservative power of peasant traditions. But, Gael or pre-Gael, all paid tribute to Crom, for his power was too preponderant, and the dread of him too deeply rooted. "Until Patrick's advent he was the god of every folk that colonized Ireland."[3] When the pagan Irish swore by "the sun, wind, and elements,"[4] it is not

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then architraved into horizontal layers overhead—framing the mysterious fire of which everybody stands in awe—on those sultry days of autumn when the barometer portends a coming thunderstorm.

[1] "*Crom Dubh*, a celebrated personage, who was contemporary with St. Patrick, and of whom there are traditions at the highest mountains in Ireland, viz., at Sliabh Donard . . . at Croagh Patrick . . . and at Brandon Hill" (R. Hitchcock in Trans. Kilk. Arch. Soc., vol. ii, p. 130). Cuilcagh and Slieve Anierin may be added to the mountain list.

[2] Even Bury loses sight of these considerations when he writes that, if St. Patrick's achievement at Magh Sleacht had been of much importance, "it would inevitably have stood out in the earliest records as one of the decisive victories, if not the supreme triumph"; and "the later accounts impute to it a significance which it did not possess" ("Life of St. Patrick," pp. 124-5).

[3] "Revue Celtique," xvi, p. 35.

[4] See "Tripartite Life," vol. ii, p. 567 (Verse quoted from "Leabhar ha h-Uidhri," folio 118); also "Silva Gadelica," p. 407.

improbable that they had Crom and his terrors specifically in mind. Among the *Sen-Tuatha* he never forfeited a jot of his pristine authority and might. It is in their settlements the mementoes of his personality are yet chiefly to be found. Cromm Cruaich was the name of his idol at Magh Sleacht. Idols in abundance he had elsewhere, but their story has everywhere vanished out of memory. In "Domhnach Chruim Duibh" his name was treasured among the national institutions, and admitted to partnership with the names of Ireland's most distinguished saints, when the gods of all those contending races, whose rise and fall he had witnessed, were forced to hide from Patrick's anger under earth-mounds and raths.

Nor do I hold that *all* indications of Crom's influence have been effectually excluded from our bardic literature. His potency being concealed, we often hear but ambiguous utterances; and, like a Greek chorus, we are reduced to wonderment by being kept in ignorance of the power behind actors and stage. But in one instance, at least, the figure of Crom is uncurtained, and he is exhibited as *Crom na Cairge*, "who dwells at a rock on the eastern sea," whence his son the Piast (Monster), *Ard na g-Cath*, is despatched to demand battle of the Fianna.[1] If the Fianna be taken to represent, as Keating's introduction of them would warrant, the military arm of Cormac MacAirt—the monarch whose vigorous statesmanship finally established Milesian supremacy in Ireland—the interpretation of this challenge presents no serious difficulty. The Milesian poet, in stigmatizing Crom as "an *everlasting* monster that is in Greece"—"at a rock on the eastern sea"—evidently intends to set him down as an evil power, unrecognized in the selecter Gaelic Olympus, and imported originally from a far distant Mediterranean habitat.[2] The wife of this wicked deity was also "a Piast of great valour," by which no doubt was meant a religious cult, firmly rooted in the country, and maintained there in defiance of the governing classes.[3] Their son, the challenger of Finn, stood for the unruliness, the turbulence, the seditious revolts of Crom's orthodox flock, the down-trodden Sen-Tuatha.[4]

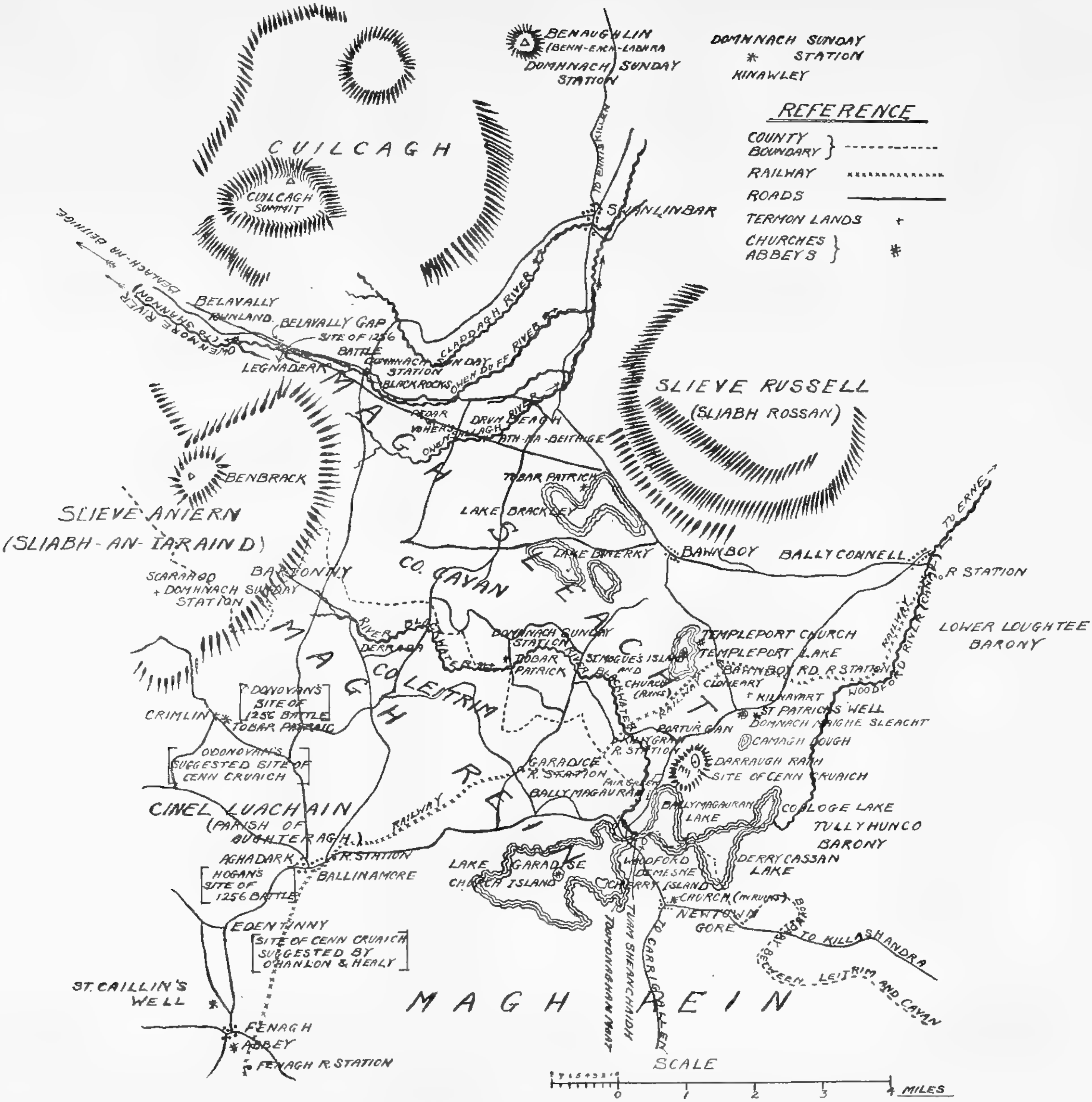
[1] "Ossianic Society's Publications," vol. ii, p. 58.

[2] This passage should not be overlooked by those who would speculate on the comparative mythology of Crom, and on the ethnology of his first introducers into Ireland.

[3] The popular belief that St. Patrick banished the "serpents" from Ireland originated, I apprehend, in a like metaphor—the use of the word *Piast* to represent a pagan rite.

[4] In this connexion it may be recalled that Cairbre Cinnceat, the usurping high-king, was fostered by a branch of the Cathraighe. A similar explanation would apply to one of the boasted exploits of "the expedition of eight"—eight mighty leaders of the Fianna—recorded in the "Dean of Lismore's Book" (p. 76), viz.:

"We bore along 'Crom nan Carn,'
O'er the fierce, stormy sea."



DALTON—CROMM CRUAICH OF MAGH SLEACHT.

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Whence D'Arcy Magee got the inspiration of his fine ode on "The Celts" I know not, though I suspect it came to him rather from the lips of some untutored peasant, transmitting a deposit of the unchronicled past, than from any speculative treatise. But I feel assured that he truly rendered the belief of pagan Ireland when he wrote:

> "Cromah, their Day-God and their Thunderer,
> Made morning and eclipse."

"Cromah," the name here used, would suggest that the word sometimes took a dissyllabic form; and the same probability might, I think, be suspected from the Dinnsenchus title, Cromm Cruaich. **M** is the radical of the pronoun in the first person singular; and, viewing the second **M** here as such, it imparts a subtle distinction to the name. Cromm would thus stand for Cruim'm, or Cruimim—that is, "I wield the thunderbolts," "Behold in me your indubitable thunder-god"! The massed gatherings of Magh Sleacht would not have interpreted these phrases as mere figurative language, but rather as the solemn self-announcement of Crom's idol when, gorgeous in his gold and silver panoply, and attended by his twelve sub-divinities arrayed in brazen integuments, he was suddenly exposed to their adoring sight.

V.

THE "MOUND OF THE FIANA" AT CROMWELL HILL, CO. LIMERICK, AND A NOTE ON TEMAIR LUACHRA.

By THOMAS JOHNSON WESTROPP, M.A.

Plate II.

[Read January 23. Published March 31, 1922.]

The field antiquities of early and prehistoric times in Ireland have only in the last thirty years begun to win the attention they so eminently deserved. Before that I can hardly recall an antiquary, save Col. Wood-Martin, who made any attempt to work out methodically even the dolmens of any one district. Now a large mass of material has accumulated, and has won the attention and approval of antiquaries outside of our islands. Unfortunately, in the very period of this desirable change the unrest and financial difficulties in the aftermath of the great war began to be felt. Even in better times few societies had published work so little desired by the rank and file of their members ; now difficulties have increased on every side. In hopes, however, that the description of an interesting group may be found worthy of publication, I lay with no further preface these notes before the Academy.

The important cemetery of Temair Erann, where the eponymi and all the chief legendary heroes, save Curoi and Deda, of the Ernai Clann Dedat,[1] are reputed to rest ; the two assembly places of the invading race of Dergthene, whence the Eoghanacht tribes of Cashel, Áine, Loch Lene and Aran, and the Dal Cais of later "Thomond" sprang ; the sanctuary of Knockainey ; the chief fort sites of early legend, Dún Cláire, Dún Crot, Dúntriliag and Brughrigh, are already recorded. However, there remain groups on conspicuous hills, diverse in nature, but illustrative of various aspects of our early remains, at Loch Gur, Knockderc, Knockseefin, Pallas Grian, Knockroe, Knockae,[2] Knockseefin, above Nicker (locally " C'nicker," rabbit warren), and Cromwell (Cromglinne) Hill. I here note the last curious and important remains.

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[1] *Supra*, vol. xxxiii (c), pp. 460-468 ; xxxiv, pp. 179-181.

[2] History of Limerick, 1826, FitzGerald and MacGregor, i, p. 296 ; and Messrs. P. J. Lynch and J. Grene Barry, in North Munster Soc., i, pp. 169, 215.

The district may be described as entirely "pre-Milesian"[1]—a clumsy term, but of fairly definite meaning. A group of tribes, some branches of the Erainn, or Ernai, held it from before the feeblest glimmer of "pale tradition," and with them, rather than with the later conquerors, the Kings of Munster, may the remains be connected.

EXTENT OF LUACHAIR.

It is only in the last ten years that we have freed ourselves from the doubtful, "received" identifications of places in Co. Limerick (made by the school of 1840), which for seventy years prevented any advance. They laid down that "Luachair" was confined to the region near Castle Island in Kerry. Their only reason seems to be that the clumsy, inaccurate maps of the reigns of Elizabeth and James marked "Sleloghor" at that place. O'Donovan placed Temair Erann and Temair Luachra near Castle Island only because there was a ford "Bealahontowragh," and Óenach Chuli, or Clochair, at Óenach Cairbre, near Monasteranenagh, and Sliab Cláire at Duntrileague; these identifications are generally maintained by conservative antiquaries, so we must study the reasons to the contrary, at least in the case of Luachair and Temair, which alone affect the subject of this paper.

Luachair, the Four Masters record, in 1598, extended to Gleann Coirbre, or Glin, on the Shannon. It included Killeedy in western Co. Limerick, says "The Life of St. Ita," alluding to the period *circa* A.D. 560. The Dind Shenchas tells how Eiblinn, Guaire's daughter, who resided on Sliab Eiblinne, or Slievephelim, on the east border of Co. Limerick,[2] "fled from Ir Luachair." The same work shows that Tul tuinne, at the northern end of the same mountains, on Loch Derg, beyond Killaloe, was in Luachair.

"The Battle of Magh Leana" supports the statement that Sliab Eiblinne was in Ir Luachair by describing Conn's raid after Eoghan Mog Nuadat as extending "from Cnamh choill to Luachair, from Sliabh Eibhlinne to Sliabh Caoin," or Slievereagh, while the fugitive, hid till then at Glenlara (presumably that place on Slievereagh), fled on to Mangerton and Beare Island. Indeed, if the Dind Shenchas be trustworthy, Luachair even extended across north Co. Tipperary to Ikerrin, where the Suir rises, to Slieve Bloom, at the

[1] I use it here as a synonym for the dark races, Ernai, Ciarrhaige, &c., in contrast with the fair Dergthene, evidently recent settlers. Most of the Co. Limerick tribes appear in the list of "Aitech Tuatha" from the "Book of Glendaloch" before the attempted affiliation of such to the Dergthene (Revue Celt., xx, p. 336).

[2] Revue Celtique, xvi, p. 152.

source of the Barrow and Nore, which seems hard to accept.[1] The raid of the Ultonians to Temair Luachair in the "Mesca Ulad" is defined in the Dind Shenchas as ending at Cenn Febrat, or Slievereagh, in south-eastern Co. Limerick.

"The Ulaid carried off from the west, from Temair Luachra, in the furious foray they made from Dun da bend to Cenn Febrat of Sliab Cain, when they wrecked the *cathair* (of Crimthann Nia Nair), and killed the king and brought away his mantle."[2] The "Mesca Ulad" says he was slain by Cu Chullaind at a ford in Crich Uathne,[3] or Owney, in eastern Co. Limerick.

Indeed, the "Book of Rights" seems to regard Temair Luachra Deagaid as the chief residence of the Thomond princes, where they gave a week's entertainment, and whence the kings of Corca Modruad could claim their daughters in marriage, which suits well their chief fort Dún Cláire.[4]

All this early evidence tends to one conclusion, but one late (if high) authority contradicts it, raising natural doubt. The Four Masters, in 1598, imply that the English army passed Temair Luachra in its march from Glin to Castle Island, and presumably near Portrinard, where they rested. I have ventured to suggest that Temair Luachra may have been at (or near) Dun Cláire, on the eastern slope of Cenn Febrat,[5] and this view has since been endorsed by Professor MacNeill and Mr. P. J. Lynch. The fort of Temair, according to the "Mesca Ulad," was on the eastern slope of a mountain in Ir Luachair, over a river glen, full of wild fowl, with forts on a ridge beyond it, and the Ulaid,[6] in their raid, went from Knockainey southward, towards Cenn Febrat to Oenach Clochair, and thence "in a straight line" to Temair—which suits in every item the site of Dun Cláire.

Temair Erann lay on the opposite (western) flank of Cenn Febrat, by a famous well and stream, and was undoubtedly the chief cemetery of the Ernai; so far my identification of it[7] has, I believe, been accepted by all who have studied its evidence. There were two ancient burial grounds of the

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[1] *Ibid.*, xv, p. 448. Dun Tulcha, where the Deluge whelmed Fintan, is certainly Tontinna. See also Metr. Dind S., Todd Lect. Ser., x (ed. E. Gwynn), pp. 237–239. Clíu Mail was, like Luachair, the land of the sons of Ugaine, and was held by Clann Dedad.

[2] Revue Celt., xvi, p. 151.

[3] *Loc. cit.*, p. 53.

[4] Book of Rights (ed. O'Donovan), pp. 255, 261, 262. The history of the Dal Cais princes at Bruree nearly perished with them in the Norse raid about A.D. 830.

[5] North Munster Arch. Soc., iv, p. 159.

[6] "Mesca Ulad," p. 17. I studied this, as possibly bearing on the strikingly similar Dunganville fort, *supra*, xxxiii, p. 26.

[7] *Supra*, xxxiv, p. 179. Cf. "Senchas na Relec" (Petrie's "Round Towers," pp. 100, 101). R. Soc. Antt. Ir., xlviii, p. 111.

Ernai-Clann Dedat; it and one at another "holy" well at Cul m brocholl, among the Ciarrhaige, in Kerry, but yet to be located.[1] It is interesting to note that in no case does contradiction appear as to the persons buried in the two places, and the monuments on Cenn Febrat agree minutely with those named in the early poem *circa* A.D. 990–1010.

At Temair Erann lay buried Deda's brother Febra, from whom the mountain was named; Deda's son Garban; the wife of Daire, son of Deda; her son Lugaid Laegde; the latter's daughter Ethne (with her grandmother) in the conjoined barrows; besides "Erc of Ir Luachair." At Cul m brocholl were laid Dega's daughter Dairine; her husband Lugaid mac Con; his son (or father) Mac Nia;[2] the latter's sons Lugaid, Dau, Trian, and Echu Badamna; with "Cathmol, son of Erp," perhaps the above "Erc." Had we such place indications as at Cenn Febrat for Cul m brocholl, another most interesting legendary sanctuary might be discovered—a typical example, with a god's mound (of Lug Long hand) and graves of the half-divine heroes and heroines so characteristic of ancient Ireland's chief sanctuaries, the Brugh, Tailltiu, Temair, and Cruachu.

The other tribes dwelling round the hills of our district were the Uaithne and Arada,[3] divided by the River Saimer, or "Morning Star"; and the Mairtene, with their five branches, who worshipped at Knockainey Hill, the Dilraige, Margraige, Sibenraige, Calraige, and Gargraige. Round the Galtees lay the Crotraige and Eatharlaige, of Aherloe, and the tribe of Clíu lay along the valley and far into Co. Tipperary, to the east, in Clíu Mhail Mhic Ugaine.[4]

CROMWELL HILL (Ordnance Survey Map, 33).

There is a large, conspicuous hill, north-east from Knockainey, and about four miles from it, called Cromwell Hill. The only antiquities known to me between the two ridges are a stone circle and earth-ring, cut by a laneway, in Ballinamona, an outlier of the Loch Gur group, and two rather large defaced earthworks, beside the Mahore, a tributary of the Cammogue, on a gently rising ground, at Castle Farm, to the north of Hospital. There are, perhaps, traces of conjoined rings in Ballinascoola, but I reserve judgment.

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[1] "Mosaulum Tale," Todd Lect. Ser., xv, p. 137. As to the Clann Dedat (affiliated to Conaire) being true Ernai, see Leabar na hUidre, "Clann Dedat i Sil chonaire agus Ernai" (Archiv für Celt. Lexik., i, p. 20).

[2] See Todd Lect. Ser., xvi, p. 5, for Oendia, Caindia, and Trendia.

[3] For the Uaithne descent, see "Corcalaidhe," p. 65.

[4] Silva Gadelica, ii, p. 576. 'Aine drives the tribes off the hill "into Luachair," which suggests that the latter territory had been "set back" from Clíu at the date of the poem. We hear of a Luachair 'Aine on the Feil ford, but only the Feale on the west border of Co. Limerick is known to us (Rev. Celt., xv, p. 448).

No trace of the hospital or castle remains, for East Limerick has a shameful record of vandalism—witness the partial destruction of the fine Cistercian Abbey of Monasteranenagh, and the complete effacement of Abbey Owney, also the demolition of most of the castles and churches sketched by Thomas Dynely in 1680 (and, indeed, of several standing in 1840), and of the greater circle to the west of Loch Gur.

The hill is close to the border of Co. Tipperary, which follows no ancient line, cutting through Clíu, Owney, and Ara. It is a bold and rather picturesque mass, 585 feet high. It is not, as some have asserted, called after the Lord Protector "on his way to attack Limerick," whither (of course) he never went. Such names generally represent an Irish form, "Crom Choill," "Cromgleann," or "Cromaill"—"sloping wood," "glen," or "cliff." Mr. Roger Frewen, in whose farm it is included, heard from his grandmother, an Irish speaker, that it was named "Crom-aill," or "sloping cliff"; this tallies with the recorded form "Cromal" in 1299, but not with "Cromyglaon" or "crooked glen" in 1583. It gave its name to the old Limerick family of Cromwell, of Cromwellstown, at the earlier period; and Isolda Cromwell got dower off it in 1324. The Harolds held it in 1399. Some 200 years later we find the pardon of James MacMorris O'Rahelly, of Cromal, in 1578. In 1583 Knockgromel, or Cromwell Oknowing, was a poor, low castle, or peel tower, also called "Cromyglaon" and "Gromwall." In 1637 its owner, Francis Fitton, of Ainey (husband of Jane Lacey, of Cnockenegromwille), was "a distracted lunatic." It was held by William Fitton and Annabell Browne in 1658; passed to the FitzGeralds, of whom James was attainted in 1688; and the lands were sold to Benjamin Burton in 1703.[1] It was evidently a place of some importance, even in the Bronze Age, as its fine long dolmen attests, with the tumulus and little cairns; a ring fort lies at its foot. The outcrop of "Cromaill" is called "Cashlán Chruim Dubh," which is an interesting piece of folklore, if somewhat discredited by its evident source—the popular interpretation of the name. Crom Dubh looms rather largely in Co. Limerick, at it, Ballyneety, Croom, and Askeaton; so someone, aware of this, may have originated the tradition; the mound, as we shall see, was connected with the *Fiana* in 1826.

Crom.—Crom Dubh, who gives his name to "Garland Sunday," the last in July, is a problematic personage, whose tale often meets one from Co. Mayo southwards. At Askeaton, Ballyneety, Loch Gur (where he is described as "a little black man who first brought wheat to Ireland"),[2]

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[1] *Supra*, xxvi (c), p. 187; Fiants of Eliz., No. 3364; Peyton's Survey, p. 6; Civil Survey, xxxi, p. 3.

[2] Limerick Field Club, i, p. 56; North Munster Arch. Soc., i, p. 215 (J. Grene

and elsewhere he was connected with the beginning of harvest, and brought in the first sheaf, *stooping* under its weight, whence his name. He appears as a pagan opponent of St. Patrick, or as his servant, or even a bishop; he withstood him and St. Benen at the "Mionnán," high up Croaghpatrick on Clew Bay. The Cruach, with its swarm of demons in the legends of the saint and its great ring wall of massive dry stone, was more than probably the sanctuary of a mountain god; the demons eventually became serpents. Yet Crom was St. Patrick's confidential servant, and as such was questioned by the *Síd* folk as to their hope of heaven in the Cashel and Askeaton tales. Also, when the demons tried to capture his soul (their "good friend," they called him), St. Patrick and a crowd of saints and angels rescued Crom for his charities and good works.[2] He is now usually identified with Cenn Cruach, or Crom Cruach, to whom wholesale human sacrifices are said to have been offered by Tigernmais. De Jubainville regards him as a pre-Celtic Fomorian god.[3]

Whatever (or whoever) may have been Cenn Cruach, O'Curry and Borlase make him "a maggot," a very improbable statement. He was "Cenn Cruach," or "the head of the Reek"; the name is at least as old as the second century at Pencrick or Pennocrucion in Britain.

Lug was also a god of mixed reputation, handsome above all, accomplished and brilliant, but cruel and revengeful. We read of "the savage race of Lug" in *Fled Bricrend.* His slaying of his mother's father was defensive; but his cold cruelty is marked by his ingenious *eric* on the sons of Tuireann. His *Lugnasad* games, at Tailltiu, on the four weeks round the chief festival on August 1st, were for the harvest, when the sun was most powerful. The children-sacrifice there only rests on a corrupt text; but to whom was the

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Barry); Rev. Celt., iv, pp. 185–191 (D. FitzGerald), and xiii, p. 435; Limerick Field Club, iii, pp. 55–7 (P. J. Lynch). The three days following Lammas Day (says N. O'Kearney, R. S. Antt. Ir., ii, 1852, p. 130) were sacred to 'Aine in conjunction with Crom Dubh. See also Folk Lore, xxvii, pp. 226–9. The Gaulish god Rivos brings in the harvest on August 4th (Rhys., Brit. Acad., 1905, p. 87).

[1] I have noted these tales in Folk Lore, xxviii, p. 189, p. 191. For Crom Dubh, see xxvii, p. 229. Colgan names him as a saint (Trias Thaumat., p. 508). As servant of St. Patrick he resembles Lug when servant of St. Brigid (Thes. Palæo-Hib., ii, p. 344), or St. Hervé in Brittany.

[2] Book of Fermoy, f. 62, Ir. MSS. Ser., R. I. Acad., i, p. 30. Cf. Revue Celt., xx, p. 428. For the grave of "Patrick's druid or bishop," see Ir. Texte (Stokes and Windisch), iv, i, p. 264.

[3] Irish Myth. Cycle (tr. R. Best), p. 62; or, he suggests, Taranus. See also Professor MacCulloch, "Religion of the Ancient Celts," pp. 79–80. Perhaps "Crom Dubh" is a libellous term. See curiously fanciful note by Borlase, "Dolmens of Ireland," p. 472, on the serpents "Crom Dubh, Crofin, and Crovdearg." For the sacrifices at Mag Slecht see O'Curry's "MS. Materials," p. 538; "Voyage of Bran," ii, p. 149, p. 161.

boy to be sacrificed at Tara when the harvest failed? Probably to Lug, whose shrine, "Cro Luga," was there.[1]

As "the Gaulish Mercury," identified as such as being "inventor of all the arts," as Caesar writes, he also is "master of all the arts together" in early Irish literature. He was the object of excessive human sacrifice on the great mountain of Puy de Dôme,[2] whence he took his name "Dumias" or "Dumiatus" "of the *duma*." He was associated with monoliths in Gaul, his figure being carved on the Menhir of Kervadel, now at Ker Nuz, and at one near Peronne.[3]

Is it not possible that "Crom Dubh" is a Christian libel on this glorious but terrible and blood-thirsty god? A caricature must have a general likeness to the actual person, however exaggerated.

The great monolith on the west circle of Loch Gur was, on Windele's visit, about 1840, known, as now, by the name *Ronnach Chruim Duibh*[4]; so the name preceded the lamentable flood of bad philology, guesswork, and unfounded druidical assertions which overwhelmed it since 1870. If Professor Macalister's revision of *Ronnach* as *Rothannach*, "the *wheels* of Crom Dubh," be accepted, we get an apparent side-light from "the Battle of Magh Rath," relating to an event in A.D. 637. "A boy walks the road of raths, around which are dug the graves of Roth"; this is revised into "the road of Roth, around which are the graves of heroes."[5] This was apparently a monument among cairns, and with an ancient road near it, as at Loch Gur.

Now (not to enter too far on a most contentious and obscure subject), the sort of primeval zeppelin, the *Roth Ramhat*, or "rowing wheel," full of men and destined to hurl down fire on Ireland at the Last Day, was connected with a druid of this district, Mog ruith, the "slave of Roth," whose great "rowing wheel" lay, as fragments of rocks, at Cleghile, not far from Limerick Junction, and far eastward near Dublin; he is usually confused with the *Roth Ramhat* myth, save in his one early local story of Co. Limerick (the *Forbais Druim Damhgaire*), at Knocklong, six miles from Cromwell. The Askeaton and Ballyneety harvest tales and the "Sunday of

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[1] Folk Lore, xxxi, p. 111; "Echtra Airt" ('Eriu, iii, p. 149, p. 155). For other human sacrifices in Ireland, see "Three Irish Glossaries," p. 70 (Emania); also 'Eriu, ii, p. 86. Not to cite the separate sources as to Gallo-British human sacrifice, I may refer to MacCulloch's "Relig. Ancient Celts," pp. 235-6.

[2] Tertullian, "Apologeticus adversus Gnosticos." M. Moncedas in Revue Hist., xxxv, p. 225. MacCulloch, "Relig. Anc. Celts," p. 24, for epithet "Dumias," and Revue Archéol., 1874 (ii), p. 332.

[3] "Rel. Anc. Celts," p. 284; "Les Dieux Gaulois," Courcelle Seneuil, pp. 8, 9.

[4] Topog. of Kerry, Limerick, &c. (J. Windele, MS., R. I. Ac., C. i, 23).

[5] 'Eriu, vi, p. 241; also "Battle of Magh Rath" and "Life of St. Mochulla" (Analecta Bolland., xvii, p. 135).

Crom Dubh" stand in striking connexion with the great harvest festival of the *Lugnasad*, covering a fortnight to either side of August 1st, its chief holy day. This, in one story, commemorated the marriage of Lug, the sun god,[1] with 'Eriu (the soil of Ireland); and at one of his fourteen towns of "Lugdunum," in France, Belgium, and Germany (Lyons, a few say St. Bertrand) the festival was held at the beginning of August, and was attended "by all Gaul"; it was eventually transferred to the Emperor Augustus as Apollo. His altar was dedicated on August 1st at Lugdunum.[2]

Nothing (it is true) can differ more from the glorious Lug ("master of all knowledge," "like the sun was the splendour of his face") than the name or epithet "black crooked one"; but it does not differ more than that in the Achill legends, where Lug, son of Cian, is entitled "Duldauna," "black surly one,"[3] instead of *Ildanach*, "master of all knowledge,"[4] or than "the Devil Huccain" (who replaces Lug in the "all science" story of Mag Tura in its travesty) in the Life of St. Hervé in Brittany.[5]

"Vae victis." The servants of the victorious Galilean branded their defeated opponents with insulting names in more places than in Ireland.

The Lugnasad was kept in Gaul, Britain, and the Isle of Man on the same day,[6] and under the same name, "Laa Lhuanys" (Manx) and "Lunasdal" (Scottish), as in Ireland. In Wales, I presume, Roman rule

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[1] Folk Lore, "Marriages of the Gods at the sanctuary of Tailltiu," xxxi, pp. 109–141. Lug figures as "Erin's lover" down at least to O'Dalaigh's poem, 1387, Maurice, Earl of Desmond, being compared to him; as, indeed, was Prince Charles Edward, three and a half centuries later, by Seaghan O'Tuama. So the evident solar god MacGrian also marries 'Eriu.

[2] See, for example, Sir J. Rhys, British Acad., 1910, p. 225; and for Tailltiu, pp. 215-217. The 'Oenach games at Cruachan (O'Curry, "Manners and Customs," ii, pp. 342-5) and Tailltiu were in honour of Lug. For Augustus as Apollo see A. E. Cook, "The European Sky-god" (Folk Lore, 1905).

[3] W. Larminie, "West Irish Folk Tales," pp. 1-9; J. Curtin, "Hero Tales of Ireland," pp. 1–34, p. 283, p. 296 sqq.

[4] Lug's title, Ildanach, Samildanach, "master of all arts together," is Caesar's "inventor of all the arts" (De Bello Gallico, vi, 17), applied to his Gaulish form, "Lugus Mercurius." See "Irish Nennius," p. 64; "Sons of Tuireann" (Atlantis, iv, p. 155); "Coir Anmann" (Irische Texte, 111), p. 315; Revue Celt., xxvi, p. 129; xxxv, p. 289; and a special study, xii, p. 52. Also, *supra*, xxxiv, p. 141; and M. Loth's admirable paper on Lug, Revue Archéol., xxiv (II), pp. 205-230.

[5] "Les Saints de la Bretagne" (A. Le Grand), p. 49. Revue Celt., vii, p. 231; "Religion of the Ancient Celts" (MacCulloch, 1911), p. 92.

[6] British Academy, "The Coligny Calendar," 1910, p. 215. I totally disagree with the statement (p. 237) that games in honour of a pagan god would have "attracted the whole artillery of the early Christian missionaries" in Ireland against them; they modified gradually, and the god soon became a "founder" and a mortal. The breaking even of the pillar of Mag Slecht is contradicted by early writers, who saw it leaning but extant.

substituted *Augustus* for Lug. If Rhys was correct in reading "this Hesus" on a statue of the Gaulish "Mercury," Lug,[1] we have yet another proof of the human sacrifices offered to the god of Light among the Celts. Some say that the modern "Crom Dubh" folk tale is only derived from Keating's "History"[2] of Crom Dubh about 1640; but, if so, how was "*Cromm duban Sunday*" kept at least so far back as 1117?[3] and why is the name of Crom Dubh attached to a pillar stone at Loch Gur alone? One natural rock at Croom, in Co. Limerick, also has a vague "Cromm Dubh" folk derivation (according to Windele)[4]; so (as we see) has the Cromwell cliff. I know of no other cases.

THE REMAINS.—The hill has two side spurs, the great dolmen occupying the western, and the *Caslán chruim duibh* the southern. At the latter, a deep, sickle-shaped, sloping glen runs up the hill. This glen was a favourite fox covert in my memory, some forty-five years since. The *Caslán* is a rock-knoll with (I think) traces of being fenced by a dry stone ring-wall, like that of the Dún Hill at Howth, Co. Dublin, with its mound and cairn. Its bold crown on the noble white cliff recalls the fortified rocks of Cashlán Gar and Cahercashlán in Co. Clare. Below, in the glen, is a cave, called, like the dolmen, "Diarmuid and Grainne's bed"; another is named after a "fairy piper"; and a huge split rock has its halves called "the old man" and "the old woman," but Mr. Frewen gave me no tale of its origin.

We ascend to the summit of the plateau and get a noble view; the Galtees, Slievereagh, and Ballyhoura lie southward; and, far away, in Kerry, the Paps, "the two breasts of Dana, mother of the gods."[5] In the opposite direction are the distant hills of Co. Clare, the long flank of Slievephelim, and the dark pyramid of Knockroe, near Pallis, each crowned with three earthworks. We stand within a ring of the hill gods[6]; "their god is the god of mountains," seems to apply to the tribes of Munster, Oebinn, of Craglea; Echtge, the god Nuada's daughter,[7] of Slieve Aughty; Ebliu, of Slieve-

[1] Brit. Acad., 1906, p. 326; Esus is Mercury, i.e., Lug, one of Lucan's horrid triad of man-eating gods (i, 444–6, the ancient comment, "Hesum Mercurium credunt," supports this).

[2] History (Ir. Texts Soc.), ii, p. 123, "Crom Cruaidh."

[3] Annals of Ulster, A.D. 1117.

[4] Croom in early records is "Cromadh," in 1151; "Crumech," 1215; "Crometh," 1302; "Cromothe," 1581. Perhaps a "crooked ford" on the Maigue. See also "Dolmens of Ireland" (Borlase), pp. 771–2, Crom Dubh.

[5] *Da cich Danainne*, "Cormac's Glossary" (ed. W. Stokes), p. 4. John Windele's very striking sketch of the "Two breasts" is given in Topography, Co. Kerry (MSS., R. I. Acad., C. 123, p. 56).

[6] *Supra*, xxxiv, p. 53, p. 151.

[7] Silva Gadelica, ii, p. 126; Galway Arch. and Hist. Soc., p. 59; Rennes Dind S.; Rev. Celt., xv, p. 458. The "child-eating legend" also attaches to *Ethni*, daughter of Crimthann. Lady Gregory found Echtge was still remembered in her mountains.

phelim; Clíu, the divine harper, of the Galtees; Febra, Cain, and Áine; Donn Firinne, son of the god Midir; Mis, Dana, and the local monarch, Bodbh Dearg, of Slievenaman. Nearly every hill and mountain on our horizon is crowned by a circle, mound, or cairn, often connected with tradition of a deity.[1]

At the south edge of the summit is the highest "cairn," a rock knob, on which rests a small cairn, or rather mound, 21 feet to 25 feet across, formed of large slabs laid on their sides and embedded in earth; it is about 5 feet high, but, from its position, is the most conspicuous monument of the hill. On the south-east spur is another regular knoll with the trace of another heap of earth and smaller stones, 15 feet across and barely 3 feet high. Between these cairns, in the "dip" of the hill, is a small limestone pillar, 5 feet 10 inches high by 10 inches by 9 inches, now used for a gate-post, but (like the little pillars on the Eagle Mount, near Bruree,[2] and Knockastoolery, near the cliffs of Moher, in Co. Clare) probably set up in early times.

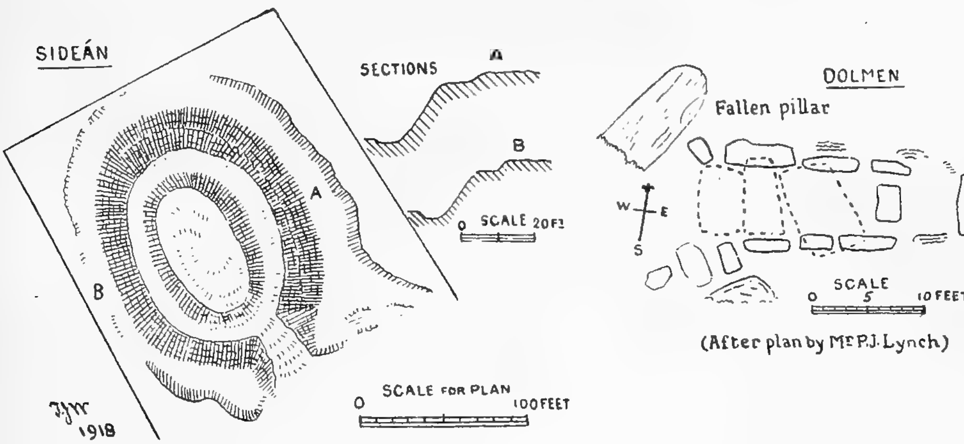

Fig. 1.

Sideán na Feine.

On the eastern edge of the plateau, down the slope, we see a large, long, shapely mound like an overturned boat (Pl. II, fig. 1). FitzGerald's "History,"[3] in 1826, says of it:—"There is a large mound, like an inverted basin, composed of earth and stones, on Cromwell's Hill, in the barony of Small County, which is called *Sighcann* (Sigheann or Sideán) *na Fiona*, 'after' the wild warriors of the Fianna Eirionn." The Fiana are not prominent in local tradition here,

[1] Note the curious rededication of a mound, "Colliculum angelorum," near a mound, "Sithean beg," and therefore probably "Sithean mor," before the *Sid* folk yielded to the angels (Adamnan's "Life of St. Columba," ch. xliv).

[2] *Supra*, xxxiii, pp. 490–1.

[3] FitzGerald and MacGregor's "History of Limerick," i, 406.

save at the Seefins (in Ballyhoura, and near Pallas), also at Ardpatrick, anciently called *Tulach na Fëinne*,[1] whence the warriors marched to the fatal battle of Gabra, in the mid-third century. Glenoisín, near Seefin, in Ballyhoura, also recalls the great poet's name, and the ruling princes claimed descent from Ossian's daughter, the wife of Cormac Cass. One always suspects a comparatively late origin for attempts to bring the later Finn cycle into vital relation with the older traditions, pedigrees, and usages. I need only add that the Fiana were represented rather as violators than as makers of such mounds. Amid the many instances, notably in the "Acallam na Senorach," where the tradition of Norse and Danish treasure-seeking[2] gets transferred to the third century warrior bands, I need only recall how Finn's warriors dug into the *Síd* mound of Cuillean, at Cullen, four miles from Cromwell Hill, to force its divine inhabitants to rejuvenate Finn himself.

The *Sideán* has been carved out of a natural ridge of red earth, and carefully shaped and raised. Save for its very shallow fosse, like that at "Sheenafinnoge" and other tumuli in the county, it resembles the inauguration mound of the Dal Cais princes at Magh Adair in Co. Clare. Like the latter, it has a ramp, or gangway; this feature is not found at other motes and tumuli of the district, so far as I have examined them, though gangways across the fosses are not uncommon. The fosse is usually 9 feet wide, and often barely one foot deep. It, like the top of the mound, was evidently left unfinished. The sides of the mound are steeply scarped, save to the south; at the ramp they rise 15 feet on a base of 12 feet to the west, and 19 feet on 21 feet to the north-east down to the hill slope. The flat-topped mounds at Bruree, Ballingarry Down, Ballinvreena, and Cush[3] are like it, made on slopes, and even more uneven in height, so as to keep the summit fairly level.

The platform measures about 100 feet north and south, and 85 feet east and west, the base being about 125 feet and 110 feet. There is a terrace or "set-back" 10 feet to 12 feet wide round the edge, and the centre is occupied by a rude, unfinished-looking mound, in parts 10 feet above the terrace and 27 feet above the field. It may be recalled that the mound of Magh Adair is 24 feet high, and the Eagle Mount 23 feet. North from the *Sidcán* in the next field is a circular hollow.

The terracing of the top of the mound is better shown in the finer mound

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[1] Acallamh, Silva Gad., ii, p. 118.

[2] Wars of the Gaedhil (ed. Todd), p. 115, "Never was there . . . a mound . . . which was not plundered by the collectors, . . . neither was there in concealment belonging to the Fiana or the *Síd* folk anything that was not discovered by these . . . men of Denmark through paganism and idol-worship."

[3] Proc. R. I. Acad., xxxiii (c), pp. 452, 474.

of Masonbrook, Co. Galway,[1] which has three stages. Two very slightly marked "set-backs" are also apparent on the conjoined tumuli in the assembly of Óenach chuli in Co. Limerick. Other notable cases of such "terracing" are found at Cruachan Ai (Rathcroaghan) and Slanemore (Slemain Midhe) in Westmeath, where a smaller platform occurs on the mound. Whether in some cases this marks a former ring-wall, as at Bruree and Eagle Mount, we can only conjecture.

The sloping summit from the cairn to the mound was very suitable for a crowd of spectators if ceremonies took place on the latter.

One service due from archæology to Irish literature is illustrating the structures, armour, and weapons so often mentioned in our ancient tales. The *Sideán* or *Síd* mound occupies a conspicuous place. The formal worship of its old gods was ended, but the awe and observances were ingrained in the Irish mind; and the Church, when it abolished the worship, did not try to desecrate or destroy the mound. In many cases bound up with ancient assemblies it was protected by the law down to late Christian times.[2] So the High King Diarmaid, in the mid-sixth century, put men to death for neglecting the solar games of the god Lug at Tailltiu, and the games and temporary marriages continued to 1770, the fair to 1816. So Magh Adair was the great Dalcassian assembly place till 1570, and its "iraghts" (*oireachtach*) were kept up to the great famine of 1845.[3]

I found no tradition of such assemblies at Cromwell Hill. The long Norman occupation obliterated the record (if such existed), and no fair, like those of Ballinvreena and Knockainey, replaced them to our days. We are amassing notes on undoubted *sideán* places—they are very different in character; we have rocks, sea-rocks like the Bull and Rockabill; hillside rocks like Oebinn's *Síd* at Craglea, the Campulnamuckagh and Sheeaun on Inisturk, and Croachateeaun, with its vivid local awe of "the Dannans," in Co. Clare;[4] some are earth-mounds, like Magh Adair, Sheenafinnoge, near Monasteranenagh, and perhaps Kilfinnan, the three small tumuli at Temair Erann and the conjoined mounds at it,[5] Knockainey and Clogherbeg. An outstanding case in literature is the *Duma na ngiall*, the mound of the hostages, where lay the white, round-ended slab, now set up on Tech Chormaic, at Tara. It was attributed

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[1] *Supra*, xxxiii, p. 507, Plate XLIV; for Eagle Mount, see xxxiv, p. 66, and Slanemore, R. S. Antt. I., vol. li, p. 134 (T. J. Shaw).

[2] Ancient Laws, i, pp. 129, 233; ix, p. 220; v, p. 473.

[3] *Supra*, ser. iii, vol. iv, pp. 55-60. "*Síd*, person of the broad-topped, smooth *liss*, where the hosts assemble" (Feis tighe Chonain, p. 91), well describes such ceremonial mounds.

[4] *Supra*, xxxi (No. 2), pp. 50-52; R. Soc. Antt. Ir., xxxv, p. 345.

[5] *Supra*, xxxiii, p. 465, pp. 469-474.

to the "last Fir Bolg King," Eochaid Garb (placed by others among the Tuatha Dé), whose wife "Tailltiu" fostered the god Lug. On it the three war goddesses, Badb, Macha, and (Neman) the Morrigu, worked magic against the Fir Bolg at *Cnoc gabala na ngiall.*[1]

They were aided by the great gods[2] Ogma (the Gaulish Ogmios), Bodb Dearg (the pre-Celtic king-god of Munster), Midir of Uisnech, Diancecht, the grandfather of Lug, and Oengus from the great tumulus of Achad Alldai, at New Grange, in the Brugh cemetery. In a previous paper we have studied the rich folk-lore of the *Síd* mounds of Slievenaman.[3] Those we find there were mounds "of the men" and "of the women"—a suggestive fact, needing cautious elucidation. A cooking hearth, *Fulacht na Morrigna,* near the *Síd* of Air Feimhin there, brings the war goddesses again in contact with such mounds,[4] and the same may be implied by the royston crows, sacred to Macha and her colleagues, at Sheenafinnoge.

As to Finn's connexion with such monuments, we have a very illuminative (if late) story, probably based on immemorial belief. It seems clear that the mound gods, or *Síd,* were "pre-Celtic" deities to whom the Brito-Gaulish "Tuatha Dé" were affiliated (like the "pre-Celts" to the "Milesians") before our tradition commences. We are told how the Tuatha Dé got a share of the mounds and retired "into the *Sídbrug* to speak with the *Síd* underground."[5] Also the tumulus of Finn's warrior, Failbe, became an Assembly mount seven years after his death.[6]

As at Knockainey, and indeed most sacred spots of the "older faith," the *Síd* mounds used to open on *Samhain* night (November 1st). Finn had a friend Cethern, who, going to woo a lovely woman ("banshee") at the *Síd* of Bri Eli, had been slain by the inmates, and, of course, had to be avenged by his leader. The vendetta began badly, and Finn's friend and poet, Oirchel, was also slain at the mound. The angry warrior went to consult Fiachal mac Conchinn, at Slievemargy, in Queen's County, and was advised to seek vengeance at *Da Cich Danainne* ("the Paps," visible from Cromwell Hill) "behind Luachair." There were two mounds, "*Síd* strongholds," perhaps the cairns on "the two breasts" of the mother-goddess, so Finn

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[1] Leabhar Gabhala (ed. Macalister and MacNeill), i, p. 151.

[2] Revue Celtique, i, p. 40 (MS., T.C.D., H. 2. 17, f. 93).

[3] *Supra,* xxxiv, p. 152.

[4] 'Eriu, i, pp. 187–8. For the "Fulachts," the larger were "F. na Morrigna," the lesser "F. Fian."

[5] See Táin bo Cualnge (ed. Dunn), p. 63; Mesca Ulad, p. 1; Bruden Da Derga (Rev. Celt., xxii, p. 17); Echtra Nerai (*ibid.*, x, p. 221); and many others; also my note, *supra,* xxxiv. They range from the disc barrow to the lofty chambered tumulus.

[6] Todd Lect. Ser., xvi, p. 55.

watched till one should open. On *Samhain* a "man" came out of one and crossed to the other *Síd*; Finn pursued and speared him as he ran, and then went to Bri Eli and surprised a woman, whom he held as a hostage for the return of his spear. It was thrown out of the mound, and he learned that he had killed the slayer of his friends.

Unsatisfied with his success, he set off to Slieve Donard, in Co. Down, to its famous cairn (though the old name "Sliab Slanga" has been altered to honour a later hermit, Domangard) and caught another banshee, taking her brooch, which she redeemed with a vessel full of gold and silver. The tale how the Fiana dug into a *Síd* near Dungrot,[1] and forced its inmates to rejuvenate Finn, is generally known. To enter on the encyclopædic subject of the Finn myths lies outside our scope. I would only point to the number of extremely primitive stories assimilated by them, and that Finn was a lineal descendant of the god Nuada, the common ancestor of the Munster princes, who, under his title "Derg," gets connected with a fort in Mag Femen,[2] and is apparently confused with Bodb Derg, of Slievenaman, whose mere affiliation, through Oengus of the Brugh, to the Celtic pantheon is very evident. In the words of the ancient tale of Bricriu's feast,[3] "the sleep of a *Síd* mound knows of an awakening," for "gods do not easily die," and it is still evident that those (worshipped before the Celtic Dergthene forced their way through the Suir and Maig valleys, from the coast of Co. Waterford, to the border of Co. Galway) are still active for good or evil in the popular belief. Men cross themselves "for fear of the Dannans" at Croachateeaun, and pass hurriedly after nightfall Oebinn's *Síd* on Craglea and the *Duma* of Donn of the Sandhills, near Lahinch, in Co. Clare; children will not play on the mote of Ludden, and the fairy lights on the motes of the great cemetery of Temair Erann, on Slievereagh, are at least respected; the tumuli and cairn of 'Aine (as we saw) were the scenes of processions and rites.[4]

In Ireland we live among survivals of the remotest past, not, as elsewhere, seeking for their dead bones.

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[1] Book of Leinster, 145, b. 8.

[2] "Fianaigecht" (ed. J. MacNeill, Ir. Texts Soc.), and many sources. The attempt to make the god Nuada Necht King of Leinster in later days probably arose from recollection of its (possibly historic) King Nuada the Sage ("Lives of the Saints," Book of Lismore, p. 237). Nuada as a human name occurs at least seven times in the Annals of Ulster from A.D. 751 to 810, in East Connacht and North Leinster. The mothers of the Finn champions were usually of the god race, the Tuatha Dé (Cath Finntraga, ed. Meyer, p. 14).

[3] Ed. Ir. Texts Soc., pp. 213, 197.

[4] J. Grene Barry, N. Munster Arch. Soc., iv, p. 11, for Ludden Mote. Men did not sit on the three tumuli on Cenn Febrat for fear of the Tuatha Dé (Silva Gadelica, ii, p. 124, from Acallamh). For the 'Aine celebrations see *supra*, xxxiv, pp. 59–60.

The Dolmen.

Though Borlase, and later on Mr. P. J. Lynch, have so fully described and the latter has planned (illustrating with Dr. George Fogerty's beautiful photograph) the long dolmen on Cromwell Hill[1]—the paper in the pages of the extinct "Limerick Field Club" is virtually lost to scholars outside of Ireland—I may therefore briefly note that the monument is an *allée couverte*, a type rarer in northern Munster than the cist. The axis lies north-east and south-west, and it stands on the bold north-eastern spur of the hill. Four slabs (rarely rising more than 3 feet over the field) support three covers, one still in situ. Near the north-western corner lies a slab 8 feet 6 inches long by 5 feet wide. If (as I think probable) this was set upright, the structure was very like the noble example at Creevagh, in Burren, Co. Clare, but without its ring enclosure, rock-cut avenue, and neighbouring tumulus. It is about 25 feet long and 9 to 7 feet wide, tapering eastward. The western stones are set across the line of the side slabs; five of the latter remained to each side in 1839. The unmoved cover is 9 feet by 6 feet, by 15 inches thick. There are three irregular stones set near the south-eastern corner. I saw no trace of a covering mound, but such probably existed. A well gushes out on the northern slope, between it and the *Sideán*.

Though so close to the "Mound of the Fiana" and bearing the name of "Diarmuid and Grainne's bed," no definite tradition attaches to the site. As is well known, the dolmens are the only type of remains which are not elucidated by our ancient literature. It is a problem to us, for the awe (if such it was) of our early authors did not keep them silent about the tumuli, gods' mounds, pillars, and circles. I think the Rev. Geoffrey Keating, about 1630, first discussed the dolmens, and from him the wide acceptance of their "Diarmuid and Grainne" origin seems to date.

He writes that *Suidhe Finn*, or *Sliabh na ban*, was called after Finn Ua Baoiscne, and that *Leabaidh Dhiarmadha Ui Dhuibhne*, in Ui Fiachrach Aidne, was named from Dermot. He adds that these facts *prove* that such persons lived, and mentions "flagstones, supported on pillar-stones, or idol-altars," "the populace call them beds of the Fian."[2]

The rare combination of a rich mass of very early literature (locating and giving us tales, earlier in some cases, even in their present forms, than the ninth century) relating to the primitive monuments of the districts of

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[1] Ord. Survey Letters, Co. Limerick (R. I. Acad. MS.), p. 409; Borlase, "Dolmens of Ireland," i, p. 49; Mr. P. J. Lynch, "Limerick Field Club," iii, p. 54.

[2] History (Ir. Texts Soc.), ii, pp. 325, 349, 825.

Ir Luachair and Clíu in south-eastern Co. Limerick, and a most important series of such remains on the ground renders it important that the district should (as opportunity serves) be worked out and recorded. A complete understanding of such antiquities is as necessary to the understanding and criticism of early Irish literature as linguistic study. When the antiquary has dealt with the tales of Curoi and Crimthann Nia Nair, of Mog Nuadat and Oilioll Aulom, as he has dealt with the chief epic of the Táin bo Cualnge,[1] we shall be on surer ground. This can only be tentative at present, and the severity of the times sorely hinders; but meanwhile the linguist, topographer, and field antiquary must do their part, though finality be not yet in sight.

APPENDIX.—Crom and Lug.

At the reading of this paper it was objected that Crom was a "pre-Celtic" deity, an object of fear and hatred in Ireland, and so could not be Lug. As to the first, I think it very probable that Crom (like Bress, Tethra, Oengus of the Brugh, Bodb Dearg, and, perhaps, the Dagda) was pre-Celtic. They have no record in Gaul or Britain, if "Dagorix" be not the last. De Jubainville first suggested that Crom was pre-Celtic and of the Fomore.[2]

This does not, however, affect the later substitution of Crom for Lug, however different the origin. Casual identifications occur in every great mythology. The Romans identified their Mercury with the gods Hermes, Thoth, Odin, and Lug, as culture gods, and, very probably, the early inhabitants of Gaul were as unscientific. The latter, possibly, were pleased when the "Celtic" conquerors recognized their mountain gods and obscure tribal deities as being their own chief god, "Victor Magniacus," or Lug.

No one doubts that a swarm of local gods lie hidden in Lug's endless names—Adsmerius, Alaunus, Arcecius, Artaius, Arvernorix, Biausius, Canetonenis, Clavariatus, Cimicinus (god of roads), Dumias, Magniacus, Naussatis, Rivos,[3] Smertullus, Smertorix, Tocirenus, Vassacoletus, Veilaunus, Victor, Visutoctus—and many more (even "Moccus," the swine god!) were hardly all *derived* from the *one* light god of the Lugdunum towns in Germany,

[1] For example, in Professor Ridgeway's notable essay in the "British Academy," 1903, p. 21.

[2] "Irish Mythological Cycle" (tr. Best), pp. 61, 62. The Fomore were "champions of the *Síd*" (Encycl. Relig. and Ethics, iii, p. 283). If Vallancey can be trusted, "Crom Eocho" was the Dagda ("De Rebus Hib.," iv, p. 495). He cites a now unknown Irish MS. in Trinity College, Dublin.

[3] Rivos, or Rivros, has his festival on August 1st; the harvest was dedicated to him in Gaul (Brit. Acad., 1905, p. 87), and he brings the corn in, like Crom. *Ibid.*, 1910, p. 231.

Belgium, and Gaul. Such names as Lug, Esus, and Nuada ("light,"[1] "strength," and "wealth" perhaps) were themselves elusive, and as little personal names as the corresponding use of the first two in our own worship. So perhaps "Lugus," while it appears in many place-names, like Lugodunum and Luguballium, and personal names, like Lugobelinus (Llewellyn), Lugueslis, Luguadex (Lugaid), Lugviri (Lugair), Lugotorix, and Luguselva, never occurs on votive tablets, save the vague plural deities *Lugoves*, in Spain and Switzerland. Professor MacCulloch shows that many local gods of agriculture were (like Lug) identified with Mercury.[2] To ignore this vitiates all mythological research.

As to the difference of character, we have shown that, in at least one ancient source, Crom abounded in charity and good works, and in others that Lug was thought of as revengeful and cruel. He was the object of excessive human sacrifice on Puy de Dôme, and so akin to the stone god, "Cenn Cruach," of Magh Slecht. Perhaps, as harvest god, the blameless boy, so nearly sacrificed at Tara to ensure a good harvest, was to be offered to Lug at his shrine "Cro Loga" there.[3]

Sun gods and harvest gods have usually this horrible side to their character, and it must have called out horror in their worshippers and coloured their myths. Even Apollo appears (in the first hundred lines of Greek literature), coming on like the night, avenging his priest's tears with his arrows, and making a vast slaughter-heap of men, mules, and dogs, as he had slain the mouse, the wolf, and the python. The more barbarous Lug probably presided over less deserved and more deliberate slaughter at Puy de Dôme, if not at Magh Slecht or at Tara, and could well have been identified with the "Head of the Mountain" at Pennocrucion or Croaghpatrick.[4]

Not only as a chief god of the Gauls, British and Irish, was Lug likely to "absorb" local gods. He was ancestor of the later princes of Munster, and, as an archaic myth asserted, helped to free by his counsel that province from the oppression of the Fomorian god Bress.[5] Among the Ernai his advance may have been slower.

The "official" Dergthenian pedigree shows, embedded in its later strata,

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[1] Lucdunum, i.e. "Mons lucidus" (Hericus, Vita S. Germani). "Lougus" is said to mean "raven" in Gaulish (Pseudo Plutarch, ed. Didot, vi, p. 14); more probably the god's attendant ravens bore his name, as the scald crows in Ireland bore that of their goddesses, Badb and Tethra.

[2] "Religion of Ancient Celts," p. 24.

[3] Echtra Airt (Eriu, III, p. 149), for Cro Loga, see "Second Battle of Mag Tura."

[4] Lug gives his name to Slieve Lowe (Sliab Luga), in Co. Sligo, so far as I know the only mountain bearing his name.

[5] Metr. Dind. S. (Todd Lect. Ser., x), p. 119.

Fig. 1.

The Sideán of the Fiana, Cromwell Hill, Co. Limerick.

Fig. 2.

The Dolmen, Cromwell Hill.

Westropp.—Mound of the Fiana.

at least four early pedigrees, found in various settings, and thus easily detached. One is from Art Imlech and Bressrig, pre-Celtic gods; the second from a *Siabra*-god Nia Segamon, and two others from Celtic gods. One of these favoured by the MacCarthys in later times is from Allot and Nuada; the other is better attested as archaic. It runs thus in the "Mosaulum Tale":—Lug Feidlech, Nuada Aicnech, Luigthine, Daig, Dergthene (or "Corb Oluim," the first Celtic prince of the later royal line), Oengus Mog Neid, Eoghan Mog Nuadat, and Mais or Oilioll Aulom. The official pedigree gives—Log Feidlech, Lachtaine, Nuada Airgthech, Deirgthine, Deaga, or Ethleann, Lug, Lachtaine, Nuada, Dergthened, Deaga Derg; but it is quite clear that a pedigree of Dergthene, the eponymous of the princes of Mag Femen, Cashel, and the later Thomond, was rejected (probably for its open "paganism") by them and seized by the Corca Laide, who identified its "Daig" or "Deaga" with their own ancestor, Dega or Deda.[1]

Other non-Milesian tribes forced Lug into their ancestry, and most probably confused him with earlier gods. Perhaps one of these clumsy compromises identified him as a god of harvests, hill-tops, and human sacrifice with a similar deity, eventually nicknamed "Crom Dubh."

[1] "Mosaulum," Todd Lect., xvi, p. 29; Keating's History, iv, p. 114. The Saltair of Cashel gave "Eithleann, Lug, or Lug Mannrach, Deag mannrach." See Corca Laidhe, p. 25.

NOTE IN PRESS.

As Mr. Dalton's paper on "Cromm Cruaich" only reached me after my essay was in pages, my conclusions are in no sense a reply to or criticism of is monograph.—T. J. W.

VI.

IRISH POETS, HISTORIANS, AND JUDGES IN ENGLISH DOCUMENTS, 1538–1615.

By THOMAS F. O'RAHILLY, M.A.

[Read February 27. Published June 30, 1922.]

In the succession of desperate, if more or less isolated, struggles for national freedom which marks the history of Ireland in the latter half of the sixteenth century, Irish poets, as was natural, are in general found ranged on the side of their country.[1] English writers of the time complain that their poems incited to resistance and rebellion, and tended "for the most parte to the hurte of the English or mayntenance of theire owne lewd libertye." "They seldome use," says Spenser,[2] "to chuse unto themselves the doinges of good [*i.e.* loyal] men for the ornamentes of theire poems, but whomsoever they finde to be most lycentious of lief, most bolde and lawles in his doinges, most daungerous and desperate in all partes of disobedience and rebellious disposicon, him they sett up and glorifie in theire rymes, him they prayse to the people, and to younge men make an example to followe." In retaliation the English government looked upon the Irish *literati* with particular disfavour, and time and again punitive measures were put in force against such groups of enemies as "rebels, vagabonds, rimers, Irish harpers, bards, and other malefactors." As the conquest proceeded the lot of the harried literary class became more and more desperate, until in the disastrous battle of Kinsale Ireland's literary organization was crushed no less than her political independence.

But, while there is frequent enough denunciation of "rimers" in general, as well as references to the "brehon laws," we seldom find the names of individual Irish men of letters recorded in contemporary English documents. In the following pages I have brought together most of the references I have been able to find to particular poets, historians, and judges, in the hope that

[1] Not that these poets, any more than any other section of the Irish aristocracy of the time, were always animated by motives of pure patriotism or always possessed even a moderate amount of political foresight.

[2] "View of the State of Ireland," ed. Grosart, pp. 118, 117.

the information I have gleaned concerning them may be of some assistance to future investigators of the literature of this period. My principal source of information has been the Fiants of Elizabeth, in which are preserved the names of tens of thousands of Irishmen to whom "pardons" were granted at various dates, but especially during the years 1599–1603.[1] I have also drawn on the Patent Rolls of James I, which contain many similar pardons granted during the early years of that king's reign. Other documents of the period have also been utilized, particularly in Section III.

Of about fifty individuals, mostly belonging to the period 1570–1603, whom we find described as "rimers" in the Fiants and elsewhere, less than a dozen can at the moment be identified with poets some of whose compositions have come down to our day. Two-thirds of them, it is pretty safe to say, will never be more than mere names to us; their very names in most cases would be for ever unknown were it not for their chance preservation in these English records. Facts like these help us to realize how small a fragment of our literature has survived the wreck of our native culture in the Elizabethan conquest and in the Cromwellian and Williamite re-conquests that succeeded it.

I begin by giving (Section 1) the name of everyone whom I find described in the Fiants as "rimer," "bard," "chronicler," or "brehon."

I.

1. "Ferral m^c^Thomas alias M^c^Keoghe, of Donarde, county Dublin, rymor," 16 Apl., 1549 [Fiants Edw. VI, no. 279]. *Fearghal* (*mac Tomáis*) *Mac Eochadha*, of Donard (*Dún Ard*), Co. Wicklow. A poet of this name, doubtless the same man, has left us a poem on Aodh (mac Seáin) 'O Broin, beginning *Mairg do-ní deimhin dá dhóigh* (H. 1. 14, fo. 84 b; H. 4. 4, p. 51).

2. "Toll O'Molmore m^c^Keighe, of Rathtorkyll, county Kildare, rymor, indicted in the xxxiv Henry VIII for stealing one pork, of the price of 5*s*., belonging to Patrick M^c^Hwe, of the same place, rymor," pardoned 11 May, 1549 [Fiants Edw. VI, no. 293]. *Tuathal* (*mac Maolmuire?*) *Mac Eochadha*,[2] and *Pádraig Mac Aodha* (or *Mac Eochadha?*). The place seems unidentifiable. In Fiants Eliz. 3146 mention is made of the lands of "Rathnekill alias Rathturkyll," Co. Kildare.

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[1] In the following pages, when there is no indication to the contrary, the names taken from the Fiants are those of persons to whom "pardons" were granted. The date (or year) given is the date (or year) of the Fiant, and the number of the Fiant is given in square brackets. The Fiants have been published as appendices to the Reports of the Deputy Keeper of the Public Records (the Fiants of Edward VI in the 8th Report; those of Elizabeth in the 11th to 18th Reports).

[2] Cf. a namesake pardoned in 1598, § 14, *infra*, foot-note.

3. "Ouin oge McCrossan,[1] of Ballymccrossan, rymor," 10 June, 1550 [Fiants Eliz., no. 508]. *Eoghan* (or *Eóin?*) *'Og Mac an Chrosáin*, of Ballymacrossan, near Geashill, in King's Co.

4. "Shane mcDoghe McKeogho, late of Ballenescorney, co. Dublin, rhymor," 25 Jan., 1570 [no. 1478]. *Seán* (*mac Donnchadha?*) *Mac Eochadha*, of Ballinascorney, near Brittas.

5. "William mcCragh O Hefernan, bard of Rosonyany," 2 Jan., 1572 [no. 1971]. *Uilliam Mac-raith*[2] *'O Hifearnáin*, of Rossaneny,[3] at Windgap, Co. Kilkenny. For a son of his see next paragraph.

6. "Hennese McCragh, son of William McCragh O'Fernan, bard," 12 Jan., 1572 [no. 2063]. *Aonghus Mac-raith* (son of *Uilliam Mac-raith*) *'O Hifearnáin.* (The only place-name mentioned in this Fiant is Tullaghbroge, *i.e.* the parish of Tullaghanbrogue, in Co. Kilkenny.)

7. "Talleighney O Mulconery, of Cowlegad, rymor," 12 Jan., 1572 [no. 2042]. *Tuileagna 'O Maoilchonaire.* Although other place-names in this Fiant would point to Co. Kilkenny, it is just possible that "Cowlegad" may be the present tl. of Coolegad, in the par. of Delgany, Co. Wicklow.[4] But more probably the present poet is to be identified with "Tullegne mc Torne O Mulconere," of Co. Kilkenny, who was pardoned 17 March, 1584 [no. 4341].[5] This is probably the Tuileagna (son of Torna) 'O Maoilchonaire, who wrote a poem (23 L 17, fo. 152a) in praise of Sir Nicholas Walshe, who was prominent as a judge in Ireland under Elizabeth's government. Tuileagna (or Tuilgne) 'O Maoilchonaire, who in 1603 wrote a genealogical poem on the Leinster families (23 D 5, p. 161), and to whom also is ascribed a poem on the castle of Glashare, Co. Kilkenny (O'Curry in Ac. Cat. 407),

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[1] Of this family was Sir Patrick Crosbie, employed by Elizabeth's government, who was "the son of Mac-an-crossan, O'More's Bard, or Rhymer, and the ancestor of the Glandore family and of Crosby of Ardfert, in Kerry."—O'Donovan, "Tribes of Ireland," p. 25.

[2] Here and in § 6 the use of Mac-raith as a second forename in this family is to be noted. So "Donogh mcCrahe O Hiffernain, of Tipper, husbandman," in Fiant 6564. The O'Heffernans also used Mac-raith by itself as a forename: see § 10, *infra*. In the Tipperary Hearth-Money Records for 1665-7 I have noted three men called Magrah O'Hiffornane (pp. 116, 65, 121).

[3] The only other occurrence of this place-name in the Fiants is in no. 2065 (12 Jan. 1572), in which "John McEvard, of Rosoniani," is pardoned. Here "McEvard" possibly means no more than "the bard's son."

[4] In Fiant 6577, which deals with O'Byrne's country, there are five men of this surname ('O Maoilchonaire) pardoned.

[5] A namesake is mentioned in Fiant 4916 (14th Aug., 1586): "Tulligne O Molconere, of Castleton [*i.e.* Castletown, Queen's Co.], and Dermod O Molconere, of same, husbandmen." Another is "Tullius O Mulconry, of Gort in waga," Co. Galway, 1591 [no. 5617].

is doubtless the same person; as also Tuileagna Ruadh 'O Maoilchonaire,[1] author of a poem on Fiacha (mac Aodha) 'O Broin (H. 1. 14, fo. 108a).[2]

8. "Rory O Kyngy, rymor," 23 Feb., 1573 [no. 2209]. *Ruaidhrí 'O Cionga*, of Co. Westmeath or neighbourhood (Mac Eochagáin's country probably). In an earlier Fiant (no. 59, 1 Apl., 1559) "Rory O Kenga," who may well be the same man, is pardoned as one of the followers of "Brassell Shennaghe, *alias* Foxe, chief of his nation."[3]

9. "Derbe McCragh mcDonogh, of Mountayne castell, yeoman, John mcEnas McCragh, rymor," 10 May, 1573 [no. 2272]. *Seán (mac Aonghusa) Mac Craith*, of Co. Waterford.[4] We find a namesake, who may well be the same man, living at Burges[5] (near Clogheen, in the south of Co. Tipperary), in 1601, viz., "John mcEnes McCraghe, of Bureisee" [no. 6564], otherwise "John McCragh mcEneas, of Burgeise, gent." [no. 6565].[6]

10. "Meolmory mcEnish O Hernane, of Sronyll, co. Tipperary, Faraghell mcMeolmory O Hernane, Mac Crah O Hernane, and Aherny O Hernane, of the same, rhymors," 12 Sept., 1577 [no. 3102]. *Fearchar*[7] *(mac Maolmuire) 'O Hifearnáin*,[8] *Mac-raith 'O Hifearnáin*, and *Aithirne 'O Hifearnáin*, of

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[1] To this Tuileagna Ruadh is further ascribed (wrongly ?) the poem *Cuir srian rem chorp, a Choimdhe* in O'Con. Don's MS., fo. 56b.

[2] The name Tuileagna (like Torna) was a very common one in this family, and it is not always easy to discriminate between the different members who bore it. A note in English written by Tully Conry (Tuileagna 'O Maolchonaire) is preserved in Laud 610 (ZCP. viii. 181). "Tullius Conry" was teacher in the diocese of Clogher early in the seventeenth century (Archiv. Hib. ii, pp. 21, 23, 28). Somewhat later flourished Tuileagna 'O Maolchonaire, O.S.F., "seancha coitchenn 'Eirenn," whom we find in 1638 criticizing Mícheál 'O Cléirigh's book of genealogies of the Irish kings and saints, and in 1658-9 living in Madrid.

[3] An earlier member of this family was Séamas (mac Cairbre) 'O Cionga, scribe of the covenant drawn up in 1526 between Mac Eochagáin and An Sionnach (Misc. Arch. Soc., i, 197).

[4] From various other Fiants (nos. 2335, 2930, 4795, 5446, and 6481), as well as from the present one, we see that people named McCragh lived at Mountaincastle (near Modeligo, Co. Waterford); hence it is very probable that this was also the place of residence of the poet, although the Fiant does not explicitly say so.

[5] This is the place which is nowadays always assumed to have been the birthplace of Geoffrey Keating. But the assumption seems to rest on no more solid basis than an unsupported assertion of Haliday's; and it is significant that in the seven references to Burges in the Fiants persons named McCragh, O Daly, O Kenedy, and Lonergan are mentioned as residing there, but no one of the name of Keating.

[6] Among the MacCraiths of Burges in 1601-2 was "Rorie mcEa McCragh" [nos. 6522, 6583], namesake of a poet attached to the O'Byrnes, who flourished 1579-1597 (O'Gr. Cat. 503, 508).

[7] The anglicized form would represent **Fearchal*, with dissimilation of the second *r*.

[8] The anglicized form here represents a colloquial Irish form of the surname, viz., *'O Hearnáin* (perhaps < *'O Hiorthnáin* < *'O Hithearnáin* < *'O Hifearnáin*; cf. *ārthach*, dial. form of *aithearrach*).

Shronell, two or three miles west of the town of Tipperary. The same, or another, "Oharney O Hiffernan," of "Ballenloghan" (probably Ballinlough, east of Tipperary town), was pardoned in 1587 [no. 5006].

The Shronell district was the principal seat of the 'O Hifearnáin family. In Shronell[1] itself the following members are pardoned in other Fiants (I omit the surname, which is variously spelled O Hiffernan, O Hirnan, etc.): John, "gentleman," 1577 [no. 3043]; Murrihirtagh m^c^Rery and Ee m^c^Mwrihirtig, "kerns," 1577 [no. 3097]; Rorie, "yeoman," 1584 [no. 4526]; Teig, "yeoman," 1585 [no. 4743]; John Eglany [*Seán an Ghleanna* ?], Donogh m^c^Shane, Eneas fitz John, Mulmorye m^c^Gillenyneafe, and Ferragher m^c^Gillenyneafe, 1601 [no. 6490]. See further §§ 15, 16.

The 'O Hifearnáins appear to have been attached to the Earl of Desmond's family. See, for Conchubhar Ruadh 'O Hifearnáin, § 18, *infra*, and, for Mathghamhain 'O Hifearnáin, the poem *Ceist cia do cheinnéochadh dán* (cf. § 15). So, according to depositions made by him in 1591, Muircheartach Liath 'O Hifearnáin acted as messenger between the Earl of Desmond and Miler Magrath (Cal. S. P., 1588–92, pp. 419, 429); and "Morieitaghe Rowe O'Hiffernan, servant and guide to the traitor John of Desmond in his rebellion," was slain in 1580 (*ib.*, p. 286).

11. Grant to Thomas Earl of Ormond of lands, etc., in various counties, and also of "five knights' fees of lands in Tollaleishe, Killagholiaghan, and other towns, which John FitzMorice dwelling in the manor of Claneleis, near the country of Conallaughe, and a certain (   ) O Daley the rymer lately held, with the tithes of the same, Co. Cork,' '10 Dec., 1578 [no. 3513]. The places mentioned are: Tullylease (*Tulach Léis*), in the north of Duhallow, close to the border of Co. Limerick; Killagholehane, the parish in which the village of Broadford, in the south-west of Co. Limerick, is situated; and Cleanglass (*Claonghlais*), adjacent to the last and in the same county. The land referred to was evidently in the Geraldine country, and the O Daley one of the Earl of Desmond's poets.[2] See further § 50, *infra*.

12. "Meylmorry m^c^Twohill M^c^[K]eogh, rymor," 27 Aug., 1582 [no. 4008].[3] *Maolmuire (mac Tuathail) Mac Eochadha.* The same name is given as "Mulmurry m^c^Toell M^c^Geighoe" of "Cullitory" (perhaps Coolatore, near

[1] Here also in the eighteenth century lived the poet Uilliam Dall 'O Hifearnáin (or 'O Hearnáin).

[2] McKenna in his edition of the poems of Aonghus Fionn (p. vii) quotes this Fiant, and concludes, very rashly, that "the reference here is probably to Aonghus, and we may gather from it that he was born as far back as 1548."

[3] Place uncertain. There are only three personal names in this Fiant; the first belongs to Co. Kildare, the second is that of the "rymor," the third belongs to Co. Carlow.

Ferns) in 1587 [no. 5110], and as "Moylemurry m^c^Tohell M^c^Keoghoe," of Pallis, Co. Wexford, in 1601 [no. 6517; see § 14, *infra*]. Cf. also "Mollmory M^c^Kehughe" in a Co. Wicklow Fiant of 18 Mar., 1582 [no. 3844].

13. "Ouin m^c^Molaghlin M^c^Aogain, brehon," 19 Sept., 1582 [no. 4079]. *Eoghan* (or *Eóin*?) (*mac Maoileachlainn*) *Mac Aodhagáin*, of or near "Kerrucruyn," i.e. Carrowcrin, which is quite close to Duniry, Co. Galway. See further § 28.

14. "Donald McKeogho, son of McKeogho, rymor," 28 April, 1584 [no. 4372]. *Domhnall Mac Eochadha*, son of the chief of his name.[1] There were three poets of this name attached to the O'Byrnes and living about this time, viz., Domhnall Mac E., Domhnall son of Fearganainm Mac E., and Domhnall Carrach Mac E. (see O'Reilly, pp. cxliii–cxlv; Abbott-Gwynn Cat., pp. 47–49; and O'Gr. Cat., pp. 504–514). The following also may be identical with one of these poets: "Donill M^c^Kehewe," 1582 [no. 4019]; "Donell M^c^Keghoe," 1601 [no 6577]; "Donell M^c^Keoghoe" of Fiant 6517, quoted in the next paragraph; and "Donnell M^c^Lowe O'Chycho" (*sic*), of "Balliboght, near Ballimore," 1603 (Cal. Pat. Rolls, Ja I, p. 35 b).

In other Fiants we find men of this surname (Mac Eochadha) mentioned, some of whom, although the Fiants do not describe them as "rymors," can be identified with known poets. From these Fiants we also infer that this poetic family was settled mainly at "Pallice," *i.e.* the present townlands of Pallishill, Pallis Lower, and Pallis Upper, in the north of Co. Wexford, about midway between Arklow and Carnew. (*a*) "Rory M^c^Eghoe, of Rapiers,[2] said co. [*i.e.* Wexford], gent., Thomas m^c^Rory M^c^Eghoe, of same, John m^c^Rory M^c^Eghoe, of same," 1581 [no. 3733]. (*b*) "Thomas M^c^Keogho," of, apparently, "the Pallaice, co. Wexford," "Shane M^c^Keoghoe, of Rahin Conogher," "Rory m^c^Shane M^c^Keogho," 1598 [no. 6200]. (*c*) Farroll m^c^Loud M^c^Keigho, Lowe m^c^Farrell M^c^Keigho, Farrell m^c^Ferrel M^c^Keigho, Gillernow m^c^Lowe M^c^Keigho, Thomas m^c^Farrell M^c^Keigho," 28 May, 1598 [no. 6232]; no place-name mentioned. (*d*) "Thomas M^c^Keoghoe, of Pallice, Lewes M^c^Keoghoe, Farreyle m^c^Farrell Keoghoe, and Enos O Daylie [see § 31], of same, ... Fargenanyme M^c^Keoghoe, of Pallice, Donell M^c^Keoghoe, Dermot m^c^Donnell M^c^Keoghoe, Teig m^c^Moylemurry M^c^Keoghoe, Farreyle m^c^Lowe M^c^Keoghoe, Moylemurry m^c^Tohell M^c^Keoghoe [see § 12], Shane m^c^Rorie M^c^Keoghoe, and Tohell M^c^Keoghoe, of same," 15 May, 1601 [no. 6517]. (*e*) "Mulmurrey M^c^Ferral M^c^Keoghe," "Farrale M^c^Lowe

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[1] Place not stated. The nearest place-names in the Fiant belong to Cos. Kildare and Carlow.

[2] "Rapiers" is now Rathpierce, in the north of Co. Wexford, a little to the east of Pallis.

M^cKeoghoe," and "Shane M^cKeoghoe," all of "Killevane," 3 Mar., 1604 (Cal. Pat. Rolls, Ja. I, p. 31 b).[1] Among the poets who may be identified in these lists are *Fearghal mac Luighdheach, Fearghal 'Og, Fearganainm, Giolla-nanaomh, Rudhraighe,* and *Tomás*; possibly also *Seán mac Fearghail* or *Seán mac Pilip* (see for all these poets H. 1. 4 *passim*, and cf. O'Grady Cat., 502, 648).[2]

15. "Mahon O Hifernan, rimer," 14 May, 1585 [no. 4642]. *Mathghamhain 'O Hifearnáin.* There are no place-names mentioned in this Fiant, but the persons pardoned appear to belong to "co. Cork." This is doubtless the poet of the name who was author of *Ceist, cia do cheinneóchadh dán* and other pieces.[3] He may well be identical with the man of the same name whom we find in the Shronell district in other Fiants, thus "Mahon O Hiffernan, of Sronill," 1579 [no. 3547]; "Mahowne O Hiffernan, of Immelid [*i.e.* Emly], husbandman," 1579 [no. 3567]; "Mahowne O Hiffernane, of Latten [Lattin, adjoining Shronell], yeoman," 1587 [no. 5006][4]

16. "Enis roe O Hiffernan, rymer," 14 May, 1585 [no. 4644]. *Aonghus Ruadh 'O Hifearnáin.* That this poet lived at Shronell[5] we see from a later Fiant [no. 6565], dated 6 Aug., 1601, in which "Eneas roe O Hiffernan alias O Hiffernane, of Sronell, gentleman," is pardoned, as also "Hugh m^cMurtagh O Hiffernan" and "Murtagh m^cEnees O Heffernan," husbandmen, of the neighbouring townland of Lattin.[6]

17. "Uline O Mulconry, of Clonhy, gentleman, rimor, Gelernuve Keighe, of Clonpluckane, rimor, Ferfesse O Muckory [*sic*], Padine oge O Mulcony [*sic*],

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[1] This begins with a pardon to "Phelim M^cFeagh of Ballmacorre" (*i.e.* of Ballinacor), and the only other place-name mentioned is this "Killevane," which is probably Kilcavan (*Cill Chaomháin*), tl. and par., close to Pallis, in North Wexford.

[2] The following names of other members of the Mac Eochadha family may be worth quoting; they all belong to the district made up of Wicklow and portions of the adjoining counties. I omit the surname in each case: Philip and Edmond duff, 1582 [no. 3844]; Shane, 1582 [no. 4019]; Dorren nyne Rorie [*Doireann 'nghean Rudhraighe*], Mulmory m^cTeige, Toole m^cMulmory, James m^cDonogh, Shane m^cWilliam, and Rorie m^cShane, 1598 [no. 6232]; Edmond Lowe ("of Holiwood"), Eniste, Connoghor roe, Mulmore m^cFergananim ("of the Three Castles"), Donogh buy m^cRanall, and Carroll, 1601 [no. 6577].

[3] Published in "The Irish Review," Apl., 1912, p. 82; O'Gr. Cat., 392; I.T.S., xx, 114.

[4] Cf. a later (1641–1652) namesake of the same district in T. O'Donoghue's edn. of P. Haicead, p. 159.

[5] The present Fiant (4644) appears to deal with "co. Limerick," but from other Fiants (1576, 3043, 4733) we see that the Shronell district was at this time often regarded as belonging to Co. Limerick instead of to Co. Tipperary.

[6] The last-named had been already pardoned a few months previously, viz., "Morriertagh m^cEneas O Hiffernan, of Latten" [no. 6490].

of same, rimor," 1 June, 1585 [no. 4678]. *Iollann 'O Maoilchonaire,*[1] of Cloonahee, near Elphin, Co. Roscommon ; *Giollarnaomh* (i.e. *Giolla-na-naomh*) *caoch* ['*O Maoilchonaire*], *Fearfeasa 'O M.*, and *Páidín 'Og 'O M.*[2] "Clonpluckane" (*Cluain Plocáin,*[3] FM. iv. 1238) was in Roscommon, but its exact situation has yet to be discovered. In 1583 were pardoned "Brian O Mulconre, of Clonplocan, Moyllon mcShane McPadin, of same" [no. 4240] ; the latter evidently stands for *Maoilín 'O Maoilchonaire,* son of *Seán* and grandson of *Páidín* (probably the Páidín who died in 1506). Other members of this family were pardoned in 1590, viz. "Ollishe mcO [*sic*] Molconnere, of Gorteslogbe, Melaughlen, Flarin, Turne, and Feel O Molconnere, of same, Farfasse O Molconnere of Ballekillecomin" [no. 5439], i.e. *Eólas* (?), *Maoileachlainn, Flaithrí, Torna,*[4] *Fítheal,* and *Fearfeasa* ; the two place-names are not easy to identify,[5] but may be taken as belonging either to Leitrim or to the adjoining portion of Roscommon.

18. "Theobald fitzJohn Bourke, of Derryclowny, Moriertagh mac Rory O Hiffernain, of same, rimor, Mulmory O Hiffernaine, of same, stockagh [*stócach*], Ferreghar O Hiffernaine, of same, stockagh," 8 July, 1585 [no. 4733]. *Muircheartach* (*mac Ruaidhrí*) *'O Hifearnáin,* of Derrycloney, near the town of Tipperary, about mid-way between Caher and Golden.

In the same Fiant a pardon is granted to "Conoghor O Hiffernane, rymor," i.e. *Conchubhar 'O Hifearnáin.* This was the "Cono Roe [*Ruadh*] Oharnan, being an Irish Poet," whom James fitzMaurice in 1572 sent to Emly, Co. Tipperary, to Perrott, Elizabeth's President of Munster, as the bearer of "a cunning and subtle excuse" for declining to meet the President in single combat.—"The History of Sir John Perrott," London, 1728, p. 62. "Knoghor O Hiffernan, of Laten" (*i.e.* Lattin, west of Tipperary town), pardoned in 1601 [no. 6564], may be the same man.

19. "Flan mcEneas oge McCraghe, of Garrestown, rymor," in 1586 apparently [no. 4935]. *Flann* (*mac Aonghusa óig*) *Mág Craith,* of Garrison, near Pallas Grean, Co. Limerick.[6] Possibly to be identified with Flann

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[1] Mentioned in a marginal note in Egerton 88 (O'Gr. Cat. 129z). He is probably the *Iolland* who wrote, *ca.* 1572, part of the so-called YBL (col. 43, foot).

[2] Writer of a marginal note in H. 3. 18, p. 83 (Abbott-Gwynn Cat. 359).

[3] Tuileagna 'O Maolchonaire, O.S.F., refers, *ca.* 1640, to a MS. entitled *Leabhar Chluana Plocáin*—Gen. Reg. et Sanct. Hib., ed. Walsh, p. 133.

[4] Perhaps the *Tornae* of YBL, col. 44, foot.

[5] "Gorteslogbe" may represent Gortnasillagh, which is the name of places in Leitrim, Roscommon, and elsewhere. "Ballekillecomin" may be Ballycummin (*Baile an Choimíne*), on Lough Boderg, where 23 N 10 was written about 1578, in the house of Seán 'O Maoilchonaire (cf. 'Eriu, i, 38).

[6] With "Garrestown" cf. Ir. *garastún* = "garrison." "Donell McCrath, of Garreston, yeoman," was pardoned in 1587 [no. 5006].

Mág Craith,[1] the author of *Iomdha éagnach ag 'Eirinn* (cf. O'Gr. Cat. 380), though this is also attributed to Aonghus Fionn and others.

20. "Moilen O Mulconnerie, cronickler," 5 May, 1601 [no. 6504]. *Maoilín 'O Maoilchonaire*, in Co. Limerick.[2]

21. "Donogh O Fylan, of same [viz. Donowre], rimer," 7 May, 1601 [no. 6507]. *Donnchadh 'O Fialáin*, of Donore [*Dún Uabhair*], in MacEochagáin's country, in the present Co. Westmeath. A poem of his, written on the occasion of a visit to the O'Byrnes of Ballinacor, Co. Wicklow, has survived (O'Gr. Cat. 506).

22. "Patrick M^cKigan, of Currabeg, brehowne," 12 June, 1602 [no. 6658]. *Pádraig Mac Aodhagáin*, of Carrickbeg,[3] a little to the south of Ballymahon, Co. Longford. Some years previously this "Patrick M^cEagan, gentleman," had been made by Elizabeth's government "seneschal of Correbeg alias Ballem^ckeagan, in the co. Longford," with licence to "prosecute and punish by all means malefactors, rebels, vagabonds, rymors, Irish harpers, idle men and women, and other unprofitable members,"—Fiant 5528, dated 12 Feb., 1591. The Mac Aodhagáins of Carrickbeg were evidently brehons to 'O Fearghail Buidhe,[4] who was ruler of that part of Longford. 'O Fearghail Buidhe himself lived close at hand, at "the Pallice" [no. 5091], *i.e.*, the present townlands of Pallas Beg and Pallas More, a couple of miles to the east of Ballymahon.

II.

In the case of a large majority of the persons pardoned in the Fiants of Elizabeth, no indication is given as to the callings pursued by the various individuals. Hence we may expect to find the names of many "rimers," "chroniclers," and "brehons" appearing on these lists without their being so described. Moreover, as these particular professions were well known to be obnoxious to the English of the day, it is only natural that poets and others when seeking pardons should have preferred to have themselves described in innocuous terms like "gentleman" or "yeoman." In the present section my main object has been to quote such names as may with

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[1] Who may well be a different person from Flann mac Eoghain Mhéig Craith, the panegyrist of the anti-Irish Earl of Ormond and of (probably) Queen Elizabeth.

[2] The name preceding this belongs to "the Corrie," the name following to Carrigogunnell.

[3] The identity is established by comparing Fiants 5063 and 5091, in which the same place is called "Carrigbegge" and "Corrybegge." Possibly the original name in Irish was *Coirthe Beag*, changed later to *Carraig Bheag*.

[4] The 'O Fearghails had long been loyal to Elizabeth's government, so there is nothing surprising in one of their brehons being made seneschal.

more or less of certainty be identified as those of poets, etc., who are otherwise known. Were anything like a full list available of the literary men of the time, it would doubtless have been possible to suggest many more identifications than I have done. But even when no such identification may be possible, it is not without interest and value to have on record the names and places of residence of members of the learned families of Ireland just before our native learning was engulfed in the general ruin of the country.

23. (*a*) "Connor oge O Corcran m^cConchour, of Irris, Ferfeasse O Dwgenan, of Inishkellen, Brian O Corcrane, . . . Shane O Corcrane, of the same, . . . Hugh O Chorcran m^cMelaughlin, of Kilnelyawe, . . . Matthew O Lonine, of the Arde, Aghye O Hossye, of Baelle Iossey, . . . Cherwoy O Hoghssy, of Balyoshye, Owen Macabe, of Inniskellen, Wm. oge O Corcrane, of same," 18 Jan., 1586 [no. 4810]. (*b*) "Ogha O Hagassa, of Balyogahsa, freeholder, Kithrin O Hogassa, of same, . . . Bernard O Hogassa, of Balliogassa, freeholder, Barnard O Corcran, of Fearran amuny, student, John O Corcran, student, Wm. O Corcran, student, of same,[1] . . . Miler O Hogasa, of Baliogasa, freeholder," 1591 [no. 5602]. (*c*) "Eoghy O Hoasa, Carovy O Hoasy, Coochogerie O Hoasy, Melaghlen oge O Hoasy, Brien O Corcran," 28 Feb., 1592 [no. 5716]. (*d*) "Brian O'Corcran, of Carrick, gentleman, . . . Cirroury O'Hossy, of Ballihosy, Moelaghlin oge O'Hosy," together with five other O'Corcrans (including "Shane" and "William oge"), 7 Decr., 1603 (Cal. Pat. Rolls, Ja. I., p. 34b).

In the above lists we have members of the learned families of Maguire's country (Fermanagh). *Brian 'O Corcráin,* whose name appears in all four lists, was the author of the prose romance "Eachtra Mhacaoimh an Iolair,' and of seven poems preserved in the O'Conor Don's MS. According to these documents he resided in 1586 in Enniskillen; in 1591 in "Fearran amuny," which is probably the present Farnamullan (*Fearann-an-mhuilinn*), in the par. of Cleenish (to the south of Enniskillen), of which the 'O Corcráin family were hereditary airchinneachs; and in 1603, at Carrick, near Church Hill, Co. Fermanagh.

Several members of the family of 'O Heóghusa are also mentioned, including the well-known *Eochaidh 'O Heóghusa,* whose name appears in all

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[1] In the same Fiant are mentioned six other "O Corcran" students belonging to other places, and one priest of the name. One is reminded of what Davies wrote in his letter to Salisbury in 1606: "Albeit Hugh M^cGuire that was slain in Munster [in 1600] were indeed a valiant rebel, and the stoutest that ever was of his name, notwithstanding generally the natives of this county are reputed the worst swordsmen of the north, being rather inclined to be scholars or husbandmen than to be kern or men of action, as they term rebels in this kingdom."

the lists except the last. They all, so far as we can judge, resided at Ballyhose (*Baile 'I Eoghusa*), on Castlehume Lough, Lower Lough Erne. The name of *Cithruadh 'O Heóghusa* occurs, in various corrupted forms, in all four lists. *Maoileachlainn 'Og 'O Heóghusa* is mentioned in 1592 and 1603. The *Eochaidh mac Maoileachlainn*, whose death is referred to, as well as that of Tadhg Dall, in the poem *Táinig dias fhuinn Ghaoidheal*,[1] is, I conjecture, none other than Eochaidh 'O Heóghusa,[2] in which case the Maoileachlainn 'Og just referred to was probably a younger brother of Eochaidh's.[3]

Attention may also be called to "Matthew O Lonine, of the Arde," pardoned in 1586, i.e. *Matha 'O Luinin*, of Arda,[4] on the Erne, between Belleisle and Cleenish. This Matha, in 1571, wrote the Irish law tract in the MS. Nero A. vii (O'Gr. Cat. 141, 146; and cf. *ib.*, 78, 79).

24. "Miellien oge McBrodie, of the Synngaragh," 17 July, 1585 [no. 4753]. This is the well-known *Maoilin 'Og Mac Bruaideadha* (†1601), of Shingaunagh, in the par. of Kilmacrehy, near Liscannor, Co. Clare.

25. (*a*) "Teig McBrodie, of Knockinalbie," 18 May, 1586 [no. 4860]. (*b*) "Teige McBrody, of Knockan allany, gentleman," 1 May, 1602 [no. 6615]. Here we have *Tadhg Mac Bruaideadha*, i.e. Tadhg mac Dáire, who, as we also know from another source, resided at Knockanallan (*Cnoc an Altanaigh*), in the par. of Kilmurry, in the west of Co. Clare.

26. (*a*) "Morris mcDavid duffe," in Co. Kerry, 21 Apl., 1601 [no. 6498]. (*b*) "Morris mcDa duff, of Pallice, Ellean ny Owen, his wife, John mcDa duff, of same. . . . Susanna ny Da Duff, of Kilecrydane," 14 May, 1601 [no. 6515]. This is almost certainly the well-known poet *Muiris (mac Dháibhí Dhuibh) Mac Gearailt*, together with his wife, brother, and sister. "Pallice" is Pallis (*an Phailís*) to the west of Killarney, near Beaufort Bridge. Kilmedane is a few miles to the north, near the present railway station of Ballybrack.

27. (*a*) "Beolhaghe duff McEgane, of same [viz., Pallis], Beolhagh mcOwen McEgane, of same," 14 Jan., 1585 [no. 4576]. (*b*) "Beolagh duf

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[1] Ascribed to Fearflatha 'O Gnímh in 23 D 4, p. 115, but to Aonghus 'O Dálaigh in O'Con. Don's MS., fo. 408a.

[2] Eochaidh 'O Heóghusa, it may not be amiss to add, appears to have died quite early in the seventeenth century. O'Reilly, who makes him flourish as late as 1630, is certainly wrong.

[3] "Miler O Hogasa," i.e. *Maolmhuire 'O Heóghusa*, pardoned in 1591 (*supra*), is not to be confused with Meyler Hussey, of Mulhussey, Co. Meath, whose name occurs frequently in the Fiants of Elizabeth between 1559 and 1580. The name of the latter in Irish would be *Maolmhuire Husaé*. This caution may be necessary in view of O'Grady's conjecture (Cat., p. 153) that the Meathman was of the family of 'O Heóghusa.

[4] For the association of this place with the 'O Luiníns see Hogan's Onomasticon, s. v. *Ard*.

M^c^Egan, of Pallace," 11 June, 1586 [no. 4888]. (*c*) "John Boelagh m^c^Shane m^c^Eagaine, of Gortnerlogh, Bolagh duffe m^c^Carribre M^c^Eagaine,[1] of Killclure, Cosne M^c^Boelie of Gortneclogh, Owen Boelagh, of same, . . . Carribre[2] and Cosne m^c^Donnell M^c^Boelagh, of Gortneclogh," 1600 [no. 6469]. All three Fiants deal with the followers of Mac Carrthaigh Mór. Here we have *Baothghalach Dubh Mac Aodhagáin*, of Pallis, near Killarney, in 1585–6, and of "Killclure"[3] in 1600, when the place of Domhnall, Earl of Clancar (†1596), had been taken by his son-in-law Fínghin. Baothghalach Dubh was thus of the branch of the Mac Aodhagáins who were brehons to Mac Carrthaigh Mór.[4] He was also apparently something of a poet. Thus he appears to have the best claim to the authorship of *Dia do chruthaigh grianbhrugh Nimhe.*[5] Another poem, in praise of MacCarthy, is ascribed alternatively to Baothghalach Dubh or to Muiris mac Dháibhí Dhuibh (O'Gr. Cat. 542); the latter also, as we have seen (§ 26), lived at Pallis, which was one of the residences of Mac Carrthaigh Mór.

28. The MacAodhagáin family of brehons had by the sixteenth century carried their profession into many parts of Ireland; indeed they are found almost as widely spread as the 'O Dálaigh family of poets. I append the names of a few members of other branches of the family apart from that of West Munster (§ 27):—

(*a*) "Carbary M^c^Egan of Bally M^c^Egan," *i.e.* Ballymacegan, in the extreme north of Co. Tipperary, is mentioned in a State paper of the year 1591 (Cal. S.P. 1588–92, p. 426). This is evidently the *Cairbre* (son of *An Cosnamhach,*[6] etc.) *Mac Aodhagáin,* whose name is the first appended to a document of arbitration between O'Kennedys drawn up in 1584 (GJ. 89, p. 88).[7] His son, Flann Mac Aodhagáin, of Ballymacegan, is best known from the *testimonia* which he gave the Four Masters on the completion of their works.

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[1] Cf. "Beholagh m^c^Carbery M^c^Egan," of Co. Cork (?), 1590 [no. 5412].

[2] Also pardoned in 1601, "Carbrie m^c^Donell M^c^Egaine" [no. 6555].

[3] Either Coolclogher (*Cúil-chluthair* ?), close to Killarney, and adjoining the townland of Castlelough, or Kilclogherane, in the parish of Kilbonane. "Gortnerlogh" and "Gortneclogh" doubtless represent the present Gortnaglogh in the adjoining parish of Kilnanare.

[4] His father *Cairbre* (Fiant 6469) may possibly be the Cairbre (son of Conchobhar), with whom MacFirbis (p. 325, col. 3) begins his pedigree of MacAodhagáin "ollamh cloinne Carthaigh," But more probably he is the "Carbery m^c^Shane M^c^Hegan, of Pallice," pardoned in 1585 [no. 4677].

[5] Printed in Trans. Gael. Soc. Inverness, xxvi, 100.

[6] Perhaps the scribe of part of H. 4. 22 (cf. Abbott-Gwynn Cat. 212–213).

[7] "Carbery M^c^Eagan, of Lessine," 1601 [no. 6519], may be the same man. One of the places called Lisheen in Co. Tipperary, viz., that in the par. of Dorrha, is near Ballymacegan.

(*b*) In Co. Galway we find the Mac Aodhagáins in possession of four castles in 1574, including that of Duniry[1] (*Dún Daighre,* the place associated with the writing of the Leabhar Breac), which was owned by "Carbery M^cEgan and the judges," and the castle of Park (*an Pháirc*; between Tuam and Glennamaddy), owned by "John M^cEgan."[2] It was in this castle of Park, as Dr. G. U. Macnamara has shown,[3] that Egerton 88 was written, *ca.* 1569. In the Fiants we find pardoned in 1590 "Carberie M^cKegan,[4] of Kyarowvadyn,[5] Owin M^cKegan, of same, and Gillepatrick M^cKegan, of Park, gentlemen" [no. 5476], and in 1591 "Farganauyn [*Fearganainm*] M^cKegan, of the Parke, Teige oge M^cKegan, of same" [no. 5613]. It was at Park[6] that Baothghalach Mac Aodhagáin (Boetius Egan), bishop of Elphin, to whom Mícheál 'O Cléirigh dedicated his "Foclóir," was born. An earlier namesake of the bishop's, "Behillagh M^cKegan, of the Cregan,[7] gentleman," pardoned in 1590 [no 5447], may well be identical with Baothghalach Ruadh Mac Aodhagáin,[8] who took part on the side of the North in the "Contention of the Bards," and whose explanations of difficult words formed the chief source of this "Foclóir" of 'O Cléirigh's.

(*c*) In the midland districts the MacAodhagáins had long been settled. We have already referred to a branch of them in South Longford (§ 22). In 1564 we find "Shane M^cEgan" as judge in a dispute between O'Molloy and MacGeoghegan (O'Gr. Cat. 152). Many people of the name are mentioned in Fiants dealing with the Midlands. As an example, taken at random, may be given the following from Mac Eochagáin's country in South Westmeath:

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[1] "Gillernew M^cKeigin, of Cunery," Co. Galway, was pardoned in 1585 [no. 4613]. "Cunery" here is probably a mistake for "Dunery," *i.e.* Duniry.

[2] Journal Galway Hist. and Arch. Soc., i, 111, 112.

[3] North Munster Arch. Journal, ii, 149 ff. At *Páirc* too were written part of H. 2. 16 (YBL) and of H. 3. 18 (see Abbott-Gwynn Cat., pp. 347, 358, 360).

[4] A namesake, "Carbery M^cKegan, of Aghrim, co. Galway," was pardoned in 1584 [no. 4355].

[5] This looks like a misreading of Kyarowecryn, in which case the "Owin M^cKegan" here would be identical with the brehon pardoned in 1582 (v, § 13).

[6] So Meehan, "Irish Franciscan Monasteries," 361.

[7] One of the half a dozen places in Co. Galway called Creggaun, one of which is close to Park.

[8] O'Reilly ("Irish Writers," clv) says that this writer was "of a Momonian tribe"; and later writers have imitated and amplified this assertion. McKenna (Ir. Texts Soc., xx, p. xi) says that he "was master of the Bardic School in Ormond at which Michael and Lughaidh O'Clery (as Michael tells) received their poetic education." But the MacAodhagáins were jurists by profession, not poets; and Michael O'Clery says nothing at all about Baothghalach's school being in Ormond. There seems in fact to be no evidence whatever that this Baothghalach was a Munsterman or that he lived in Munster.

"Carbery[1] McKygan," of Montrath, 1581 [no. 3762]; "Carbrie McKeigan, of Kilcumreragh, 1581 [no. 3775]; "Carbry McKigane," of Syonan, 1600 [no. 6450].

29. (*a*) "Enis O Dallye alias O Dallye," 14 Jan., 1585 [no. 4576]. (*b*) "Eanes O Dally, of same" (viz. of "Cloynomine"), 1601 [no. 6658], *i.e.* of Clonmeen (*Cluain Mín*), the seat of 'O Ceallacháin, near Banteer, in Duhallow, Co. Cork. Here we have the poet *Aonghus 'O Dálaigh Fionn.* In (*a*) his name occurs immediately after those of "Donald, earl of Clancarr," and his family; the first place-name mentioned is "Castleloughe,"[2] which is given with the name next following that of the poet. Aonghus, as we know, was head of his name; hence the "alias O Dallye" of the Fiant. Furthermore, we know that he was as closely connected with Mac Carrthaigh Mór as with 'O Caoimh of Duhallow; he has left a poem[3] (23 N 15, p. 151) on the death, *ca.* 1586, of Tadhg, the only lawful heir of the Earl of Clancar, as well as an elegy on the Earl's death in 1596.

30. (*a*) "Eneas keaghe O Daly, of Moyntervarye," 31 Aug., 1590 [no. 5456]. (*b*) "Eneas Odaly otherwise O'Daly of Cahir," Co. Cork, described as "yeoman," 20 Feb., 1604 (Cal. Pat. Rolls. Ja. I., p. 32 a). This *Aonghus* (*caoch*) *'O Dálaigh* must be the Aonghus 'O Dálaigh who lived at Ballyroon, in S.-W. Cork (where he died in 1617), and to whom the satire on Irish families is ascribed. "Cahir" is the townland of Caher, adjoining Ballyroon, and like it situated in Muntervary (*Muinntear Bháire*), i.e. on the promontory separating Bantry Bay from Dunmanus Bay. From the pardon of 1604 we infer that Aonghus was then 'O Dálaigh Cairbreach, head of the Carbery branch of the family.[4]

31. (*a*) "Enyes O Dalye, of Palees," 28 May, 1598 [no. 6232]. (*b*) "Enos O Dalie," of "Pallice," 15 May, 1601 [no. 6517]. Here we have *Aonghus* (*mac Daighre*) *'O Dálaigh,* poet to the O'Byrnes, of Pallis, in the north of

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[1] The name Cairbre, like Baothghalach, was a very common one at this time in the Mac Aodhagáin family everywhere.

[2] *i.e.* Castlelough, on the shore of Lough Leane, one of the residences of Mac Carrthaigh Mór.

[3] This is one of several historical poems by Aonghus Fionn which do not find a place in Fr. McKenna's edition.

[4] In "Pacata Hibernia," ed. 1810, p. 528, mention is made of "Odalie" of Muntervary, who in 1602 was brought before Carew charged with bringing messages from the "rebels." This "Odalie" was very probably Aonghus, but it is just possible that he may have been the same person as "Laghlin Odallye" who later on in the same work (pp. 576, 651) is mentioned as the bearer of messages from the "traytor" Tirrell to Carew.

Co. Wexford, where also, as we have seen (§ 14), his fellow-poets of the Mac Eochadha family resided.[1]

32. "Carrol O Dale, of Pallice," Co. Wexford, 14 Nov., 1597 [no. 6160]. Also "Carroyle boye [*buidhe*] O Dalie," of some unspecified place in Co. Wexford, 15 May, 1601 [no. 6517].

These particulars regarding *Cearbhall* (*Buidhe*) *'O Dálaigh* are of importance in that they help to definitely fix in time and place a personality who has hitherto been left to the mercy of oral tradition and its still more unreliable commentators. According to the traditional anecdote (which was first printed in Walker's "Historical Memoirs of the Irish Bards," 1786, app., p. 60, as obtained from Cormac Common of Co. Mayo),[2] one Carrol O'Daly[3] was a suitor for the hand of a Miss Eleanor Kavanagh, but for one reason or another her father arranged that she should marry another man. When the wedding-party had assembled, Carrol entered, disguised as a harper, and played and sang the song *Eibhlín a rúin*[4] (or otherwise secretly made himself known to her), with the result that Eleanor immediately eloped with him. In confirmation of the substantial truth of this legend, it can be shown that the

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[1] This Aonghus and the Cearbhall of the next paragraph are the only O'Dalys I have noticed among the Fiants of the Wicklow-Wexford district. The O'Dalys, though well established in perhaps the greater portion of Ireland, were evidently very few in numbers in South-East Leinster.

[2] Compare the versions, obtained in our own day, in 'O Máilles' "Amhráin Chlainne Gaedheal," pp. 192-3 (Galway), and in "An Lóchrann," Sept., 1918, pp. 2-3 (Cork). In both of these Cearbhall, in order to attract the attention of the lady (who is called *Ailíneoir* in the former, and the *Rudaire Caomhánach's* daughter in the latter version), takes to shoemaking and, when an opportunity arises, makes a pair of "magic" shoes for her.

[3] Common, as a Connachtman, not unnaturally confuses him with other O'Dalys nearer home, but the date he suggests is more correct: "Carroll O'Daly (commonly called *Mac-caomh Insi Cneamha*), brother to Donough More O'Daly, a man of much consequence in Connaught about two centuries ago" (*i.e.* about 1586). Hardiman ("Irish Minstrelsy," i, 356–7) accepts this identification of Carrol as the brother of "Donogh More," but, as the latter died in 1244, he naturally objects to the sixteenth-century date as too late. O'Reilly (p. cxii) identifies the Carrol O'Daly of popular tradition with the Cearbhall 'O Dálaigh of Corcomroe (Co. Clare), whom the Annals record as having died in 1404. So does W. H. G. Flood, so far as concerns Carrol the lover of "Eileen Kavanagh" (*sic*). The words and music of *Eibhlín a rúin* were, he affirms ("Story of the Harp," p. 62), "composed in 1386 by Carrol O'Daly, a famous Irish harper"; the date 1386 having apparently been arrived at by subtracting four centuries instead of two from the date of publication of Walker's "Memoirs"!

[4] Common's version appears to be our only authority for the association of this air with Cearbhall 'O Dálaigh. It should be noted that the lady's name is everywhere (even in Common's version) given as "Eleanor" (*Eilíonóir*), not "Eileen" (*Eibhlín*). On the other hand, we have contemporary evidence that Cearbhall was an expert musician; see the reference to P. Haiceud's poem, *infra*. But the connexion of Cearbhall with this particular song and air of *Eibhlín a rúin* must, I fear, be regarded as quite unproven.

principal actors in it lived in the Wexford-Carlow district in the early part of the seventeenth century. Domhnall Caomhánach, usually known as Domhnall Spáineach, was a prominent figure in the history of East Leinster towards the end of the sixteenth century.[1] He died on 12 March, 1631, and at his death was seised of Clonmullen and other lands in Cos. Carlow and Wexford.[2] His wife Eleanor survived him, and his son and heir was Sir Morgan Cavanagh, who was then of full age and married.[3] This Sir Morgan had "married early in life Eleanor, daughter of the second Viscount Mountgarret, by whom he had sixteen children."[4] With his father-in-law, Sir Morgan joined the rebellion of 1641, and was killed in an engagement near New Ross in March, 1643.[5] Among Sir Morgan's children was a daughter named Eleanor (who was doubtless so called after her mother and paternal grandmother), as we learn from an unpublished love-song, beginning *Do mhúsgail mé d'éis luighe araoir go sámh,* which, according to the title prefixed to it in MSS.,[6] was composed by Cearbhall 'O Dálaigh, for Elíonóir, daughter of Sir Murchadh Caomhánach. Among Pádraigín Haiceud's poems is one addressed in 1630 to Cearbhall 'Og 'O Dálaigh, who is described as a man of many accomplishments—poet, musician, wooer and so on.[7] A poem by Cearbhall 'Og in reply to this has also been preserved.[8] A short poem beginning *Fada ar gcomhthrom ó chéile*[9] is in at least one MS.[10] entitled "a little love-lay addressed by Cearbhall 'O Dála to his lady-love, Eleanor Cavanagh."[11] There can be little doubt that the Cearbhall 'O Dálaigh who was in love with Sir Morgan Cavanagh's daughter, and who is traditionally said to have eloped with her, was either the

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[1] Cf. D'Arcy M'Gee's "Art Mac Murrogh," 124 ff.

[2] Inquisitions, Co. Carlow, no. 41; Co. Wexford, no. 84.

[3] *Ibid.*

[4] D'Arcy M'Gee, *op. cit.*, 128.

[5] Gilbert's "History of the Irish Confederation," ii, p. 260, and "Contemporary History of Affairs in Ireland from 1641 to 1652," i, p. 62.

[6] H. 5. 28, fo. 189b (transcribed *ca.* 1679); H. 4. 26, p. 118 (transcribed in 1701). In the latter the author's name is given as Cearbhall *'Og* 'O Dála.

[7] T. 'O Donnchadha's edition of P. Haiceud's poems, p. 107.

[8] *Ibid.*, 108. Cf. also *ib.*, p. 44, where he is called "Cearbhall 'O Dálaigh" (without the *'Og*).

[9] Cf. "Dánta Grádha," 1916, p. 22.

[10] St. F. vi. 2, p. 371, where the title is *Laoi bheag chumuinn ó Chearbhall 'O Dhála chuim a mhuirnnín .i. Eilīonóir Cháomhánach.*

[11] Mention may also be made of a love-song beginning *Im leabaidh araoir do shíleas féin ag teacht,* found in many MSS., and ascribed by them to Cearbhall, or Cearbhall 'Og, O Dálaigh. O'Reilly assigns it to the latter, whom he makes to flourish *ca.* 1680. In H. 4. 24, p. 127, the author is called *Cearbhall 'O Dála na mban,* which reminds one of *Diarmaid na mban* as a popular name for Diarmaid ó Duibhne (Oss. Soc., iii, p. 50*n.*).

Cearbhall (Buidhe)[1] whom we find pardoned in 1597 and 1601 or (more probably) a son of his, Cearbhall 'Og.

The Cearbhall 'O Dálaigh who flourished in the first half of the seventeenth century seems to have been a man of great notoriety in his day. The story of his elopement with Eleanor Cavanagh spread far and wide. In every Irish-speaking district there are probably even to-day old people who have learned traditionally the outlines of the story. From P. Haiceud's poem, to which I have referred above, it seems clear that in his own day Cearbhall was widely known as the possessor of much the same accomplishments as have clung to his memory in popular tradition ever since—that is to say, love-making,[2] witty speech, versifying, and ingenious craftsmanship of many kinds. In some parts of Munster his remarkable doings and sayings have been so vividly handed down by tradition that those who tell them take it for granted that he belonged to their own district.[3] On the other hand, it may be well to point out that another Cearbhall 'O Dálaigh would seem to have been invested with love-making and harping attributes even before the seventeenth century, as we see in the romance (probably sixteenth-century) of "Tochmharc Fhearbhlaidhe,"[4] which has for its theme the mutual love of Fearbhlaidh and Cearbhall 'O Dálaigh, the latter being represented as the son of Donnchadh Mór 'O Dálaigh, of Finnyvara, Co. Clare.[5]

33. (*a*) "Owin M[c]Crahe, of Ballilomasine, husbandman, John m[c]Owen M Crahie, of same," 6 Oct., 1585 [no. 4764]. (*b*) "Owen m[c]Donogh M[c]Cragh, of Ballylomasne," 11 Apl., 1601 [no. 6495]. (*c*) "Flan M[c]Owen, of Ballelomasne, and Rorie m[c]Thomas, of same, farmers, John M[c]Owen, of same, gent.,"

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[1] For the epithet *buidhe* cf. the rime preserved in Munster :

Cearbhall Buidhe na n-abhrán
do sheinneadh streanncán ar théadaibh,

—J. O'Daly in Oss. Soc., iv, p. 64. See also O'Leary's "'Ar nDóithin Araon," pp. 6 ff.

[2] Cearbhall, like Diarmaid ó Duibhne, is popularly supposed to have possessed the *ball searc*, by means of which he could compel any woman he wished to fall in love with him.

[3] Needless to say, Cearbhall's name has, in course of time, become (as was inevitable) a convenient peg on which to hang many things he never did or never said. So in the South one may notice how some storytellers will try to fasten an anecdote on to Aogán 'O Raithile, or Eoghan Ruadh, or some other poet who happens to be well known locally. The authenticity of some of the poems and quatrains attributed to Cearbhall in late MSS. is similarly open to question.

[4] Published in "'Eriu," iv, 47 ff.

[5] According to the same romance, Donnchadh Mór had a brother known as *Macaomh Inse Creamha*, who was endowed with the power of knowing secrets. (Cormac Common, quoted *supra*, p. 100 *n.*, also makes the *Macaomh* brother of Donnchadh Mór, but he is, of course, wrong in identifying him with Cearbhall). According to O'Flaherty, the *Macaomh* was "a memorable antient magician," who got his name from the island of Inishcraff, in Lough Corrib (Description of H-Iar Connaught, ed. Hardiman, p. 25).

19 May, 1601 [no. 6521]. Here we possibly have two known poets, viz. *Eoghan* (*mac Donnchadha Mhaoil*) *Mac Craith* and *Flann* (*mac Eoghain*) *Mac Craith.*[1] "Ballilomasine" is in Tipperary, but is now obsolete. From the "Tipperary Hearth-money Records, 1665–7" (pp. 25, 91), in which it occurs as "Ballylomas(s)ny," we see that it was in the barony of Iffa and Offa West.

34. *Donnchadh (an tSneachta) Mac Craith* was a man of importance in his day and district. Fiant 4638, dated 8 May, 1585, begins with a "pardon to Donogh Antueaghta [*sic*] m^c^Shane M^c^Craghe," and to "Margaret Browne, his wife." An earlier Fiant, no. 3097, dated 7 Sept., 1577, similarly begins with a "pardon to Donogho M^c^Crah, of Galbally, in Arhlo [*i.e.* Aherlow], co. Limerick, gentleman," who is, beyond doubt, the same man.[2]

In 1582–3 we find him taking part in the Desmond rebellion.[3] A letter from Ormond to the Privy Council, dated 5 April, 1583, announces the submission of "Donnoghoe M^c^Crahe" among other "rebels."[4] A letter from the same on July 10, 1583, gives a list of the noblemen and gentlemen who came to him at Cork and gave pledges, among the gentlemen being "Donogh Mac Cragh (a rhymer)."[5]

"Donnchadh an tSneachta" is mentioned as a poet in Eoghan 'O Dubhthaigh's satire on Miler Magrath; the satirist taxes him with having composed, *ca.* 1579, a poem in laudation of the Countess of Ormond (23 N 13, p. 192). At least one of his compositions has come down to us, namely, a poem (O'Con. Don's MS, fo. 378b) in which he laments the tragic deaths of James fitzMaurice (1579), John of Desmond (1582), and the Earl

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[1] For the latter see foot-note, § 19, *supra.* The *floruit* of Eoghan mac Donnchadha Mhaoil, who is known as the author of some religious pieces, has not yet been satisfactorily determined. If an inference may be drawn from the way in which the names are interchanged in some MSS., he would be identical with the Eoghan Mac Craith who, besides taking part in the "Contention of the Bards," was author of *Tugadh an t-ár-so ar 'Eirinn* (written in 1620), and of a couple of poems on the O'Briens of Clare and Tipperary, one of which is dated 1658. O'Reilly is very far wrong in placing him as early as 1200, and so too, I think, is Meyer ("Irish Metrics") in identifying him with the fourteenth-century poet, Eoghan an t'Orthóir.

[2] The persons pardoned in Fiant 4638 belong to "counties Limerick and Cork" (no more precise locality is assigned to any of them), but from the fact that ten of the thirty-one persons pardoned bear the Tipperary surname of Mac Craith, we might have inferred that Donnchadh an tSneachta lived close to the Tipperary border, in just such a place as Galbally. I may add that another Mac Craith *an tSneachta* appears in 1601 and 1603, viz., "Wm. M^c^Kraigh alias intnaghte" [no. 6495], otherwise "Wm. M^c^Cragh alias yntuaghe (*sic*), tailor," of Castlegrace, near Clogheen [no. 6762].

[3] "Donough M^c^Cragh and Thomas Oge M^c^Rory M^c^Cragh lie in the Decies," 22 Sept., 1582.—Cal. S. P., 1574–85, p. 399.

[4] *Ibid.*, p. 439.

[5] Bagwell, "Ireland under the Tudors," iii, 112, note.

of Desmond (1583). He himself was destined to fall a victim to the same tyranny, as we see from the following words of Philip O'Sullevan Beare: "Donatus Macrahus cognomento Niueus[1] Ibernus vir apud populares suos frugalitate et liberalitate notissimus, Momoniarum praefecto Anglo, quem hospicio acceperat, non modo lautum splendidumque conuiuium instruxit, sed etiam domesticos suos choraeas atque ludos exhibere iussit. Paucis in diebus praefectus hospitem Corcacham accersitum vltimo supplicio afficere imperauit, causatus viro probo et frugali non fuisse substantiam alendae tantae familiae parem, atque adeo tot domesticos, non nisi furtis, rapinis, vel aliis artibus vetitis (quod nullo modo probatum est) ab eo ali necesse fuisse." [2] The date of his death may be placed about 1597, for on 25 Nov. in that year Galbally and other lands in Cos. Limerick and Tipperary, "possessions of Donnagh M[c]Craghe, of Galbally, attainted," were granted to one George Sherlocke [no. 6175]. In "Pacata Hibernia" (ed. 1810, pp. 257, 259) reference is made to the deep impression which the "execution of Donogh MacCraghe" had made on the people of Munster.

35. (*a*) The family of Mac-an-Bhaird in the sixteenth century were settled in several districts. Perhaps the most important branch of them was that in MacMahon's country of Farney, Co. Monaghan, of which the following members were pardoned in 1601:—"Hugh m[c]Dermod M[c]E.,[3] Flann m[c]Morishe M[c]E., Coconnaght m[c]Coconnaght M[c]E., Patrick oge m[c]Morish M[c]E., Patrick m[c]Cowle M[c]E., Nise [*Aonghus*] m[c]Hugh M[c]E., Nise m[c]Adam M[c]E., Patrick m[c]Toell M[c]E., Patrick moyle M[c]E., Patrick baune and Maurice m[c]Toell M[c]E., Coconnaght m[c]Patrick M[c]E., Noo [*Nuadha*], Flan, and Lissagh m[c]Dermod M[c]E., Shane and Cormac m[c]Patrick moile M[c]E., Patrick m[c]Thomas M[c]E., Patrick oge m[c]Patrick M[c]E., Owin M[c]E., Dermot m[c]Conoghor M[c]E., Patrick cam M[c]E., Conor m[c]Flin M[c]E., William oge M[c]E., Dermot m[c]Melaghlin M[c]E., Mullaghlin M[c]E., Hugh m[c]Melaghlin M[c]E., William m[c]Manes M[c]E.," and also "Patrick m[c]Dermot M[c]E." [no. 6563]. Some of these appear also in an earlier Fiant relating to the same district, in which I find: "Patrick moyle m[c]E., Awe [*Ádhamh*] M[c]E., Patrick m[c]eviccarie [*mac an bhiocáire*] M[c]E., Connor m[c]Flyn M[c]E., Patrick m[c]Thomas M[c]E., Dermot m[c]Gilpatrick M[c]E., Patrick bane m[c]Toole M[c]E., Moris m[c]Toole M[c]E.," 6 Mar., 1592 [no. 5724]. In another Co. Monaghan Fiant "Owne, Connor, and Deirmod M[c]E." were

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[1] Wrongly translated "Donough MacCarthy, surnamed the White," in M. J. Byrne's "Ireland under Elizabeth," p. 39.

[2] Historiae Catholicae Iberniae Compendium, 1621, fo. 106b.

[3] In these Fiants the name is variously spelled M[c]Evard, M[c]Evarde, M[c]Ewaird, etc., all of which I here abbreviate to M[c]E.

pardoned 4 Dec., 1602 [no. 6734].[1] Several of these are probably to be identified with known poets; thus among the authors in the O'Conor Don's MS. we find Mac-an-Bhairds with such names as *Aodh mac Diarmada, Conchobhar, Diarmaid, Laoiseach,* and *Pádraig* (*glas*), which also appear in the Fiants quoted above.

(*b*) Of the Donegal branch of the family the following were pardoned 26 Feb., 1603: "Gillpatrick McAwarde, . . . Hugh boy McAwarde, . . . Morris McAward, Donogh McAwarde, Owen McAward, . . . Ennys oge McAward, Owen roe McAward, William oge McAward, Connor roe McAward" [no. 6761]. Here we have two known poets, *Eoghan Ruadh Mac an Bhaird* and *Conchobhar Ruadh Mac an Bhaird.* Two of these Donegal names, *Uilliam 'Og*[2] and *Eoghan,* are, it will be observed, also found among the Monaghan Mac-an-Bhairds, *supra.*

(*c*) In Co. Sligo the following "McEwards," all belonging to Ballymote and all described as "rymers," were pardoned 19 April, 1603: "Gillepatrick Cam," "Donald," "Geoffrey," and "Moilmory" (Cal. Pat. Rolls, Ja. I, p. 23). This Geoffrey may well be the *Gofraidh Mac an Bhaird* who engaged in a poetical controversy with Fearfeasa 'On Cháinte (23 L 17, fol. 149a); while "Moilmory" may be the poet *Maolmuire Mac an Bhaird* of the O'Conor Don's MS.

(*d*) There was also a strong colony of Mac-an-Bhairds in Co. Galway, mainly in the barony of Kilconnell (O'Kelly's country), in which two of them held castles in 1574. Seven Mac-an-Bhairds of Ballymacward, in this district, were pardoned in 1603.[3]

36. "Luigh O Clery, Gillebride O Clerie, Twohell O Clery, Shane O Clery Dermot O Clery," all of Co. Donegal, 26 Feb., 1603 [no. 6761]. Here we have the well-known *Lughaidh 'O Cléirigh,* biographer of Aodh Ruadh. The others are doubtless relatives of his; he had a brother *Giolla-brighde,* and first-cousins *Seán*[4] and *Diarmaid.*

37. "Nice ballagh McIlliosa, Ogneiff, Art McNullo, Ferflaha Ogneiffe, Bernard oge Ogneife, Enrias McMarchais," 18 May, 1602 [no. 6633]. In an earlier Fiant we have "Henrias McMarcas," 25 June, 1601 [no. 6556].

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[1] To these may be added "Arowaill" (*Cearbhall?*), "Brien mcArowill, and Donell mcArowill" Mac-an-Bhaird, of Drumgole, Co. Monaghan, pardoned in 1591 [no. 5603].

[2] One of the two of this name is doubtless the Uilliam 'Og Mac an Bhaird who addressed a poem to Toirdhealbhach Luineach 'O Néill (23 L 17, fo. 78a).

[3] Cal. Pat. Rolls, Ja. I, 19b, 28b. I forbear from quoting names in the case of this branch of the family, as I have no evidence that they were devoted to literature at this period.

[4] Probably not the same as his contemporary and namesake who extolled the descendants of 'Ior in the "Contention" (O'R., clvi).

In neither Fiant is any place-name mentioned, but from the personal names it is easy to infer that both belong to the North-East, to Co. Antrim. Here we have the poets *'O Gnímh* (head of his name), *Fearflatha 'O Gnímh,* and *Ainnrias Mac Marcuis.*[1] Hence we see that the distinction observed in MSS. between 'O Gnímh and Fearflatha 'O Gnímh was a real one. It is said that when Seán 'O Néill visited Queen Elizabeth in 1562, he was attended by, among others, " O Gnive, his poet,"[2] whom Hardiman and later writers have wrongly assumed to have been Fearflatha 'O Gnímh. O'Reilly speaks of the latter (whom he places too early, *ca.* 1556) as " poet to the O'Neills of Clannaboy."[3]

38. The principal seat of the 'O Duibhgeannáin family was the extreme north of Roscommon, together with the adjoining parts of Sligo and Leitrim. The following 'O Duibhgeannáins from this district are mentioned in the Fiants[4]: Mulmurre, Dovagh [*Dubhthach*], and Ferfas, of Shancough (*Seanchua*), Co. Sligo, 1585 [no. 4706]. Mulmory, Donogh, and Ferfasse,[5] of Kilronan (*Cill Rónáin*), Co. Rosc., 1585 [no. 4727]. Cahill roe and Oghey, of "Clonmore," Co. Leitrim, 1585 [no. 4797]. Kirrowe m^cNysse[6] [*Ciothruadh mac Aonghusa*], of "Killerre" (prob. Killerry, near Lough Gill), Kirrowe and Dowle[6] [*Dubhghall,* or *Domhnall ?*], of Carrick (*i.e.* Carrick-on-Shannon ?), Dalvay [*Dalbhach,* or *Dolbh*], of same, Cogogrie, Farfasse, Toell, Richard, Fartasse (*sic*), Moylemorre, Kirrew, Dalvay, Donnogh, Cahell ro, and Coaghe [*Cobhach ?*],

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[1] From these Fiants we see that O'Grady (Cat. 343n.) was mistaken in thinking that Ainnrias's real surname was MacCraith. Only one of his compositions appears to have survived, viz., a poem of 12 stt., *Anocht is uaigneach 'Eire,* ascribed to him in O'Con. Don's MS. and 23 F 16, whence it has been edited by Miss Knott in 'Eriu, viii, 191 ff. A version of the same poem in Brussels MS. 6131–33 is ascribed to Eoghan Ruadh Mac an Bhaird, and has 28 stt. (Meyer in 'Eriu, iv, 188). There is an anonymous version in Göttingen MS. 773, as I learn from a transcript by Stern ; this version has 30 stt., but appears to be a jumble of two poems, viz. *Anocht is uaigneach 'Eire* and *Cáit ar ghabhadar Gaoidhil.*

[2] Hardiman, Irish Minstrelsy, ii, 157. I have not succeeded in discovering the earlier source from which presumably Hardiman derived this information.

[3] In the year 1700 Edward Lhuyd purchased part of the MS., H. 3. 18, from Eóin 'O Gnímh, of Larne, Co. Antrim (Abbott-Gwynn Cat., pp. 140, 152).

[4] For brevity's sake I omit the surname, and when they are identifiable I give only the current form of the place-names, while retaining the Fiants' spelling of the Christian names.

[5] These three men are almost certainly identical with the preceding three. "Mulmory" is the *Maolmuire* who in 1578 succeeded his father, Dolbh, son of Dubhthach, as 'O Duibhgeannáin Cille Rónáin and *ollamh* of Tirerril (FM. p. 1704). For "Donogh" read "Dovogh" (= *Dubhthach*). We have here Dubhthach 'Og mac'I Dhuibhgeannáin, author of the poem *Leanam croinic clann Dálaigh* in praise of Aodh Ruadh 'O Domhnaill and his ancestors (St. A. v. 1, fo. 78 b ; see also O'R., cxlvii).

[6] In the case of these names the accompanying surname is spelled "O Downegan" (instead of "O Dowgenan").

of Drumcollop, Co. Leitrim; also Pherrell [*Fearghal*], of Gowel, and Donnell, of Corrabarrack, in the same co., 1590 [no. 5439]. Ferffessa, of Ballindoon, on Lough Arrow, Co. Sligo, 1590 [no. 5459]. Mulrony, of "Ballydowganan," Co. Sligo, 1590 [no. 5498]. Diermott, of "Killmolaishe," and Fiall [*Fítheal*], of Ballindoon, Co. Sligo, 1593 [no. 5805]. Farfessy, of Roscrib, and Fearfeassy, of Behy, both in Co. Sligo, 1593 [no. 5815]. Gillepatrick, "yeoman," of Castlemore, near Ballaghaderreen, 1592 [no. 5740].

"Fearfeasse O Dwgenaine, rymer," of Moygara, near L. Gara, Co. Sligo, was pardoned 19 Apl., 1603 (Cal. Pat. Rolls, Ja. I, p. 24 a); he is doubtless identical with one of the Fearfeasas just mentioned.[1] Another and earlier poet was "Calle Dowe [*Cathal Dubh*] O Doeygynane, poet and sarwant unto Teyke O Rworke," in 1560, who is mentioned in Harl. 3756 (O'Gr. Cat. 153).

39. The following members of the well-known family of Mac Firbhisigh are recorded as having been pardoned; they all belong to Lackan (*Leacan*),[2] on Killala Bay, in the west of Co. Sligo[3]:—(*a*) James; Dowaltagh, Bryen, and Ferfessa; Dermod; Hugh, Filgerney,[4] Mullmory, Kervoy, and Gilloglas, 3 Sept., 1590 [no. 5459]. (*b*) Gillernowe; Donogh, "carpenter"; Mullmurry and Fynnegony, 5 Apl., 1593 [no. 5805]. (*c*) Dualtagh, Gillysamore, Thomas, Findwny, Cowconnaght, Gannon, Thorna, Kirhrooe—all described as "kernes," except Thomas, who is "husbandman," 19 Apl., 1603 (Cal. Pat. Rolls, Ja. I., p. 22 a). The *Dubhaltach MacFirbhisigh* of (*a*) and (*c*) is very probably the man of that name who was one of the scribes of Egerton 88;[5] while in "Gillysamore" (i.e. *Giolla-íosa Mór*) in (*c*) we have the father of Dudley Mac Firbis (Dubhaltach Mac Firbhisigh), the well-known antiquarian, who was murdered in 1670.

40. The Mac Conmidhe family of poets are found mainly in Tyrone and in West Sligo. To begin with the latter:

(*a*) "Hennos M^cNemy,[6] of the Collyn, Owen M^cNemy, of Kearowengonn,

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[1] Another of this name, "Ferfeasse O Dwgenan," of Enniskillen (Maguire's country), was pardoned 18 Jan., 1586 [no. 4810].

[2] Among the anglicized spellings in these documents are "Leckane" and "Leackane." Do these point to an Irish form in -*án*? (I note gen. *Leacáin* in Abbott-Gwynn Cat., p. 138).

[3] I here omit the surname, which is variously spelled "M^cCrusie" (in Fiant 5459), "M^cFirbishy," "M^cFearbissy," etc.

[4] Filgerney, Fynnegony, and Findwny are all apparently corruptions of the name *Fionduine*, which is found in the Mac Firbis pedigree (Hy-Fiachrach, 104).

[5] O'Gr. Cat., 134. From another note (*ib.*, 136) in this MS. we infer that this Dubhaltach was son of Séamas. In the Mac Firbis pedigree (Hy-Fiachrach, p. 102) we find mention of *Séamas* (who was grand-uncle of the well-known Dudley Mac F.) and of two sons of his, viz. *Dubhaltach* and *Brian Dorcha*. These are evidently the "James," "Dowaltagh," and "Bryen," pardoned in 1590.

[6] Compare "Aeneas Conmy" (or "macny Moy"), who was teacher of two students

Flan McNemy, Salomon alias Solon [*Solamh*] McNemy, of same, Morrish McNemy, of Kill, . . . Connoght [*Cú-chonnacht*] McNemy, of Ballecottell, . . . McMea [*Maicnia*] McNemy, of Killglasse," 3 Sep., 1590 [no. 5459]. The place-names, taken in order, are to-day : Culleen (*Coillín*) in the par. of Kilglass, Carrowgun in the par. of Castleconor, Kilglass, Cottlestown (*Baile 'I Choitil*) in the par. of Castleconor, and Kilglass. (*b*) " Kuchonnaght McNemye, of Ballechottle," and "Wm. O Mughan mcMorris mcConmye,[1] of Kyll," 22 Feb., 1594 [no. 5848]. (*c*) Three of the foregoing, together with eight others of the same surname, were pardoned 19 Apl., 1603, viz., Owen, Maccinea, Flann, Shane, Twohill,[2] Aworkagh [*Eachmharcach*], Tirrelagh, Thomas, James, Moylemorrie,[3] and Brian (Cal. Pat. Rolls, Ja. I., p. 22). These are all described as "rymers" and as of " Killeny " (*Coillín Aodha*, Hy-Fiachrach 250), *i.e.* the present townland of Culleen. The *Flann Mac Conmidhe* pardoned in 1590 and 1603 may be the poet of that name whom O'Reilly places under the year 1612.

Of the Tyrone branch of the family, the following were pardoned 1 Apl., 1601: Shane grome; Morish oge, Cormick, and Mullmorie; Clane (*sic*) mcGillbrede; Bren grome; Teig mcFloen; and Donill duff [no. 6489]. The "Bren grome [*gruamdha*] McNemee" of this Fiant may possibly be the *Brian (mac Aonghusa) Mac Conmidhe* of whom Tadhg Dall speaks (O'R., clxiii). "Cormick" may be the poet *Cormac (mac Cearbhaill) Mac Conmidhe* of H. 1. 17, fo. 89b.

To the above may be added "Shane McNemye and Magnes duff McNemye," of Aghadrumkeen, in the bar. of Dartree, Co. Monaghan (MacMahon's country), 1591 [no. 5603].

41. (*a*) "Dermote O'Coffee," of Offaly, 6 Nov., 1563 [no. 574]. (*b*) "Owny O Coffy, of Rocheston,[4] co. Westmeath, gent., Melaghlen O Coffy, of same, Moriertagh O Coffy, of same," 29 Aug., 1582 [no. 4023]. (*c*) "Murtagh Coffie, Owen Coffie, Thomas Coffie, . . . Owney O Coffie, of Rogerston, co. Westmeath, Wm. O Coffie, of Ballinkine," 25 Mar., 1600 [no. 6378]. (*d*) "Melaghlin O Coffie, of Ballinkeny, Teige mcHugh O Coffie, Teige mcShane O Coffie, of same, gentlemen," 8 Sep., 1601 [no. 6574]. The places mentioned are (besides Offaly) Rogerstown and Ballinkeeny, both near the Hill of

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who entered the Irish College, Salamanca, in 1612 and 1625 respectively (Archivium Hib., ii, 29; iii, 45).

[1] Here evidently the names of two persons have been run together.

[2] A namesake, "Twohell McNemy," appears among Tír-chonaill pardons earlier in the same year [no. 6761].

[3] Probably the "Mulmury McConmy, of Rathliewe," *i.e.*, of Rathlee, West Sligo, 1593 [no. 5805].

[4] A slip for "Rogerston," as we see by comparing it with Fiants 2227 and 6533.

Ushnagh, Co. Westmeath. Here we appear to have the names of three known poets, viz. *Diarmaid 'O Cobhthaigh* (O'R., cxlv), *Muircheartach 'O Cobhthaigh* (O'R., cxlvi), and *Maoileachlainn 'O Cobhthaigh* (H. 1. 14, fo. 108a).

42. The 'O Ruanadha family of poets are associated mainly with Mag Aonghusa's country, in the present Co. Down, where the following O'Ronys were pardoned 3 May, 1602: Loghlin oge, Hugh, Gilleduff, and Owine; Shane m^cNeyse, Neise [*Aonghus*] m^cCormock oge, Coconaght, William gromo [*gruamdha*], Hugh m^cLaughlen, Rorie. Two of these are possibly to be identified with known poets, viz., *Aodh mac Conconnacht 'I Ruanadha* (O'Con. Don's MS., fo. 62b) and *Seán 'O Ruanadha,* author of a poem addressed to the sons of Fiacha 'O Broin (H. 1. 14, fo. 118). More probably the latter is the "Shane O Rowne" pardoned in a Co. Wicklow Fiant in 1582 [no. 4019][1]

43. "Whony on Canty, of Curribordy, Ellen ny Tane ny Mahowney, his wife, Farfassie on Cantie, of same, Katherine ny Daly, his wife, ... Teige on Canty, of Clansheane, Margaret ny Fynen, his wife," 14 May, 1601 [no. 6516]. *Uaithne* and *Fearfeasa 'O'n Cháinte,* of Curravordy, to the north of Bandon, Co. Cork; and *Tadhg 'O'n Cháinte,* of "Clansheane," which I cannot identify, but which is evidently in the same district. Fearfeasa is the well-known poet of that name, who among other pieces has left us an elegy on Aonghus Fionn, to whom his wife may have been related. Tadhg is probably to be identified with the author of the poem *Uadha féin do fhás 'Iosa* in O'Conor Don's MS.[2]

44. "Morris O Mulchonile (*sic*), of Ardchile, Shane O Mulchonile, and Shane Parke O Mulchonile, of same, yeomen," 3 Mar., 1603 [no. 6755]. Here we have *Seán 'O Maolchonaire,* of Ardkyle (*Ardchoill*), near Sixmilebridge, Co. Clare, author of some poems, and famous in his day as head of the leading historical school in Ireland.[3] In an earlier Fiant we find a pardon granted to a son of his, "Donill m^cShane Mulconry, of Ardkill," 7 Sep., 1577

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[1] A third, and earlier, man of the same name, viz. "Shane O'Rono, of Tohe, co. Westmeath," was pardoned in 1561 [no. 365].

[2] The following are the only other occurrences of the surname 'O'n Cháinte ("an obscure name," O'Grady calls it) in the Fiants of Elizabeth; all the places mentioned are in Co. Cork:—"Dermot O Cantie, of Castellmahoune, Sely ny Dermot O Cartie (*sic*), of same" [no. 6539]; "Wm. reogh O Encantie, of Tymolage" [no. 6701]; "Dermot m^cConoghor ny Carty (*sic*), of Curverdy" [no. 6539], *i.e.* of Curravordy; in Fiant 6764 this last individual appears as "Dermod m^cConnoghor O Chanty, of Caenelardery" (*sic*!); "Donogh O Cantie, of Cashelbeg" [no. 6764]; and perhaps "Donell m^cDonegh O Cartie," of Co. Cork [no. 6499].

[3] As we find the same (presumably) "Seaán 'O Maeilchonaire ón Ardchoill" getting some lands in mortgage as early as 1548 (Hardiman's Ancient Irish Deeds, p. 62), he must have been a very old man at this date.

[no. 3089]. The "Morris O Mulchonile" pardoned in 1603 is doubtless the *Muiris 'O Maoilchonaire* who has left a poem in praise of Eoghan 'O Hallmhuráin, a harper (O'R., clix).

45. "Donell m^cColgan MacColgan, Shane Duw [*Dubh*] M^cColgan," of Inishowen, Co. Donegal, 5 June, 1602 [no. 6555]. The latter is probably the *Seán Mac Colgáin* to whom a poem addressed to Toirdhealbhach 'O Néill, *ca.* 1607, is ascribed (O'Gr. Cat. 388).

46. *Seán Mac Céibhfhionnaigh* is known as a poet from a quatrain in song-metre dealing with O'Connor Sligo and from a poem of his in O'Conor Don's MS. It is just possible that he is identical with "Shane M^cKevaine," of Inischrone, Co. Sligo, described as "husbandman," who, with two others of the same surname, place, and occupation, was pardoned 19 Apl., 1603 (Cal. Pat. Rolls, Ja. I., p. 22a).[1] In the Fiants I notice "Teige M^cKyevony," of Castlereagh, Co. Mayo, and "Molmory M^cKeaveny," of Inishcrone [no. 5798]; the name of the latter appears as "Mulmorry M^cKevyn" in another Fiant [no. 5606]. All these seem to have as surname *Mac Céibhfhionnaigh*, which is now anglicized "Keaveny," and is rarely met with outside Connacht.[2]

III.

In the two preceding sections the names have been drawn principally from the Fiants. The names that follow are for the most part taken from other English documents of the period. Further investigation in this direction would, I have no doubt, result in a considerable addition to the names recorded below; and, if time permits, I hope later on to supplement the present contribution.

47. In 1538 Ormond wrote to the Council in Ireland that Lady Eleanor FitzGerald, widow of MacCarthy Reagh, had gone from Munster to O'Donnell,[3] taking with her the young son of the Earl of Kildare. When they had come within seven miles of O'Donnell's country, "oon Ee M^cCraghe, a rymor, which dwellith in the countre of Tiperarie, then being in that partie at lernyng, dud mete with them, and kepte company togethers, till they came to O Donills house." This *Aodh Mac Craith* betrayed to the anglophile Ormond all he knew concerning the doings of O'Neill, O'Donnell, and the Earl of Kildare's son.—State Papers, Henry VIII, iii. 44.

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[1] For "M^cKevaine" we should perhaps read "M^cKevanie."

[2] It is to be distinguished from *'O Caomháin*, a Sligo surname (O'Donovan's Hy Fiachrach, p. 108, note), which in the Fiants and Pat. Rolls assumes the forms O Keavane, O Kievane, O Kywaine, etc.

[3] This was the well-known Maghnus 'O Domhnaill, poet and patron of literature. In the same year (1538) he married the Lady Eleanor.

48. On Jan. 27, 1542, pardon was granted to "Owen Keynan [*Eoghan 'O Ciandin*], of Cappervarget, near Rathehangan, in the county of Kildare, harper, otherwise called Owen Keynan, servant of Gerald, late Earl of Kildare, otherwise Owen the Rhymer, otherwise Owen Keynan the poet, otherwise Owen Keynan Keyeghe [*Caoch*], the blind bard; and Cornelius [*Conchobhar*] Keynan, of Cappervarget, harper, otherwise called Cornelius Keynan, son of Owen Keynan Keyeghe, otherwise Cornelius the bard."—Cal. Patent and Close Rolls of Chancery, i, 69.

49. An inquisition held in Dingle in 1584 finds that "David Duffe Gerald" joined the Earl of Desmond's rebellion, and was killed 12 June, 1581, at which time he was "seised in his lordship as of fee of one tenement in the town of Dingle in the said county of Kerry on which Thomas Moore had a mortgage of fifteen shillings sterling."—Kerry Arch. Magazine, Oct., 1910, p. 273. This is in all probability *Dáibhí Dubh MacGearailt*, whom Stanyhurst describes thus: "Dauid Fitzgirald, vsuallie called Dauid Duffe, borne in Kerie, a ciuilian, a maker in Irish, not ignorant of musike, skilfull in physike, a good and generall craftsman. . . . He plaied excellentlie on all kinds of instruments, and soong therto his owne verses, which no man could amend. In all parts of logike, rhetorike, and philosophie, he vanquished all men, and was vanquished of none."[1] Dáibhí Dubh's death in "rebellion" and the ensuing confiscation of his property would very well explain why his son, Muiris, left the Geraldine country and attached himself to Mac Carrthaigh Mór (see § 26).

50. In a list of the Earl of Desmond's rents in the Carew Papers (i, pp. 414-415) some information is given as to the lands held by the poets attached to the Earl: (1) In the "cantred of Keyery" (roughly the northern half of the present Co. Kerry): "The bloodshed of the country of Keyrry is due to the manor of the Island [Castleisland], together with the rent of Kiltarcon, the Rimors' lands for candlelight to the said manor allowed." (2) In the "cantred of Ogonyll" [*Ui Conaill*, in west Limerick]: "Lands held by the rimers of the Earl in the mountey[n] of Slewlocra [*Sliabh Luachra*], named the Brosenaghe, and by the rimers of Templay Egleantane and Ballywroho . . . When the Earl doth cross the mountain or take his journey betwixt Keyrry and Connelogh [*Conallacha*, i.q. "Ogonyll"], the foresaid rimors are wont to bear the charge for a day and night, coming and going." The lands mentioned above are, respectively, Kilsarkan, near Castleisland; Brosna, N.-W. of Castleisland, near the Limerick border; and Templeglantan

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[1] Holinshed's Chronicles, ed. 1807-8, vi. p. 60. (Stanyhurst's remarks will be found quoted more fully in "Dánta Grádha," p. x.)

and Ballymurragh, both in the parish of Monagay, near Abbeyfeale, Co. Limerick. The "rimers" referred to were of the family of 'O Dálaigh.

In the Fiants I note the following pardons of these O'Dalys: "Donald O Dalie, of Brossnaghe," 1597 [no. 6183]. "Melaghlin O Dalie," of or near Castleisland, and "Donell O Dalie, of Brasnath," 1601 [no. 6555]. "Gogherig m^c^Dallig I Daily [*Gofraidh mac Dálaigh 'I Dhálaigh*], of Brosnagh," 1601 [no. 6539]. "Geffery m^c^Donell I Dalley, of Brosnagh," 1601 [no. 6576]. "Coconnaght m^c^Molaghlin oge O Dalie, of Killtarchon, Melaghlin O Dalie, of same, yeoman, Morrogh O Dalie m^c^Teig, of Brosne, Goherie oge O Dalie, of same," 18 Mar., 1601 [no. 6477]. "Owen O Dallie, of Templeglantan, Donogh O Dallie, of same," 1600 [no. 6461]. To these may be added "Gillyse O Daly, of Templeglantan, in Limerick co., yeoman," pardoned 7 Dec., 1603 (Cal. Pat. Rolls, Ja. I., p. 26 a).

51. Of at least one of these O'Dalys, viz. *Cúchonnacht mac Maoileachlainn 'Oig*, of Kilsarkan, we find elsewhere some interesting particulars. His father, Maoileachlainn 'Og 'O Dála, is mentioned as a poet, *ca.* 1579, in Eoghan 'O Dubhthaigh's satire on Miler Magrath (23 N 13, p. 192). After the downfall of the great house of Desmond Cúchonnacht went north to Aodh Ruadh 'O Domhnaill, with whom he remained for some years, and on leaving whom he composed the poem *Cionnus do fhúigfinnse Aodh?*[1] While on his way back from Ulster he may have paid a visit to the O'Byrnes' country,[2] for in the Leabhar Branach[3] we find a poem by Cúchonnacht 'O Dálaigh (either the present poet, or a namesake of whom we know nothing further) in praise of Feidhlim (son of Fiacha mac Aodha) 'O Broin.[4] The Fiant quoted above shows him back again in his native district in 1601. From an elegy on him by Maoldomhnaigh 'O Muirgheasáin (23 L 17, fo. 106 a), we see that he lived on until 1642, and that he died at *Tolcha*,[5] where he had conducted a school.

52. More remarkable still appears to have been the career of Cúchonnacht's brother, Conchubhar 'O Dálaigh. He was a devoted adherent of

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[1] St. A. v. 1, fo. 77 a, where the title is *Cúchonnacht mac Maoileachloinn óig 'I Dhálaigh (ón Mumhain), do bhí seal fada i ffochair 'I Dhomhnaill, Aódh Rúadh, do rinne so do ría ttriall dá dhúthaigh.*

[2] There would be nothing surprising in this, for the stout fight for independence put up by Fiacha 'O Broin and his sons, at a time when most of Ireland was falling an easy prey to Elizabeth, drew from time to time not a few poets from other parts to the O'Byrne stronghold of Ballinacor—Tadhg Dall 'O Huiginn, Eochaidh 'O Heóghusa, and Donnchadh 'O Fialáin (see § 21), for example.

[3] H. 1.14, fo. 115 b.

[4] Similarly it is just possible that the Giolla-íosa 'O Dálaigh, of Templeglantan, pardoned in 1603, is the poet of that name who wrote a poem in praise of the sons of Fiacha mac Aodha (H. 1. 14, fo. 113), and who appears to be otherwise unknown.

[5] Not improbably the townland of Tullaha, in the parish of Killagholehane (cf. § 11), near Broadford, Co. Limerick.

Gerald, Earl of Desmond, to whom he was "faithful from the beginning to the end."[1] About 1582, when the Earl was reduced to extremities, Conchubhar, who was "a man of remarkable eloquence," was sent by the Earl to various Irish nobles to try to induce them to take part in the rebellion; but through timidity on the nobles' part his mission proved a failure.[2] When in November, 1583, the unfortunate Earl was surprised in the night and murdered near Tralee, Conchubhar was "at a short distance from him in the valley, watching the cattle that had been seized the day before."[3] A contemporary account[4] tells us how the Earl, in straits for want of food, had sent into the Castlegregory district "two of his horsemenne (Corroghore ne Scolly and Shane Deleo), with eighteene kearnes, to bring him a pray"; the prey thus commandeered was followed by the owners and by some English soldiers, and the Earl's death was the direct sequel. Here we find Conchubhar called "Corroghore ne Scolly," i.e. *Conchubhar na Sgoile*, doubtless from a bardic school which in quieter times he had conducted. A year afterwards (18 Dec., 1584) we find a pardon granted to "Conoghor O Daly alias Conoghor ny Scolly," of Co. Kerry [no. 4555]. But though his life was spared, his property was confiscated. An inquisition held in Dingle in 1584 found that "Conogher O Dalye of Kiltarcon [Kilsarkan] in the said county of Kerry, gentleman," had entered into rebellion with the late Earl of Desmond, "and that at the time of his entering into the said rebellion he was seised in his lordship as of fee of Kiltarcon aforesaid with its appurtenances containing seven carucates of land."[5] Friar Dominic says that Conchubhar, "when all was lost, preferred his honour and reputation to any compromise with the queen. Had he been recreant to his principles, he might have saved whatever property he owned; but in the parliament held after the wars of the Desmonds it was forfeited to the crown, as may be seen in the acts then passed; he was thrice arrested by Ormond and honourably acquitted."[6] Some years afterwards we find him making an ineffectual attempt to get his

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[1] History of the Geraldines, by Fr. Dominicus de Rosario, O.P., published in Lisbon, 1655, and translated into English by Rev. C. P. Meehan (to whose fourth edition I here refer). The author's real name was Domhnall 'O Dálaigh. He was born in 1595, and was closely related (p. 122) to the Conchubhar 'O Dálaigh of whom I speak above; indeed from what he says elsewhere (p. 92) of his father, it is almost certain that Friar Dominic was a son of this very Conchubhar.

[2] *Ibid.*, 119–120.

[3] *Ibid.*, 122.

[4] Examination of Owen mac Donnil O Moribertagh [*Eoghan mac Domhnaill 'I Mhuircheartaigh*] on 26 Novr., 1583, reprinted in Kerry Magazine, vol. i (1854), p. 98, from Thomas Churchyard's "A Scourge for Rebels" (London, 1584).

[5] Kerry Arch. Magazine, Oct., 1910, p. 271.

[6] History of the Geraldines, Meehan's translation, p. 122.

property restored. "Among the records of the Exchequer for the year 1592," wrote Herbert F. Hore, "there is a mass of pleadings before commissioners, in the countries of Desmond and Kerry, between the remnant of the followers of the late Earl of Desmond and the English grantees of the escheated properties. One of these pleadings is a petition of Connoher O'Dalie, praying to be restored to the family estate. The petitioner states that his grandfather, Melaghlin Mac Donoghe O'Dalie [*Maoilechlainn mac Donnchadha 'I Dhálaigh*], was seized of Kiltoghercon [Kilsarkan], in the county of Kerry, containing five ploughlands which descended to Melaghlin Oge, the petitioner's father, who died, says the record, 'about a year before Mr. Davells was killed.'[1] The petitioner further states that he forsook the lands, and that he was not in rebellion, nor was he attainted. On reference, however, it was found that he had been especially attainted."[2] Previous to this, between 1584 and 1589, it would appear that he spent some time in Maguire's country, if I am right in identifying him with Conchubhar Crón 'O Dálaigh, who, as a poem[3] of his informs us, left Munster after the death of the three Geraldine leaders, James fitzMaurice, Sir John of Desmond, and the Earl, and sought a new patron in Cúchonnacht Mag Uidhir († 1589).

53. From various presentments of juries in 1537 we learn the names of brehons in Kilkenny and the adjoining counties. The jurors of Co. Kilkenny complain that "Brehins law" is used "over all the countrey," "most specially within the countie of Kilkenny, whiche lordes commynly have eche of them one severall judge under them; the judges name under my lorde of Ostrey [Ossory], Rory Maklane."—Annuary of R.S.A.I. for 1868–1869, p. 100. According to the same jurors one book of the "statutes of Kylcas"[4] was "in the possession of Rory M^c^Laughire, being judge of the countrey," *ib.*, 113. The judge mentioned in these passages was named *Ruaidhrí Mag Fhlannchadha*. In a less corrupt form his name appears in the presentment of the jury of Co. Tipperary, from which we learn that Thomas Butler had as his judges "Rery M^c^Claneghye, Oyne [*Eoghan* or *Eóin*] M^c^Claneghe, Thomas M^c^Claneghe," *ib.*, 233–4. A jury of the city of Waterford in the same year (1537) finds that Lady Katherine Butler, widow of Lord Power,

[1] Davells was killed by John of Desmond about 1 August, 1579.

[2] Ulster Journal of Archæol., vii, 107 (1859). In the same article Hore suggests the identity of this "Connoher O'Dalie" of 1592 with the "Cornelius O'Daly" described by Friar Dominic. The other identifications in the present note are mine alone.

[3] ZCP. ii, 346.

[4] *i.e.*, the law of *cion comhgais*; see *op. cit.*, foot-note, p. 100, and Keating's Foras Feasa, i, p. 68. Joyce (Social History, i, 183) is very far wrong in explaining these "statutes of Kilcas" as "the local Brehon Law of Kilcash in Tipperary."

"hath ordeyned an Irishe judge called Shane M[c]Claunaghe [*Seán Mag Fhlannchadha*], and that the said Shane useth Brehens lawe and ordreth the matters of variannce of the countie moche after her will and commaundement, and taketh for th' use of his judgement called Oylegeag [*oile-dhéag*] xvi[d] stg. of every mark stg., and taketh as moche of the playntif as of the def[t]," *ib.*, 199. From the presentment of the jury of Irishtown, part of Kilkenny city, we learn that among the judges in Kilkenny were "Donoughe Makhewgan [*Donnchadh Mac Aodhagáin*], by the commaundyment of the Lorde Grace, Richard Sertall, and Malayhan Ogge Clerry" [*Maoileachlainn 'Og 'O Cléirigh*],[1] *ib.*, 135.

54. In a presentment of sessions held in Cork in 1576 it is complained that "all the lords of this country" use the following "extortion," viz., "that when any frehoulder or inhabitant within their severall countries is maried, the rumor [rimer] of that lord called Olaff Danie [*ollamh dána*] will take the best apparaill of the womane so maried or the juste value thereof."—Annuary of R.S.A.I. for 1868–9, p. 273. A particular instance of this curious privilege is given further on in the same presentment (*ib.*, p. 277), where it is asserted that "one Dermond Odayly in the name and to the use of Odaly Fynyne came to Kile Weybowd in the countie of Cork in June last past," and "haith forceably taken of Margeret ny Scally of the said Kile Waiebowed all the rayment that shee did weare, that day being newly mareid, or else the valwe of the same, to his oune contentacõn, alleadginge the same to be due to the forsaid Odayley of everye womane that is maried throughowt all Desmond and M[c]Donoghe countrye, because he is their cheef Rymor otherwise called Olowe Dane." "Odaly Fynyne" is *'O Dálaigh Fionn,* who, in 1576, may well have been Aonghus (cf. § 29). "Kile Weybowd" is evidently in Duhallow (MacDonagh's country), and would seem to be the present Killavoy (spelled "Kylewoy" in Fiant 5903), in the parish of Clonmeen.

As to the origin of this curious exaction, it is probable that at first the gift of the wedding-clothes to the poet was looked upon as an appropriate reward for the epithalamium which he doubtless produced on such occasions. A good illustration of the conservative spirit of the Irish literary class is afforded by the fact that towards the end of the seventeenth century, if not later still, we find a poet, Peadar 'O Maolchonaire, claiming wedding-clothes as his due.[2] A similar custom existed in Gaelic Scotland down to the

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[1] For the Kilkenny branch of this family see O'Donovan's Hy-Fiachrach, pp. 72, 89, note.

[2] Viz., in a short poem addressed to Tadhg 'O Rodaighe, and beginning *A mhic Geróid an ghlōir ghloin* (H. 6. 15, p. 82). The poem itself states the claim vaguely, but

seventeenth century. Martin, in his "Description of the Western Islands of Scotland" (1703, p. 115), speaking of the "Orators" or *Is-Dane* (aos dána), says that "upon the occasion of Marriages and Births they made Epithalamiums and Penegyricks [*sic*], which the Poet or Bard pronounc'd"; and he also tells us (*ib.*, p. 116) that "the Poet or Bard had [formerly] a Title to the Bridegrooms upper Garb, that is, the Plade and Bonnet, but now he is satisfied with what the Bridegroom pleases to give him on such occasions."

55. "Owen Odewhee, a preacher, and a maker in Irish," is mentioned among "the learned men and authors of Ireland" in Stanyhurst's Description of Ireland.[1] This is *Eoghan 'O Dubhthaigh*, O.S.F., author of the poem *Léig dod chomórtas dúinn* (against Miler Magrath and others); for whom see further O'Sullevan Beare's Hist. Cath. Ib. Compend., lib. iv, cap. xii, and Mooney, quoted in the 1850 edn. of O'Sullevan's work, pp. 107–8, note. This Franciscan poet and preacher is in all probability the "Eugenius Duhy," vicar of Tubbrid, who, with Geoffrey Keating, is mentioned as one of the founders of the chapel of Tubbrid (south of Cahir, in Co. Tipperary) in the inscribed slab which still stands above the door.[2]

56. "William M^cCroddan," i.e. *Uilliam Mac Rodáin* (?), is mentioned as "a brehon or judge under the Earl" of Tyrone in 1593.—Cal. S.P., 1592–6, pp. 112, 114.

57. Among those who set sail from Ardea (on the Kenmare River) for Spain, 7 July, 1602, with Connor O'Driscoll and Father James Archer, S.J., was "Dermond mac Shannaganie,[3] a Rimer" (Pacata Hibernia, ed. 1810, 429), i.e., *Diarmaid Mac* (rectius *'O ?*) *Seanchán.*

58. In the course of the inquiry set on foot by Mountjoy in Fermanagh, *ca.* 1603, the jury desired, in order to determine with certainty the profits accruing to Maguire from his mensal lands, to consult "an old parchment roll, which they called an indenture, remaining in the hands of one O'Brislan, a chronicler and principal brehon of that [*i.e.* Maguire's] country; whereupon O'Brislan was sent for, who lived not far from the camp, who was so aged

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the title in the MS. is more explicit: *Ollamhnacht .i. spré nuachair .i. éadach nuachair go coitchionn | do bhí Tadhg do chongbháil go hainndlightheach ó Pheadair 'O Maolchonaire.* It is possible that the wedding referred to was that of Tadhg 'O Rodaighe's niece-in-law, which took place in 1701, and for which Peadar 'O Maolchonaire wrote an epithalamium (H. 6. 15, p. 94).

[1] In Holinshed's Chronicles, ed. 1807–8, vi, p. 63. First printed in 1577.

[2] The inscription is dated 1644, and it has hitherto, I think, been misunderstood. The natural interpretation of it would seem to be that the founders, "Duhy" and Keating, were both at that time (1644) dead, and were buried within the chapel.

[3] Less incorrectly in Cal. Carew MSS., iv, 202, "Dermot M^cShanaughane, a Rymer."

and decrepid as he was scarce able to repair unto us."—Davies, Letter to Salisbury (1606), in Vallancey's Collectanea, i, 159 (1770).[1] Here we have *'O Breisledáin*, brehon of Maguire, and one of the "erenaghs" of Derryvullan (*Doire Mhaoláin*),[2] on the Erne, close to Cleenish Island. In the Fiants Eliz. the only person of this surname mentioned, at least in Cavan, is "James O Brissleayn, of Doeyry uulan [*i.e.* Derryvullan], husbandman," pardoned in 1591 [no. 5602]; this may be the same man.

59. Of the family of O Huiginn the following "rymers" were pardoned 19 Apl., 1603: William, Twoholl, Cormuck, Gillenewf, and Teige oge M^cTeige Daile [*Tadhg 'Og mac Taidhg Dhaill*], all of "Dwacharny," Co. Sligo; and also "Neeile M^cGilliffe [*mac Giolla-íosa*, or *mac Giolla-na-naomh*] O'Higgen rymer," of "Skardane," *i.e.* Scardan, near Sligo town.—Cal. Patent Rolls, Jas. I., p. 24 a. Some of these, or namesakes of theirs, are also mentioned in Fiants Eliz., *e.g.* "Gillernewe O Higen," Co. Sligo, 1584 [no. 4290]; "William O Higgen," together with Brian O H. and Gille Cullam O H., all of "Moytaugh,"[3] Co. Sligo, 1587 [no. 5026]. Namesakes of *Cormac 'O Huiginn* mentioned above, are "Cormock O Higgin," of Co. Mayo, 1587 [no. 5058], and "Cormock O Higgen," of "Magherie Quirk" [*Machaire Chuirc(ne)*], Co. Westmeath, 1601 [no. 6506]. The latter may well be the Cormac 'O Huiginn who addressed a poem (H. 4. 15, p. 101) to Theobald Dillon, of Killinure, in Machaire Chuirc, close to Lough Ree. On the other hand, we also have poems by one or more Cormac 'O Huiginns of Co. Sligo; see O'C. Don's MS. and O'Gr. Cat. 447.[4]

60. Although the 'O Cianáin family were associated mainly with Fermanagh (Maguire's country), it is perhaps worthy of note that no person of this surname appears among the Fiants relating to Fermanagh. On the other hand, seven persons of the name residing in Co. Armagh are pardoned in Fiant 6735, dated 6 Dec., 1602, including "Coconnaght O Kinan," priest, and "Teige O Kinane," gentleman. The latter may be the *Tadhg 'O Cianáin* who has left us the history of the Flight of the Earls, and to whom there are some references in the State Papers.

Like that of the other fugitives, the property of Tadhg 'O Cianáin was forfeited owing to his flight. It is given as consisting of 15 cows, 8 calves, 1 garron, 1 hackney, and 25 swine, the whole being valued at £22 6*s* 2*d*.

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[1] In later editions of the Letter the brehon's name is corrupted to "O'Bristan."

[2] Cf. AU. iii, 394.

[3] Perhaps for Moylough, in the par. of Achonry.

[4] Among other 'O Huiginn poets of the late sixteenth century were 'Irial, Ruaidhrí, and Seán, and names corresponding to each of these are also found in the Fiants. But a discussion of the possibility of identifying the latter with the poets will best be left to Miss E. Knott, who has, I understand, made a special study of the 'O Huiginn family.

(Cal. S. P., 1608–10, p. 537). Subsequently, however, the property was restored to Tadhg's wife "at the request of the Earl of Thomond, to whom she is allied, in consideration that the said Earl alleged that the said Teig sent him intelligence of importance from beyond the seas" (*ib.*, p. 543). Later on we find some references to his brother, *Cúchonnacht 'O Ciandín*, during investigations into an alleged "plot" in Ulster between Alexander and Lodder McDonnell, Brian Crossagh O'Neale, and Maguire's sons. Lodder McDonnell, examined on 29 May, 1615, says that "he saw Couconnagh O'Kernan [*sic*], a rhymer or chronicler to Conn Rory[1] Maguire, at Ballymoney, between Hollantide and Christmas last, and that he told this examinate that he dwelt with Maguire, and that he thinks he was brother to Teige Oge O'Keenan that went with Tyrone and died at Roome. He denies that ever Couconnagh brought him any letters or had anything to do with him, but he demanded a help of this deponent." Cúchonnacht was immediately arrested and brought to Dublin, where, on 26 June, 1615, he was put on the rack and what is euphemistically termed a "voluntary confession" regarding the plot was extorted from him (Cal. S. P., 1615–25, pp. 63, 72, 78).[2] A few weeks afterwards he was tried in Derry, and, with five others, found guilty of treason and hanged (Archivium Hib., vi, 83 ff.).[3]

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[1] *Leg.* Conor Roe?

[2] Attention has already been called to these State Paper references to the 'O Cianáins, partly by O'Grady (Cat. 385, *n.* 2), and partly by Walsh ("Flight of the Earls," 19 *n.*); but I have thought it worth while to bring both sets of references together here and to quote them somewhat more fully.

[3] In the record of the trial Cúchonnacht is described as yeoman, of "Moygh," Co. Antrim.

INDEX OF PERSONS.

[The references are to the numbered paragraphs or groups of paragraphs.]

Index of Persons—*continued.*

Most of the individuals referred to in the above Index are Poets (*fileadha*). The following families were Historians (*seanchaidh*) by profession:—Mac Bruaideadha, 'O Cianáin (§ 60), 'O Cléirigh, 'O Duibhgeannáin, Mac Firbhisigh, 'O Luinín, and 'O Maoilchonaire. In English documents the term "rimers" is sometimes applied to historians as well as to poets. Irish historians not infrequently composed in verse, and the distinction between the *file* and the *seancha* was not very tightly drawn. References to Judges or "brehons" (*breitheamhain*) will be found under the following families:—Mac Aodhagáin, 'O Breisleáin, 'O Cléirigh (§ 53), Mag Fhlannchadha, and Mac Rodáin.

INDEX OF COUNTIES.

VII.

THE BOOK OF ADAM AND EVE IN IRELAND.

By ST. JOHN D. SEYMOUR, B.D., Litt.D.

[Read April 24. Published July 31, 1922.]

The Early Middle-Irish poem, *Saltair na Rann,* is, as would appear from internal evidence, not later in date than the year 1000. Its object is to give a picture of sacred history from the Creation to the last Judgment. In that portion, however, which deals with the creation of Adam and Eve, the Temptation, Fall, and subsequent events, it does not follow the Biblical narrative, but depends on apocryphal literature. It is my intention in this paper to trace the connexion between that portion of S (as I shall briefly term it hereafter) and the apocryphal works of which use has been made.

As so very little of the *Saltair* has as yet been translated, it will be necessary, first of all, to epitomize briefly the portion to be examined. This epitome is made up as follows :—Cantos VII, VIII, XI (greater portion), and XII have been translated in full by Miss Eleanor Hull in the *Poem-Book of the Gael,* pp. 20–50. She has very kindly permitted me to make use of this. Cantos VI, IX, X, and the concluding portion of XI have been more briefly translated for this paper by Miss Mary E. Byrne, B.A., to whom my best thanks are due for this and other help. Use has also been made of the L. Breac prose version in MacCarthy *Codex Palatino-Vaticanus* (Todd Lectures, III). See in connexion with this *Revue Celtique,* XXIV, p. 243 ff. I have also added, principally in the notes, some items in Irish literature not to be found in the foregoing Cantos of S; these, where necessary, have been translated for me by Miss Byrne.

Epitome of Story of Adam and Eve.

Canto VI (beginning at l. 1035 to l. 1080).—Adam is created, and is three days without quickening of life, or a soul, to typify Christ in the tomb. He is named from four stars, Archon, Dissis, Anatole, and Missimbria. Nine months after Eve is fashioned. Adam chose her above every true gift, and prophesied that for her [woman] everyone would give up his father and mother.

Canto VII (ll. 1081–1104).—God bids them eat of every tree except one. They shall be without old age, illness, anxiety, etc., and shall go to Heaven at the age of thirty. Adam was a thousand years and six hours in Paradise.

Canto VIII (ll. 1105–1292).—The Devil is jealous, and plans to deceive Adam. When the Hosts of the Seven Heavens used to gather round their King, the animals used to come and adore Adam, and then return right-hand-wise. The Devil finds the serpent, flatters it, and tells it that, as Adam was created younger than it, it should not submit to its junior. He desires a place in the serpent's body, so that they may go together to Eve, and enjoin upon her to eat the fruit. Thus Adam and Eve will be driven out of Paradise. The serpent asks what reward it shall get for permitting the Devil to co-dwell in its body. "This," he replies, "that our union in our habits and our wrath shall be for ever spoken of." The Devil gets into the serpent's body, goes to Paradise, and addresses Eve, who says she has no time to talk to anyone, as she is about to go out and feed the animals, as that is her task whenever Adam is away adoring the Creator. The serpent speaks flatteringly to her, and inquires if life in Paradise is pleasant. She says "Yes," but they are not to eat of one tree under penalty of death. He replies that as long as she and Adam are without eating the forbidden fruit they are only on a level with the lower animals, without intelligence, and counsels her to eat. She fears to do so lest she should die, but suggests that the serpent go itself and fetch the apple for her. He promises to do so, and asks her to open the door. She agrees, provided he does not delay within. She then opens the door secretly. The serpent goes to the tree, and gives her the apple. She takes half, and reserves the other half for Adam.

Canto IX (ll. 1293–1440).—When Eve had eaten half the apple, her form changed, and her raiment fell off her. In fear she calls for Adam, who comes, and is perplexed at seeing her naked. He asks the reason, but she says she will not tell him until he eats his half of the apple. He does so, and becomes naked. Eve then tells him about what the serpent had said. Adam upbraids her. To hide their shame they took leaves of the fig tree, as that was the only tree on which there was foliage. Adam then hears an angel telling Gabriel to sound the trumpet in order to summon the angelic hosts. God comes down to Paradise. The wood of Paradise bent down in reverence before the Creator. Adam and Eve fly to the shelter of the tree. God speaks to Adam, who lays the blame on Eve. The Creator then orders the angels to put them both out. Adam implores to be permitted to taste somewhat of the Tree of Life, but this is not granted.

Canto X (ll. 1441–1468).—God says that as they have violated His law, they must go out into the world, where they will have to earn their bread with the sweat of their brow, with sickness, old age, and decay. He warns them against the temptations of the Devil. If they keep God's law, Heaven will be their reward.

Canto xi (ll. 1469–2020).—For a week after their expulsion they are without food, dwelling, fire, or clothing. Adam, in a long passage, laments his condition, and contrasts his present wretched state with that in Paradise. Eve takes the blame on herself, and asks Adam to kill her, for then God may perhaps show him greater mercy. He refuses to do so. She requests him to look for food, but he can only find green herbs, the support of the "senseless animals." Then he suggests that they do penance, so that they may cleanse away something of their sins. Eve asks for instruction in this respect. He says that she is to stand in the River Tigris for thirty-three days, while he will stand in the Jordan for forty-seven. She is to place a flag-stone under her feet (he will do the same), stand in the water up to her neck, with her hair dishevelled, and lift up her hands every canonical hour to the Lord of the Nine Orders. [Eve ? says] their lips are unclean, and Adam replies that they will beseech the creatures to pray for them. Angels come to instruct Adam each day for nineteen days. Adam asks the Jordan and all its creatures to "fast" with him upon God. The stream stands still, and the creatures within it gather around Adam. "All of them prayed—Adam, the stream, and the multitude of animals." As a result the Nine Orders beseech God, who forgives Adam. On learning this the Devil goes "like a swan, in the shape of a white angel," in order to entice Eve out of the river, and so injure her in respect of her penance. He says that she is killing herself, and that God has sent him to fetch her out. She comes out, and as she is drying herself she falls into a swoon. Lucifer conducts her to Adam, who is in the Jordan. At the sight of the Devil he is seized with trembling and abhorrence, and tells Eve the deception that has been practised on her, whereupon she falls to the ground. Adam asks the Devil why he persecutes them. Lucifer replies that he does so because it was through Adam that he fell from Heaven. He was commanded by God to worship His likeness, i..e, Adam, but refused to do so, because Adam was the youngest-born of created things. A third part of the angels supported him in this, and were cast out of Heaven. He concludes by threatening vengeance on Adam and his descendants. Adam then comes out of the stream. He and Eve are alone a year without house, fire, clothing, or any food except grass, and living in caves. Cain is born, who starts working at once, and cutting grass to help his father. A description is given of him. God takes pity on Adam, and sends Michael to teach him the virtue of seeds and the art of husbandry. He distinguishes for him on a clean stone each herb, and shows him the various utensils to be used. He bids him subjugate the animals. Seven years later Abel is born. Eve has a vision of Cain drinking Abel's blood. She tells Adam, who, to prevent the murder, makes a separate house for each. God sends Gabriel to tell Adam that Cain is attempting to slay Abel. He is not to tell Eve. Cain is "a true son of the Devil." The birth of Seth is foretold. Adam had altogether seventy-two sons and seventy-two daughters. Cain kills Abel when the latter is two hundred years old. God forbids Adam's progeny to slay Cain, lest they come under vengeance. He puts a mark on Cain, namely, a lump on his forehead. Cain dies by evening in the Valley of Jehoshaphat, where a crooked tree strikes against the lump. Since that event the valley has been barren. Seth is born, and begets children at the age of forty.

Canto XII (ll. 2021–2240).—Adam is about to die at the age of nine hundred and thirty, and tells Eve she will die nine months later. She asks what is to be done with his body, and he replies that no one is to touch it till God sends to dispose of it. He bids her go out and commence a "cross-vigil," and while she is so employed a heavenly messenger comes to tell her that Adam's soul is parted from its body, and in the care of Michael. She goes to him, and finds him dead. She weeps, but the messenger bids her look up, and see Adam's soul with Michael. She sees a seraph, with three golden wings, bearing the "beloved thing," i.e. Adam's soul. She beholds three white shining birds. The angels range themselves in ranks round the altar of Adam, on which is burnt the herb called *ornamentum*. The smoke spreads through the air, the doors of the firmament open, and God comes down with the Nine Orders of angels. He bids a seraph wash the soul of Adam in "the unpassable (?) river of the ever-living host *indatinum ciriasu*." It is then commended to the care of Michael, who is directed to place it until the Resurrection in the third Heaven, which is called Ficconicia. Angels praise God for His clemency towards Adam. The Oil of Mercy and the herb *ornamentum* are bestowed about the body, which is wrapped in three linen cloths and buried in Hebron, beside Abel's sepulchre. The waters of the Deluge washed away Adam's head and carried it to Jerusalem. It remained before the gate of Jerusalem until the cross of Christ was planted in the flesh (i.e. skull) of Adam. Here follow lines (ll. 2241–2292) which deal with the Patriarchs.

The two oldest versions of the Adam-apocrypha are contained in the Greek *Apocalypsis Mosis* and the Latin *Vita Adae et Evae*, which will hereafter be alluded to as A and V respectively.[1] A brief comparison of S with

[1] Greek text of *Apocalypsis* in Tischendorf, *Apocalypses Apocryphae*; English trans. in Ante-Nicene library, vol. xvi. Latin text of *Vita* in Meyer, *Vita Adae et Evae*, in *Abhandlungen der bayer. Akad. der Wiss.*, Cl. xiv, Bd. iii; English trans. in Charles, *Apocrypha and Pseudepigrapha of Old Testament*, vol. ii.

these will bring out some points of interest. It must be borne in mind that the narrative in both A and V only commences *after* the expulsion of Adam and Eve from Paradise (corresponding to Canto XI of S), the account of the preceding events being related at length by Eve in A only.

Cantos VI and VII.—Not represented in A or V, but built up from legends.

Canto VIII.—Not represented in V. It follows A (i.e. in Eve's account of the Temptation and Fall, as related by her to her children), but with some slight differences. In A it is not stated directly that the Devil got into the serpent's body; nor is the latter's reward mentioned. Indeed, there is some confusion with respect to the form of the tempter. At one time he is represented under the form of an angel; at another, he speaks through the serpent's mouth. The concluding portion of A is somewhat different. The serpent offers to give the fruit to Eve, then pretends to change his mind, makes her swear to give it to Adam, and then puts on the fruit the poison of desire. Nothing is said about the *half* of the apple.

Canto IX.—Also follows A, with some slight differences. In A Eve puts on fig-leaves *before* she tempts Adam. Nothing is said about her withholding information till he eats. It is *Michael* who sounds the trumpet. The trees of Paradise *bloom and lift themselves up*. The curses on Adam, Eve, and the serpent are given at length, and Adam is allowed to take with him perfumes.

Canto X.—Based on God's words to Adam in A, section 28 in the Greek, and is also influenced by the curse on him in section 24 of same.

Canto XI.—Follows V, with some important additions and omissions. In V Adam's long lament is entirely omitted. Eve stands in the river for thirty-seven days (*thirty-three* in one group of MSS.), and Adam for forty. Nothing is said about angels coming to instruct Adam for nineteen days; but Satan comes after eighteen days (nineteen in two MSS.). The writer of S may have misunderstood his original. The "fasting" upon God is not mentioned. The story of Eve's birth-pains is entirely omitted in S. Cain *brings a blade of grass* to his mother. Adam has (in addition to Abel, Cain, and Seth) thirty sons and thirty daughters, in all sixty-three children. Nothing is said in V about the clean stone on which the herbs were laid, or that Abel was born seven years after Cain, and killed at the age of two hundred (*one hundred and twenty-two* in V), or about the mark on, or manner of death of, Cain. On the other hand, S entirely omits the long vision which Adam relates to Seth in V. In one place S inserts a passage which is found in A, but not in V, where Michael (*Gabriel* in S) foretells the death of Abel and birth of Seth.

Canto XII.—Follows A, especially in the opening portion, where it is almost word for word with it. The curious passage about the "altar of

Adam," where the writer of S seems to have had a faulty original before him, is put in A much more clearly. S omits or alters the incidents of the sun and moon, of the trees sleeping, of the prominence given to Seth, of the four named angels, of Abel being buried at the same time, and of Eve's death and burial. On the other hand, A knows nothing of Adam's burial in Hebron, or of his head being washed to Jerusalem.

Certain passages and touches in S are additions clearly due to the influence of Irish ecclesiastical literature. Such are:—VIII, the allusion to the Seven Heavens, the returning of the animals right-hand-wise, i.e. propitiously, and the eating an exact half of the apple by each; XI, the mention of the canonical hours, the nine orders of angels, the "fasting" on God; XII, the cross-vigil and the appearance of the three white birds.

I shall now give some notes, in which an attempt is made to explain certain difficulties, and as well to throw light on the origin of some of the curious ideas in S, which, for the most part, are not found in A or V. These notes could be made much fuller, but I have endeavoured to condense them by avoiding, as far as possible, the inclusion of matter not directly relevant to the subject.

Canto VI.—*Three days without soul.*—The same occurs in a poem on the Creation in the Book of Lecan (MS., R.I.A.), fol. 533a ff. It appears to be an Eastern idea. A Jewish tradition held that after its creation Adam's body lay inanimate without a soul, and was green in colour (Bartoloccius, *Bibliotheca Magna Rabbinica*, t. i, p. 350). Tabari states in his *Chronicle* that it lay thus for forty years (Zotenberg, *Chronique de Tabari*, vol. i, p. 74). This belief is alluded to by Hippolytus, *Refut. of all Heresies,* bk. v, chap. 2.

Named from four stars.—Recté from the four points of the compass. This idea is widespread. It occurs in the Slavonic *Secrets of Enoch* (Charles, *Apoc. and Pseudepigr. of O.T.*, vol. ii, p. 449); in the Sibylline Oracles III, lines 24–26; in the *Elucidarium* of Honorius Augustodunensis (Migne, P.L. clxxii, col. 1117); and in the Anglo-Saxon prose dialogue between Solomon and Saturn (Kemble, *Salomon and Saturnus,* pp. 179–181). For other explanations of the name Adam see Bartoloccius, t. i, p. 79, and Heidigger, *Historia Patriarcharum* (2nd ed., 1688), t. i, p. 119. In the L. Breac prose version it is said that Adam was formed from four sods—viz., his head from Malon, his breast from Arton, his belly from Biblon, his feet from Agore. In another authority (*Cod. Pal. Vat.*, p. 24) it is given as follows:—His head from the land of Garad, his breast from Arabion, Aradon, or Adilon, his belly from Laban, his feet from Dagaria or Gagonia. In the Book of Lecan poem on Creation his head is made from the land of Malon, his breast from Arabia, his belly from Laton, his hands from Laban, his feet from Goma. This seems to be an echo of Eastern lore. A Jewish tradition states that Adam's body was made from Babylon, his head from the land of Israel, and his members from the rest of the earth (Bartoloccius, iii, p. 580). According to the Palestinian Targum on *Genesis*, God took dust from the House of the Sanctuary and from the four quarters of the world, and mixed the dust with all the waters of the earth (Friedlander, *Pirkê R. Eliezer*, p. 76n.). Moslem tradition has it that dust was taken to make Adam from where is now the Kaaba at Mecca (Tabari, i, p. 72). Adam is called the "human world" in *Apocalypse of Abraham* (ed. Box and Landman, p. 70); octopartite nature in Stokes' *Three Irish Glosses*, p. xl, and dialogue of Solomon and Saturn (Kemble, pp. 179–181); from seven consistencies, *Secrets of Enoch* (Charles, i, p. 448); from four elements (Gibson, *Book of Rolls*, p. 5; Hon. Augustodun, col. 1116).

Eve made nine months later.—According to the L. Breac prose version (*Cod. Pal. Vat.*, p. 47), this is the reason for the nine months' period of pregnancy. She was made a week after (*Jubilees*, ed. Charles and Box, p. 47); three hours after (Issaverdens, *Armenian Uncanonical Old Testament*, p. 52).

Canto VII.—*Go to Heaven at the age of 30.*—In the *Tidings of the Resurrection* it is said that all men will arise at that age on the last day. A similar belief prevails among the Moslems (*Revue Celtique*, vol. xxv, p. 239).

1,000 years and six hours in Paradise.—In view of the statement in Canto XII this is incorrect. But the writer of S has blended two legends, viz., (1) the length of Adam's life, and (2) the length of time spent in Paradise. With regard to (1) it was held by the Jews and the Mohammedans that the span of life originally allotted to Adam was a thousand years; but that, on learning that his descendant King David would only live thirty years (or three hours) he voluntarily surrendered him seventy years of his own life (Migne, *Dict. des Apocr.* ii, cols. 53–54; *Pirkê R. Eliezer*, p. 128). With regard to (2) there are numerous traditions. A Jewish one says six hours (Bartoloccius, i, p. 64). An English metrical version says seven hours (Kemble, p. 128). Tabari (p. 79) goes to the other extreme, and keeps him in Paradise for five hundred years. According to an Irish poem quoted in *Cod. Pal. Vat.*, p. 47, Adam and Eve were in Paradise till an hour beyond mid-day. The poem on Creation in Book of Lecan says fifteen days.

Canto VIII.—*Devil and Serpent.*—The relationship between the two forms the subject of numerous theories. In S the devil gets into the serpent's body. This is the view of the Church Father Theophilus of Antioch (*Theophilus to Autolycus*, bk. ii, chap. 28), who says: "The wicked demon, who is also called Satan, spoke to her through the serpent." According to the Moslem legend, Iblis placed himself between the serpent's back teeth, and so entered Paradise (Migne, *Dict. des Apocr.* ii, cols. 49, 50). Hidden in the serpent (Malan, *Conflict of Adam and Eve with Satan*, pp. 29, 56). The other conflicting theories need not detain us.

Half apple.—Various comestibles have been suggested as the Forbidden Fruit. It is said that the apple first appears as such in the writings of Venantius Fortunatus, 530–609 (*Irish Church Quarterly*, April, 1909, p. 107). It occurs also in a poem *Genesis*, sometimes attributed to Salvian of Marseilles (d. about 495), and in the *Instructions of Commodianus* (Ante-Nicene Library, vol. xviii, pp. 296, 451). That Adam and Eve each ate *an exact half* of the apple appears to be an Irish conception. It is also found in a poem in *Cod. Pal. Vat.*, p. 47, in the L. Breac prose version, and in a poem on the Harrowing of Hell in *'Eriu*, iv, p. 112. This may perhaps be influenced by a passage in A, section 9, where Eve desires to bear half of Adam's death-pangs, because it is through her they have come upon him. In A, section 19, it is said that the serpent put on the fruit the poison of desire (*lust*, Issaverdens, p. 13). This is not in S, but appears to have influenced a passage in one of the L. Breac Homilies (ed. R. Atkinson, p. 494), where Eve's gazing on the tree is treated of under the head of Adultery.

Canto XI.—*Penance in river.*—This custom was practised in Ireland by both saints and sinners. It is said of St. Mobheoc of Lough Derg (Donegal) that "often in bowing his head he plunged it under water." St. Adamnan stood up to his neck in a stream when fasting against Irgalach (*Silva Gadelica*, ii, p. 442). St. Fursa used to recite his psalms standing in a well as cold as snow (*Zeit. für Celt. Phil.*, i, p. 64). During Lent St. Fechin of Fore was wont to pray at midnight in a stream (*Rev. Celt.*, xii, p. 332). A curious story is told in Carrigan's *History of Ossory*, ii, p. 315, of a robber and a hermit doing penance together in the River Nore. Similarly the robber Merlino stands in a stream with the same object (*Fis Merlino*, ed. R. A. S. Macalister, p. 64).

Fasting upon God.—Miss Hull has kindly given me some references which illustrate this passage. Fasting upon a debtor was part of the process of distress among the ancient Irish. The resemblance between this and the Hindoo law of "sitting Dharna" has often been noted (*Ancient Laws of Ireland*, i, pp. xlviii, 82n., 83, 113, 117). The twelve saints of Ireland fasted on Dermot at Tara for a year in the quarrel for the secular power of the King against the Church. Dermot, in his turn, fasted against them, but they proved too strong (*Silva Gadelica*, ii, pp. 71, 72). Adamnan and Irgalach fast against each other (*ibid.*, p. 442). A monk fasts against God on account of the heavy additional burden the death of his comrades lays upon him with respect to saying prayers, etc. (Stokes, *Lives of SS. from Book of Lismore*, p. ix). The nobles of Ireland fast upon God to bring a plague to decrease the superabundant population (*Irish Liber Hymnorum*, ii, p. 12). In the second vision of Adamnan both human beings and animals have to make a fast of three days and three nights against the plague (*Revue Celtique*, xii, p. 431).

Cain a true son of the Devil.—A passage in a prose treatise on female genealogies in the Book of Lecan, fol. 385a ff., says that Cain was in Eve's womb when she tasted the apple from the tree in Paradise. These passages are influenced by Jewish tradition, viz., that the Devil (Sammael), at the time of the Temptation, seduced Eve, and so became the father of Cain; and that Adam had intercourse with Eve in Paradise (Bartoloccius i, pp. 74, 75, 291; Gaster, *Chronicle of Jerahmeel*, p. 16).

72 sons and 72 daughters.—52 sons and 72 daughters (*Cod. Pal. Vat.*, p. 25). 50 sons and 50 daughters in the Book of Lecan treatise on female genealogies. No numbers in any non-Irish work I have consulted agree with these.

Cain kills Abel.—Nothing is said in S with respect to the lethal instrument employed, concerning which there are countless theories. But a passage in the Book of Lecan poem on Creation has the following:—"Cain took in his hand the jaw-bone of a camel, so that he slew Abel. The learned tell us that these stones have not grown since the blood of Abel touched them." The Irish writer has here blundered his original, which appears as follows in the Anglo-Saxon prose *Salomon and Saturn* (Kemble, p. 187):—"Tell me why stones are not fruitful? I tell thee, because Abel's blood fell upon a stone when Cain slew him with the jaw-bone of an ass." The same instrument is mentioned in the *Master of Oxford's Catechism* (*ibid.*, p. 219); and in the Northumbrian poem, *Cursor Mundi* (E. E. T. S.), line 1073. According to a passage in the *Ever-new Tongue* (*Revue Celtique*, xxviii, p. 301), Cain killed his *two* brothers Abel and Paininn.

Cain's mark, and death.—The "lump" of S represents the horn that grew as a mark out of Cain's forehead, according to some theorists (Hershon, *Rabbinical Commentary on Genesis*, p. 36; Malan, p. 229; Issaverdens, pp. 39, 50; Heidegger, p. 196). I can find nothing to illustrate the manner of his death as described in S. According to the earlier legend Cain was killed by the stones of his house falling on him (Fabricius, *Codex Apocr. Vet. Test.*, i, p. 120); the better-known later tradition makes Lamech slay him. A very curious account of Cain's mark and death is found in the Book of Lecan (treatise on genealogies, and poem on Genesis). It is there said that seven lumps grew on Cain, on his feet, hands, cheeks, and one on his forehead. As he was herding sheep one day Lamech hurled at him an apple as big as a man's fist, which went through the lump on his forehead and killed him. In punishment, seven times as many lumps as were on Cain grew on Lamech, who died from the poison of these some time after. There is a parallel to some of this in Eastern lore. According to *Bereschith Rabba* (quot. Fabricius i, p. 122) Lamech killed him with an arrow or a stone. This is expanded in Malan (*Conflict*, p. 122). Cain comes into the field, and the cattle fly before him. Lamech shoots him in the side with an arrow, and then strikes him in the face with a stone from his sling. According to the *Book of the Rolls*, p. 20, Lamech threw a stone into a thicket, and hit Cain between the eyes. The transference of the lumps reminds us of Crofton Croker's story and its Japanese parallel (J. R. S. A. I., vol. xxxviii, p. 280).

Canto XII.—*Eve dies nine months later.*—This is based on the statement concerning the time of her creation in Canto VI. A passage in *Cod. Pal. Vat.*, p. 25, says that she lived ten years after him. As usual, traditions differ: e.g., A and V have six days. Mirkhond's *Rauzut-us-Safa* (ed., Rehatsek), p. 65, has one or seven years, etc.

Herb called ornamentum.—This word represents the *odoramenta* (*odoramentum* in one group of MSS.), the "spices" which, in V, Seth brings back from Paradise. But in this passage in Canto XII S is following A, not V, which last does not contain the account of the angels burning incense after Adam's death. So it may be that the writer of S had before him a Latin translation of A, in which the λίβανον of the original was rendered *odoramentum*. At any rate, the document on which S is based seems to have been corrupt or illegible here.

Indatinum ciriasu.—The second word is apparently the ablative case of "Acherusius" (or the dative case of Ἀχερόυσιος, if a Greek text was used?). Is the first word a corruption for "in lacu"?

Ficconicia.—I cannot find this name in any list of Seven Heavens, Irish or non-Irish, which I have consulted.

Adam buried at Hebron, head washed to Jerusalem, etc.—This must be explained as a blending of three distinct sets of legends. According to Jewish tradition, Adam was buried in the cave of Machpelah at Hebron. Some held that Eve was also interred with him, hence Hebron was also called Kirjath-arba, "the city of four pairs," because four patriarchs and their wives were there buried (Hershon, *Talmudic Comm. on Gen.*, p. 64; Bartoloccius i, p. 64; *Pirké R. Eliezer*, p. 148; Heidegger, p. 160). The burial at Hebron is also found in Western writings, cf. Hon. Augustodunensis, col. 1117; *Cursor Mundi*, l. 1416; *Lyff of Adam and Eve* (Horstmann *Samml. Altengl. Leg.*, p. 226). According to Christian tradition, he was buried in Jerusalem, on Golgotha, which derived its name from the belief that his skull was there. For older authorities see Gretzer, *De Cruce Christi*, tom. i, lib. 1, cap. 18, and Suicer, *Thesaurus*, s. v. κρανίον. A good treatment of the question, with translations of extracts from the Fathers, will be found in Wilson, *Golgotha and the Holy Sepulchre*, pp. 2–7, 159–166. The Moslems characteristically put the site of his grave near Mecca (Mirkhond, p. 57; Tabari, p. 94). Adam's body reached Golgotha as follows:—It was laid in the Cave of Treasures, from which Noah took it, and placed it in the ark. When dying he directed Shem to go with Melchizedek, and carry the body to the centre of the earth, i.e., Golgotha, where it was to be buried. An angel guided them thither (Malan, pp. 45, 114–5, 149 ff., 242–4; *Book of Rolls*, pp. 27–32). According to a slightly different tradition, Noah distributed the bones of Adam equally among his sons. Shem, his eldest, got the skull, as being the more noble portion, which he buried at Jerusalem (Fabricius i. pp. 60–62, 75). He was buried in Paradise according to A and V; and one group of MSS. of the latter identifies the spot with Calvary. Sir John Maundeville in his *Travels* (ed. Ashton, pp. 40, 51) also combines two traditions. He says that Adam was buried at Hebron, but that his skull was found at Golgotha in the mortice in which the cross was set up. The skull so frequently represented at the foot of the cross in sculpture and art, medieval and modern, is that of Adam.

So, as a result of our examination we find that, though S is based on A and V, it differs from them both in form and in substance. In form: for whereas these two documents only commence with the period after the expulsion, S starts with the creation of Adam, and from thence traces the events in due order. In substance: for S sometimes follows A, sometimes V; omits much of what they contain; and inserts matter of which they know nothing.

The question of form can easily be explained. The writer of S is not concerned with the construction of an apocryphon as such. His intention is to give an account of sacred history from the Creation to the last Judgment. But when dealing with the story of Adam and Eve, he finds that an apocryphal narrative with which he is acquainted has more attractions for him than the Biblical one, and accordingly he makes full use of it.

The question of substance is more complicated. Professor Thurneysen, in an article in *Revue Celtique* vi, p. 104, puts forward the hypothesis that the writer of S had before him a Latin document which contained not only A and V, but additional matter as well. But this seems a very cumbersome theory, involving as it does the existence of a curiously composite document of which nothing is known. The following seems to be an easier solution of the problem. The writer of S had before him both A and V, the former possibly in a Latin form, as may be inferred from the evidence of a couple of words in that language. In weaving his narrative he did not adhere slavishly to his originals, but made use of the one or the other, as it suited his need and his fancy. It is important to note that he has used A to a far greater extent than V, in which respect his work forms a marked contrast to the medieval versions, which all follow V. As a natural consequence his production cannot be termed a "translation" of either; it is really much more of an original piece, as may be seen from the passages translated in Miss Hull's *Poem-Book of the Gael.* At the same time he introduced matter partly from Celtic literature, partly from non-Irish writings, some of which came from the East, as I have endeavoured to show in my notes.

There appears, indeed, to have been in Ireland at the time a considerable amount of curious learning, of which our writer has made use with good results. Something of this may be seen in the Lismore version of the *Ever-new Tongue* (*Eriu* ii, p. 96), which belongs to the tenth or eleventh century, and in which a Latin apocryphon is very thickly overlaid with the most out-of-the-way knowledge. Our writer, too, has dealt with an apocryphal work according to a method which has been practised elsewhere in Irish literature, i.e., he has not set himself the task of translating, but has rather compiled a narrative, in which he has taken an original as the core, and then added to it, or omitted from it, as he felt inclined. An example of this treatment is found in the *Ever-new Tongue,* just alluded to, and in the *Transitus Mariae* (published by me in *Journal of Theological Studies* for October, 1921), where the writer has altered many details in a well-known story, incorporated considerable portions of a Syriac document, and made use as well of the *Visio Pauli* and the Greek *Apocalypse of the Virgin.*

One thing more must be said with respect to S. The earliest MSS. used by Meyer are a Paris one (his Class IV) which he dates in the eighth century, and three (his Class I) which are of the ninth, tenth, and twelfth centuries respectively. Now, S may be dated just before the close of the tenth century, which consequently implies a very early knowledge of the Adam-apocrypha in Ireland, and as well throws some interesting light on the foreign literature read in the country at that period.[1]

I shall conclude this paper by giving a short apocryphal piece dealing with Adam, which has been translated for me by Miss Byrne for the first time from the poem on Creation in the Book of Lecan: "Adam was a night

[1] The Caedmonian poem *Genesis B*, which is by some ascribed to the year 1000 A.D., and therefore contemporary with the *Saltair na Rann*, appears to make some slight use both of A and V (C. W. Kennedy, *The Caedmon Poems*, pp. xli–xliii, 23–35).

on the mountain of Paradise; he gave thanks at seeing the sun from the top of the great mountain. 'I adore, I adore thee, O God,' is the first sound he uttered; at seeing fair Eve he gave his first laugh. His first walk was to the well of Paradise; his first run was to see the birds. Fifteen days Adam and Eve were together till the demon came to deceive them. This is the reason why people say the left hand as against the right, because it was the left hand that was stretched out to the apple. After transgression they were put into the high land of Egypt; for three months one palm clothed and fed them." If all this is not pure invention on the part of the Irish writer, it resembles in part a passage in *Pirké R. Eliezer*, p. 79: "Adam stood and began to gaze upward and downward. He saw all the creatures which the Holy One had made, and he was wondering in his heart, and he began to praise and glorify the Creator, saying 'O Lord, how manifold are Thy works.'" The creatures fear him, and prostrate themselves before him.

VIII.

SOME IRISH BRONZE-AGE FINDS.

By E. C. R. ARMSTRONG, M.R.I.A., F.S.A.

[Read May 22 and June 26. Published August 22, 1922.]

Discoveries of weapons, implements, &c., associated in the same grave, hoard, or deposit, with objects whose age is approximately known, are our only means of placing in a sequence prehistoric antiquities.

The following finds preserved in the Academy's collection have in some cases been mentioned, but neither figured nor in detail described. Ten are illustrated; all belong to the latest period of the Irish Bronze Age. Those containing leaf-shaped swords with fish-tail-ended tangs might be thought earlier than those which included socketed axe-heads. But the swords found at Dowris are of this type,[1] and there is no doubt of the late date of this great hoard, which seems to belong to a period transitional between the Bronze and Iron Age.

The first find with which it is proposed to deal is the Dowris hoard. Though frequently discussed as a whole,[2] those portions of it in the possession of the Earl of Rosse and in the Academy's collection require complete illustration and description.

The hoard, which included over 200 pieces, is the largest find of associated bronze antiquities discovered in Ireland. It was unearthed about 1825 by two men trenching potatoes in a part of Whigsborough called Derrens. The spot where the hoard was found is stated to have been under cultivation; but within the memory of living persons it had been covered with copse and underwood, while the name of the locality, *Dubhros*, indicates that formerly it had been forest land. A part of the hoard, purchased, shortly after its discovery, for the Earl of Rosse, was preserved at Birr

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[1] See specimen illustrated, "British Museum Bronze-Age Guide," Pl. viii.

[2] Robinson, Proc. Royal Irish Academy, iv, pp. 237–246 and 423–440; "Dublin Penny Journal," i, p. 376, ii, p. 28; "British Museum Bronze-Age Guide," 1920, pp. 105–107; Evans, "Bronze Implements," 1881, p. 361; Montelius, "Archæologia," lxi, pp. 153, 154; &c.

Castle. Another portion, obtained by Mr. T. L. Cooke, of Parsonstown, was afterwards acquired by the British Museum.

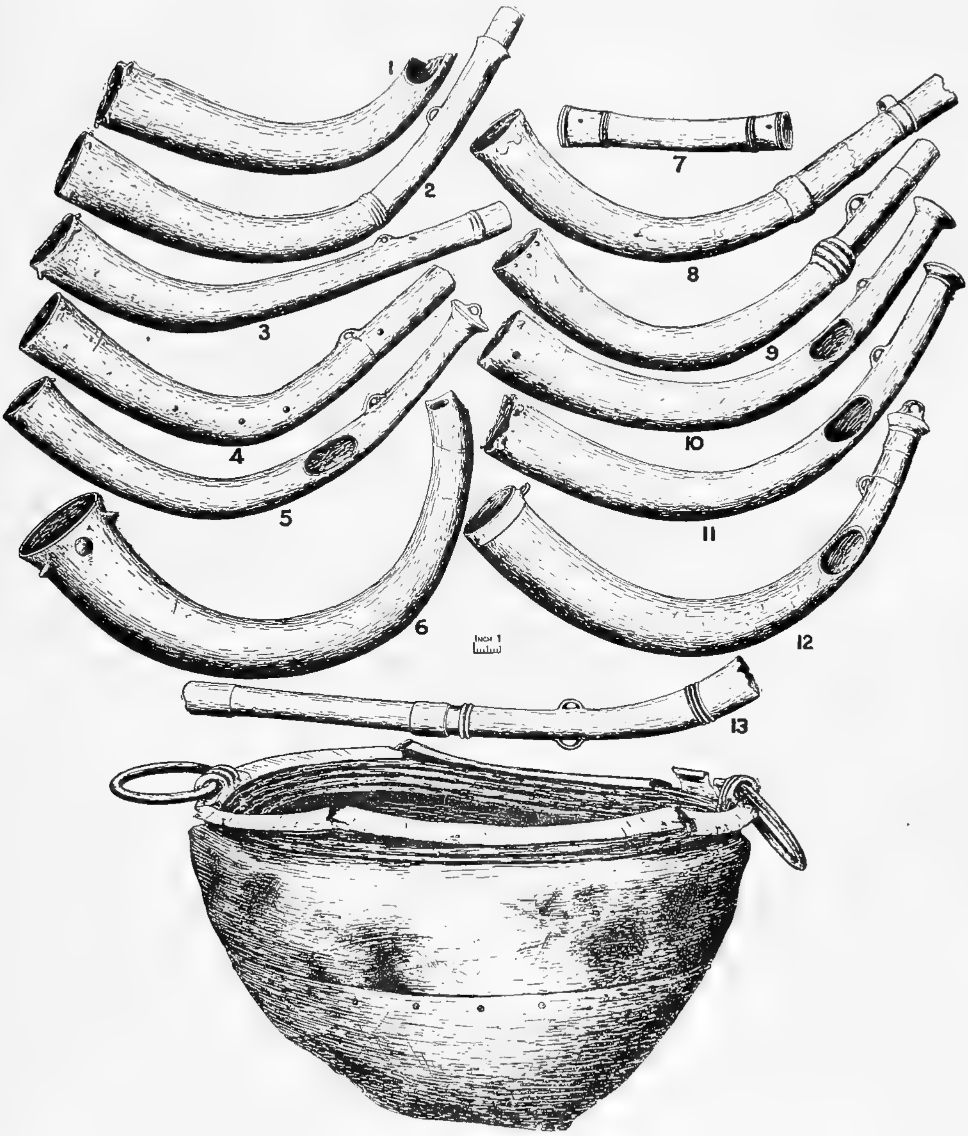

FIG. 1.

Bronze cauldron and trumpets from Dowris, in the possession of the Earl of Rosse.

(Slightly above $\frac{1}{8}$.)

The antiquities obtained by Lord Rosse included a cauldron, 13 trumpets, 31 crotals, 31 axe-heads, 3 gouges, and 29 spear-heads; 108 in all.[1]

[1] Robinson, *op. cit.*, pp. 237–240.

The Trustees of the present Earl, through the good offices of Mr. T. R. Garvey, and of our member, Mr. H. S. Upton, having recently lent these bronzes to the National Museum, this opportunity of illustrating them is taken (figs. 1, 2, and 3). The number at present extant (95) is less by 13 than stated by Robinson. It can be well understood that in the intervening years some should have disappeared. The surface of the bronzes has considerably suffered, being affected some years ago by a fire at Birr Castle. Fortunately none were destroyed; and it is hoped that careful handling will do something to restore their original condition.

The cauldron (fig. 1) measures 14 inches in depth, and 22 inches in greatest internal diameter. It is composed of four plates of hammered bronze riveted together. The upper plate, divided into two, is extended to form the grooved band below the rim, and the rim itself. The rivets joining the plates have circular heads. The centre of the base has a small patch attached by six rivets. The remains of a wooden support, which was contained inside the rim, can still be seen. The large solid ring-handles are attached to the rim by grooved sockets. On one side there are three patches below the handle; this is in so frail a state as to be almost detached from the cauldron. The whole vessel is in a much damaged condition.

The axe-heads, which number 27, exhibit (as can be seen from the illustrations, figs. 2 and 3) considerable variety. Some are oval at the mouth; others rectangular. Some have rounded, others sloping sides. The cutting edges of some are much expanded.

The spear-heads, 21 in number, all belong to the leaf-shaped type, their sockets being pierced with a single rivet-hole. Only two are ornamented; the longest (fig. 2, 6) has a slight rib at each side of the mid-rib extending below the wings as far as the rivet-holes, these being encircled by a raised rim; another specimen (fig. 3, 5) is similarly ornamented, but the ribs do not reach as far as the rivet-holes, in this case plain.

The trumpets number 12, there being in addition the connecting portion of another. Five were blown from the side; the remainder from the end. One of the latter (fig. 1, 13), imperfect at both ends, is in two parts; it is peculiar in having loops opposite to each other above and below. The small connecting piece (fig. 1, 7) is pierced for rivets at each end. One of the specimens, blown from the end, is remarkable in having four large rounded rivet-heads cast in the surface of the metal on each side of the central curve of the trumpet. The discolouration of the bronze makes examination of the surface of these trumpets difficult.

The 31 crotals are, with one exception, gourd-shaped, and grooved at the top. They are fitted with a staple and a ring for suspension. The exceptional specimen (fig. 3, 21) is rounded at the base; its upper portion is plain.

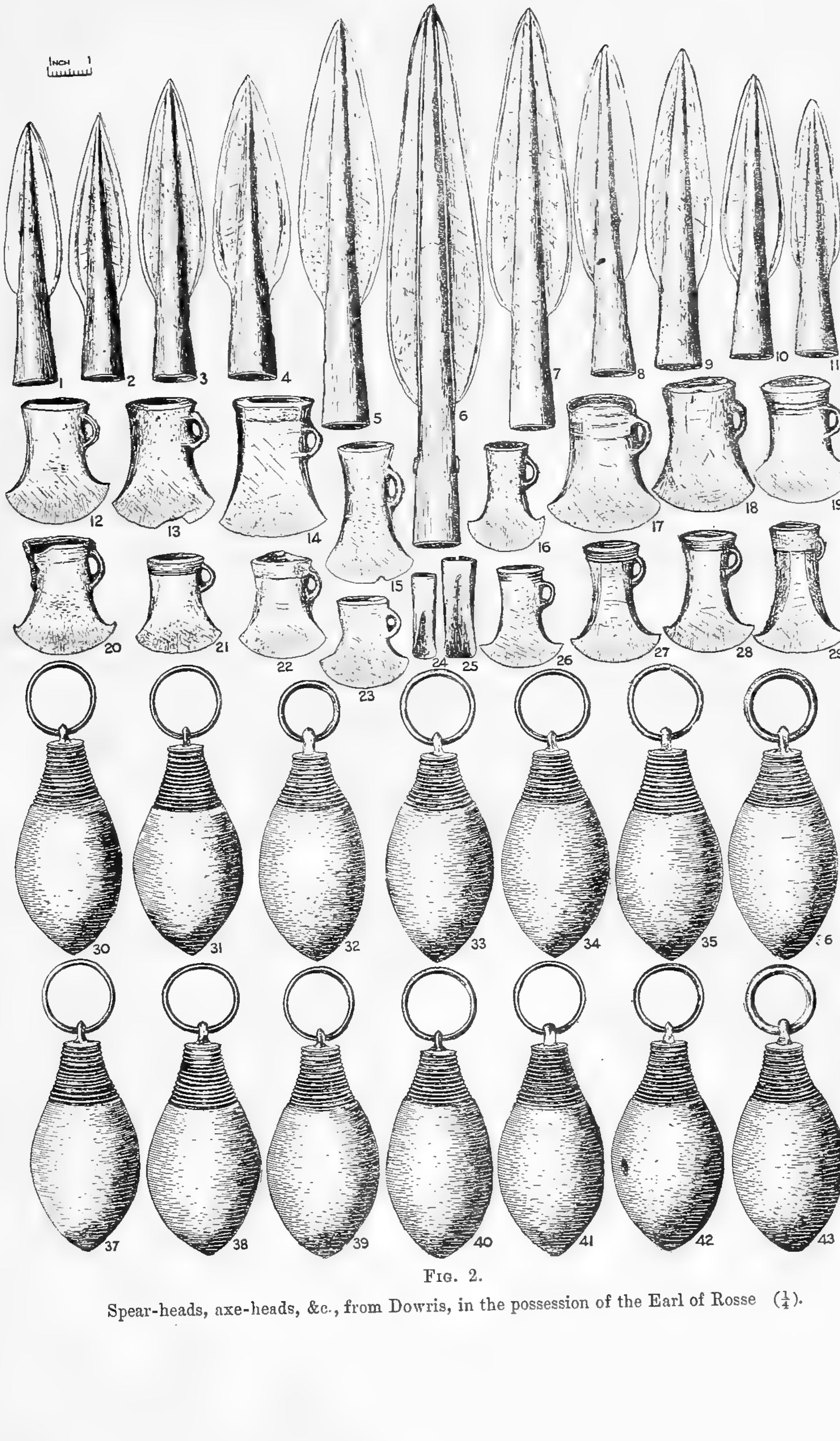

FIG. 2.

Spear-heads, axe-heads, &c., from Dowris, in the possession of the Earl of Rosse ($\frac{1}{4}$).

The two gouges (fig. 2, 24, 25) are of the ordinary socketed variety.

In the British Museum are 77 pieces from Dowris, as well as a bucket-shaped cauldron and 2 pan-shaped vessels of bronze.[1]

That part of the find obtained by the Academy includes 2 trumpets, 8 crotals, 4 leaf-shaped spear-heads, and a gouge; in all 15 pieces (Pl. III). Of these the trumpets, 3 of the crotals, the gouge, and a spear-head appear to have been given by Lord Oxmantown to Dean H. R. Dawson, and acquired, with the remainder of the latter's collection, in 1840.[2] The Dowris bronzes are distinguished by a light golden colour. A large leaf-shaped spear-head of similar hue has generally been shown as portion of the find; but this, which was deposited by the Royal Dublin Society, is stated both in the Museum register and by Wilde[3] to have been found near the old castle of Streamstown, near Banagher. It cannot, therefore, be considered as belonging to the Dowris hoard.

The leaf-shaped spear-heads and socketed gouge (Pl. III) belong to ordinary types; they do not call for particular description. One of the trumpets, shaped like a cow's horn, was blown from the end; the other from the side. The latter apparently failed in the casting some 7 inches from the lower extremity, as here it shows an encircling repair nearly ¾ of an inch in breadth. This can be seen inside as well as on the outside. In both can be observed on the outer surface small metal insertions, rectangular or irregular in shape. Some of these may be patches to repair imperfections in the casting; others are probably the remains of the pins that kept the core and hood in place while the metal was being poured into the mould. The technical methods used in casting bronze trumpets—a question of interest, indicating considerable skill in metal work—has been recently dealt with by Hubert Schmidt[4] in his memoir on the two *lurer* found at Daberkow. He has shown, among other details, that the metallic composition of the pins to keep the two parts of the mould in position was calculated to melt at a higher temperature than that used in the body of the trumpet. This would prevent the pins melting when the molten metal was poured into the mould.

The raised spikes at both ends of the smaller trumpet probably recall an older form, made of a cow's horn, with metal attachments at each end—the spikes, retained as an ornamental feature, representing the nails which fastened the mouth and end-piece to the horn.

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[1] *Ex inform.* R. A. Smith.
[2] Wilde, Catalogue (Bronze), 1861, pp. 511, 525, 613, 614, 626.
[3] *Op. cit.*, p. 515.
[4] "Præhistorische Zeitschrift," vii, pp. 94–99.

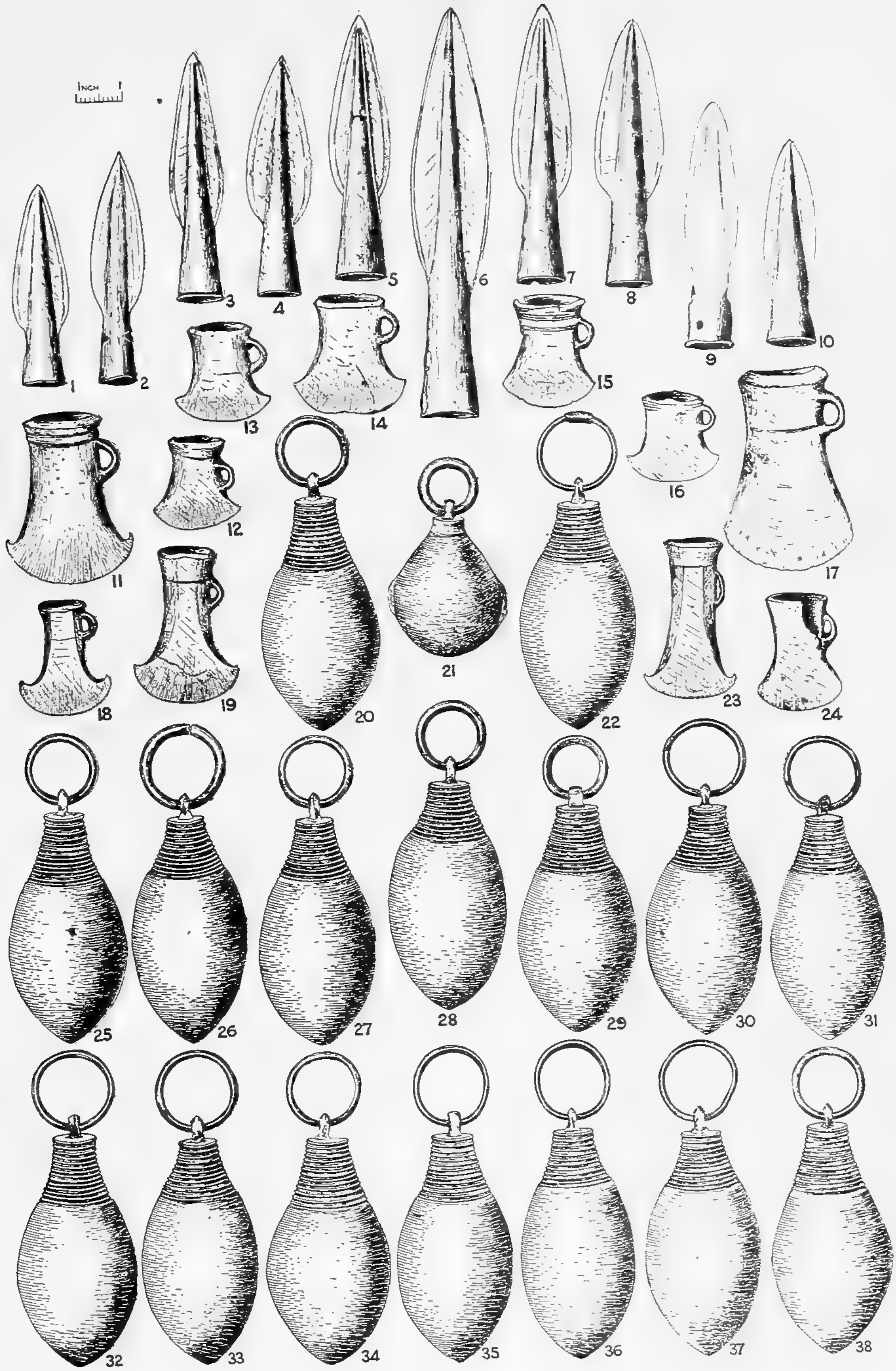

Fig. 3.

Spear-heads, bells, &c., from Dowris, in the possession of the Earl of Rosse ($\frac{1}{4}$).

The origin of the cast-bronze trumpets, of which such a number were found at Dowris, presents difficulty. Evans[1] mentioned them as one of the types that found their way into Ireland in the early Iron Age. Coffey[2] compared one type to the Roman lituus, a form of trumpet the Romans are believed to have adopted from the Etruscans, who, it may be recalled, were in early contact with the Celtic peoples of Gaul. He suggested that if the Irish trumpets were connected with those used by the Celts, the great number found in Ireland, their form, and almost complete absence from Britain, might indicate a movement of Celtic people from Northern Italy by the Rhone Valley across Gaul to the South and East of Ireland.

But the cast-bronze trumpets belong to the end of the Bronze Age, while the Celtic peoples of Northern Italy were at that period in the Iron Age.

Trumpets were also used by the Iberians.[3] Their form appears to have resembled that of the large Scandinavian trumpets, which are dated to the later portion of the Northern Bronze Age.

There are objections to deriving the cast-bronze trumpets from foreign sources, for, though they are not confined to Ireland, they occur only exceptionally in Scotland and England.[4] The Irish National Museum contains no less than thirty-three complete, or portions of, trumpets, not including the thirteen obtained by Lord Rosse with his portion of the Dowris find. Specimens from Ireland are preserved in the British Museum. Others are known to be in private hands in Ireland.

Trumpets have been frequently found together in Ireland, as at Moyarta, where three, one in two parts, were discovered in association. These, not previously published, were found, in 1902 or 1903, seven or eight feet below the surface of a bog in the barony of Moyarta, Co. Clare. They were acquired by the Academy in 1907. Two are of the cow's-horn variety, blown from the end; they measure respectively 27·5, and 23 inches, in exterior curve. A central tubular portion, of the usual form, 24·7 inches in length, fits into and appears to belong to the larger of the above specimens. The third trumpet, closed by a cap at the smaller end, was sounded by an aperture at the side; its external curve is 28·7 inches. Six trumpets found in a bog near Chute Hall, Clogher, Tralee, Co. Kerry, were acquired by the Academy in 1886. They include four blown from the end, one having a central tube fitting into

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[1] Proc. Society of Antiquaries of London, xxii, p. 128.

[2] Proc. Royal Irish Academy, xxviii, Sec. C, pp. 105, 106.

[3] Sandars, "Archæologia," lxiv, pp. 286, 287.

[4] Evans, "Bronze Implements," 1881, pp. 362, 363, "British Museum Bronze-Age Guide," 1920, p. 107.

it; and two blown from the side. These are figured (greatly reduced) in Coffey's "Bronze Age" (the six trumpets on the lower left side of Plate X). Three trumpets were found near Cloghoughter Castle, Co. Cavan;[1] four in a bog at Drumabest, Kilraughts, Co. Antrim, of which two are preserved in the British Museum;[2] three at Carrick-O'Gunnell, Co. Limerick;[3] and thirteen or fourteen near Cork in 1750.[4] In no case do trumpets seem to have been found in association with other antiquities, except in the Dowris hoard.

The cast trumpets appear to have originated in Ireland. If introduced from outside, it ought to be possible to indicate other localities where similar instruments have been found in large numbers. Failing this, we must provisionally conclude the home of the type to be where have occurred the greatest number of specimens, especially if they are elsewhere unfrequent or unknown.

The gourd-shaped bells, generally called crotals, contain a loose clapper of stone or metal; they emit little sound. They appear to have been cast by pouring the metal into the mould through an opening in the side. The mould seems to have been in two halves; the rings and end staples being cast together. To suggest a purpose for these bells is not easy. They seem to vary in tone. Possibly they may have been intended for concerted use on some kind of frame. The number of ribs with which they are ornamented differs. Those with fourteen seem to have been cast in a single mould; those with twelve in another. One specimen (Pl. III) has vertical as well as horizontal ribs. No specimens of these are known from other localities, either Irish or continental. They are peculiar to this find. As will be seen from the illustrations, they vary in size: some are pear-shaped; others more spherical.

The Dowris hoard belongs to the latest period of the Bronze Age, Montelius's fifth period. Though no trace of iron was discovered, the presence of a bronze bucket-shaped cauldron of Italian derivation indicates the find's transitional character.

Montelius's[5] date for the find extends from the middle of the twelfth to the end of the ninth century B.C. Sir Arthur Evans's[6] dating would place the cauldron, and consequently the associated objects, in the late Hallstatt period, extending from the middle of the seventh to the end of the fifth

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[1] Wilde, *op. cit.*, p. 626.
[2] *Ibid.*
[3] Ousley, Trans. Royal Irish Academy, ii, p. 3.
[4] Wilde, *op. cit.*, p. 624.
[5] "Archæologia," lxi, p. 162.
[6] Proc. Society of Antiquaries of London, xxii, p. 128.

century B.C. This divergence in date is caused by the different view taken as to the time the Bronze Age ended in Great Britain and Ireland.

The second find has been in the Academy's collection for many years. It consists of two leaf-shaped swords and two leaf-shaped spear-heads (fig. 4), described as found with a number of similar objects in the lands of Knockadoo, near Lough Gara, Co. Sligo, the property of Viscount Lorton. With his permission they were deposited in the Academy's museum, 16th May, 1840, by Sir William Wilde, forming the nucleus of the collection of Irish bronze weapons since acquired by the Academy.[1] A sentimental interest attaches to this remnant of what was apparently a large find of bronze weapons. The fate of the remainder has not been recorded.

The spear-heads are of the ordinary type; the socket of each is pierced for a single rivet. One of the swords is broken across; its edge has been much hacked. Leaf-shaped swords, with fish-tail-ended tangs, are common in Ireland. Some seventy specimens, the great majority having notched blades, are preserved in the Irish National Museum. Evans[2] (1881) gave the number of bronze leaf-shaped swords then in the collection as nearly or quite 100; but he included among these swords of Hallstatt type, also those in which the tang is rounded or rectangular, not of the fish-tailed form.

The third find (fig. 5) contains three leaf-shaped swords. In two cases the handles are broken; but in one it is of the fish-tailed variety, and there can be little doubt that the others were of the same form. The swords were found on 15th March, 1866, by John Hogan, when making a fence, about eighteen inches below the surface of the ground at Latteragh, Upper Ormond, Co. Tipperary.

The fourth find (fig. 6), acquired in 1866, consists of two leaf-shaped swords and two leaf-shaped spear-heads. These are registered together as found near Youghal, Co. Cork. Though it is not expressly stated that they were discovered in association, of this there can be little doubt; all being acquired at the same time, and their considerable patination being similar. The swords are of the ordinary type; their handles are much broken. It is worth noticing that in both the small space between the end of the hilt and commencement of the edge is thick in section; especially is this so in fig. 3, 2, where it measures $\frac{1}{10}$ of an inch. This peculiar feature is particularly marked in another specimen in the collection, the upper portion of the handle-plate of which is decorated with punched ornament extending as far as the notches in the blade. Evidently this ornamented portion was not

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[1] Wilde, *op. cit.*, 511.

[2] "Bronze Implements," 1881, p. 291.

covered by a cross-piece. The spear-heads are of the usual type; they do not call for special remark.

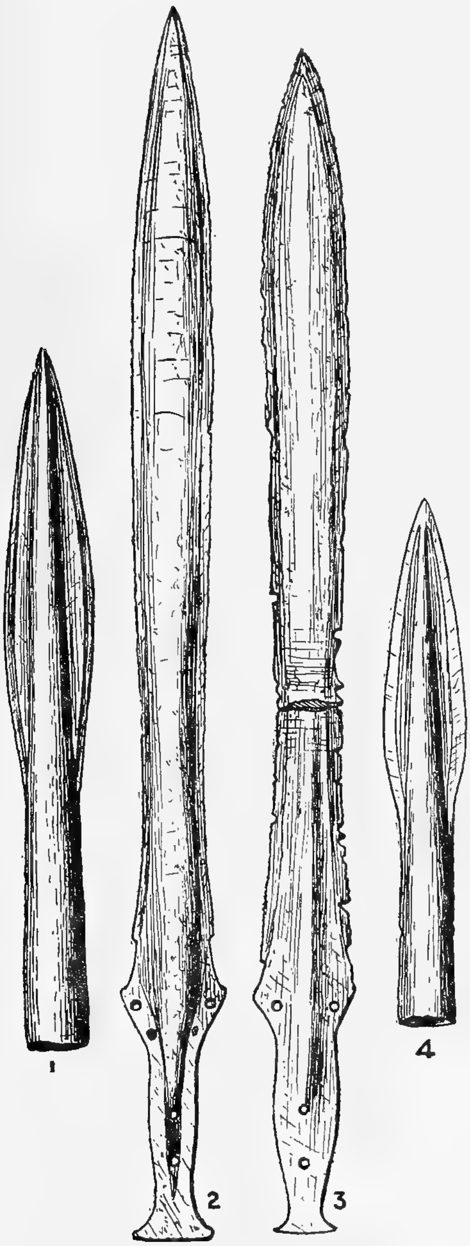

FIG. 4.

Bronze swords and spear-heads found at Knockadoo, Co. Sligo (About ⅓).

FIG. 5.

Bronze swords found at Latteragh, Co. Tipperary (About ⅓).

The fifth find includes a bronze penannular ring with cup-shaped ends (fig. 7, 13), and twenty-one bronze rings, of which two are double. All were found about 1876, near an old fort at Brockagh, Rochfort Bridge, Co. Westmeath. They were purchased from Mr. James Killian, of Dysart, Mullingar.

The two large rings (fig. 7, 17 and 22) are solid and heavy. Several of the smaller rings have attachments broken at the end, showing they were formerly joined to another ring. A thinner bronze ring threads a small solid ring that moves freely round it. Large rings threading smaller ones are not uncommon in Ireland; one formed part of the Kinnegoe find shortly to be described. An example in gold occurs in the Clare find.[1] In bronze there are three specimens in the Academy's collection which thread two smaller rings; another was found at Ballymoney, Co. Antrim.[2]

Plain bronze rings like those found at Brockagh (fig. 7, 5, 7, 14, 15, &c.) are common in Ireland; a large number of various sizes being preserved in the Academy's collection. Many of the larger specimens are hollow; the smaller seem, as a rule, to be cast solid. To suggest a use for the whole series is difficult. The larger were probably armlets; the smaller may have been used to connect straps of leather for personal or equine purposes.

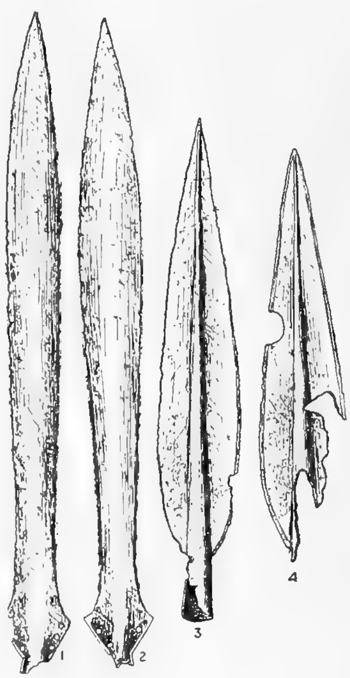

Fig. 6.
Bronze swords and spear-heads, found near Youghal, Co. Cork (1/6).

The interesting object of this find is the penannular ring (fig. 7, 13). Rings of this form, made of gold, are common in Ireland. In bronze or copper few examples are known, the Academy's collection containing, including the above, only twelve examples. A find made in 1907, at Mountrivers, Rylane, Coachford, Co. Cork,[3] included a copper penannular ring of this type, associated with two gold cup-ended rings, two socketed bronze axe-heads, and eleven amber beads; this shows that the gold and bronze or copper rings were in contemporary use, also that they may be dated to the latest phase of the Irish Bronze Age.

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[1] Armstrong, Journal Roy. Soc. Antiqq. Irel., xlvii, Pl. III, facing p. 26, No. 7.
[2] Evans, *op. cit.*, p. 389.
[3] Coffey, Proc. Royal Irish Academy, xxx, Sec. C, pp. 85–87.

The exact purpose these penannular cup-ended rings were intended to serve is uncertain. It has been considered that they passed as a form of currency,[1] on account of their similarity in form to the so-called African *manillas*, used as a medium of exchange by the natives of the West Coast of

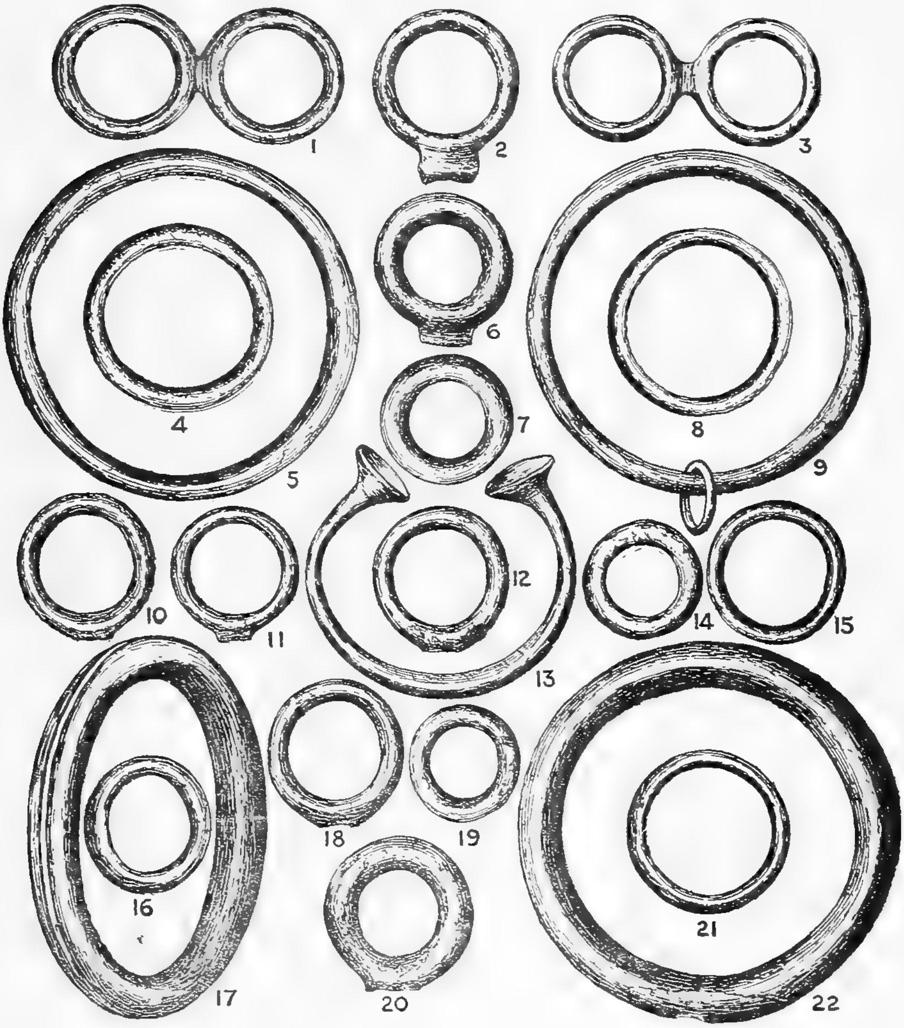

FIG. 7.
Bronze rings, &c., from Brockagh, Co. Westmeath (½).

Africa, the date of such *manillas*, as shown by the Benin castings, going back at least as early as the sixteenth century. Another view is that some forms of these rings were used as brooches for fastening the dress.[2]

[1] Betham, Trans. Royal Irish Academy, xvii, pp. 7–17 and 91–96; also Coffey, Bronze Age in Ireland, pp. 69, 70.

[2] Wilde, "Catalogue of Gold Antiquities," p. 59.

More recently it has been suggested that the type might prove to be related to the *Schwurringe* or *Eidringe* common in Northern Europe, which belong to about the same period as the Irish rings.[1] *Eidringe* have been dealt with in some detail by Olshausen.[2] They were so called from the belief that such rings, not considered to be made for practical purposes, were in ancient times used for swearing upon, this view being based on references to similar rings mentioned in the Icelandic sagas. A reasonable objection to this theory is that it seems unlikely to find mentioned in a saga probably of thirteenth century date a form of ring many centuries older.

If, however, rings of this type served in the late Bronze Age for taking oaths upon, it would show how deep-rooted in Ireland is the custom which in recent times caused so many Christian reliquaries to be used for the same purpose.[3]

The sixth find (fig. 8) consists of a leaf-shaped sword and a spear-head. The handle of the sword is broken. Both are labelled as found in 1892 by a peasant farmer in the bog near his cottage in Moolagh, Ardara, Co. Donegal. Belonging to ordinary types, they do not call for description.

The seventh find (fig. 9), registered under the year 1892, consists of a bronze socketed gouge and three rings; one of them (fig. 6, 3) having bugle attachments at the sides and transverse perforations. All are much patinated, and not well preserved. They were found together in Co. Fermanagh.

The eighth find (fig. 10), discovered near Glenstal, Co. Limerick, was acquired in 1901, through Sir Charles Barrington, Bart. It includes a socketed axe-head, a large bronze ring, two hollow rings with lateral projecting trumpet-shaped pieces, pierced by an opening from side to side, and a small flattish bronze ring. The large ring is hollow;

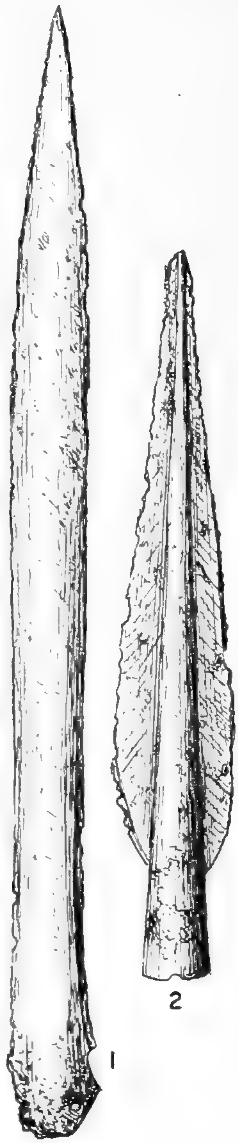

Fig. 8.
Bronze sword and spear-head found at Moolagh, Co. Donegal (About $\frac{1}{3}$).

[1] Smith, "Antiquaries' Journal," i, p. 70.

[2] "Zeitschrift für Ethnologie," 1890, pp. 294-297.

[3] The Bell Shrine of St. Seanan acquired by the Academy in 1919, through the

the joining on the inside can be clearly observed. Hollow rings with transverse perforations are by no means uncommon in Ireland; some attain a considerable size. Their exact purpose is obscure, though on the strength of a find containing some transversely pierced rings with a pin of ordinary Bronze-Age type, near Trillick, Co. Tyrone,[1] it has been suggested that such rings were used with pins to form a brooch or buckle. If so, they might be considered as forerunners of the penannular brooch, which became the ordinary mode of fastening the dress in the early Christian and later periods.

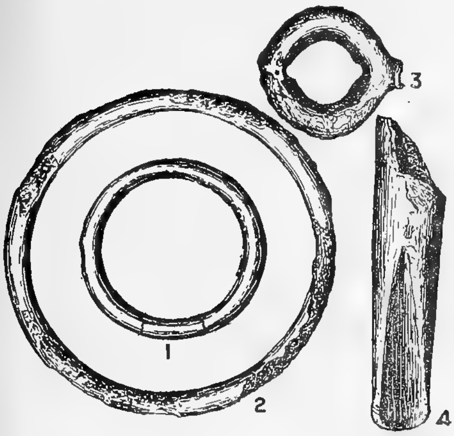

Fig. 9.

Bronze gouge and rings found in Co. Fermanagh (½).

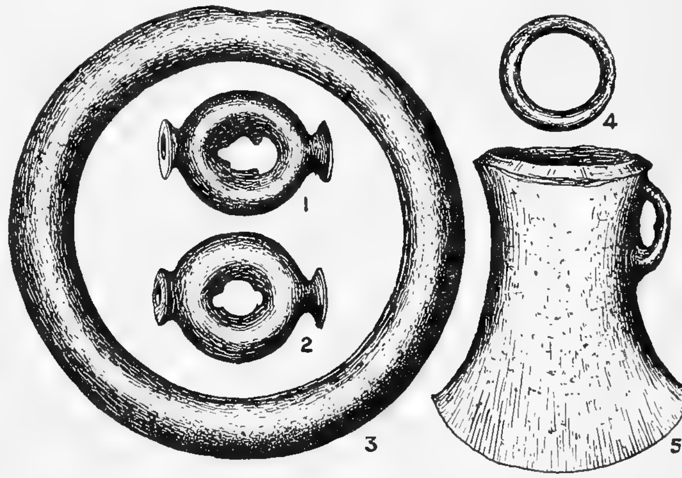

Fig. 10.

Bronze axe-head and rings found near Glenstal, Co. Limerick (½).

It may be noted that the socketed axe-head appears to have been imported into Ireland rather than there invented, for though axe-heads of this type are abundant, no example has been found decorated with the

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generosity of Mr. G. W. Panter, m.r.i.a., may be cited as an example, this shrine having been frequently sought by persons whose property had been stolen, and who wished to swear the suspected thieves. It was believed that a false oath taken upon the shrine was avenged by striking the perjurer with convulsions and death, or at the least with facial disfigurement and distortion (Westropp, Journal Roy. Soc. Antiqq., Irel., xxx, p. 240). The use of the *Domhnach Airgid* for a similar purpose will also be remembered owing to Carleton's description of the swearing on the "*Donagh*" in the story of the Horsestealers ("Traits and Stories of the Irish Peasantry"). The shrine of St. Lachtin's arm was also used for swearing upon (Todd, Proc. Royal Irish Academy, v, 463). For other examples, Petrie's "Round Towers," pp. 341, 342, may be consulted.

[1] Evans, "Bronze Implements," 1881, pp. 398, 399.

ornamental crescents recalling the outline of the winged axe-heads from which the socketed celts were evolved.

The ninth find (fig. 11), acquired in 1906 with the St. Columba's College collection, includes a small gold bulla, a socketed axe-head, a socketed spear-head, and two rings. All are stated to have been found together in 1840 in Kinnegoe Bog, Co. Armagh. The larger of the bronze rings threads a small ring which moves freely round it. The spear-head is leaf-shaped with a feathered edge; its socket is pierced for a single rivet. The axe-head is of ordinary type. The bulla belongs to the heart-shaped variety.

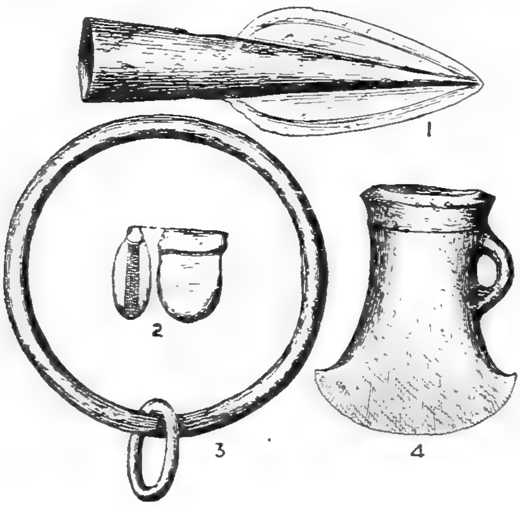

Fig. 11.

Gold bulla, bronze axe-head, spear-head, and rings found in Kinnegoe Bog, Co. Armagh (½).

Its front and back are plain; its sides are decorated with a broad band of twisted gold threads beaten into the surface; the edge of the socket being also ornamented with a small band. Four heart-shaped bullae, including the above, are preserved in the Irish National Museum. Another found in Co. Cavan is in the possession of Mrs. H. T. Clements.[1] The finding of the Kinnegoe specimen with objects of late Bronze-Age date suggests that the Irish bullae belong to this period. There are, however, objections to such a date, for the Etruscan and Roman bullae, from which it is probable that the Irish bullae were ultimately derived, belong to the Iron Age. The use of bullae persisted to late times, one having been discovered in the tomb of the

[1] Armstrong, "Catalogue of Irish Gold Ornaments," 1920, p. 43, and note.

French king Childeric (d. 481).[1] Until bullae are discovered in Ireland in attested and datable finds, no convincing date for them can be suggested.

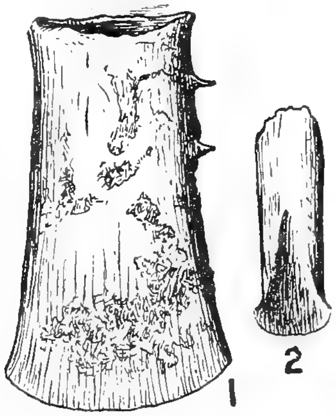

FIG. 12.

Bronze axe-head and gouge found at Boa Island ($\frac{1}{2}$).

The tenth find (fig. 12), acquired by the Academy in 1917, consists of a bronze socketed axe-head and gouge. Covered with a thick green patina, they are in a bad state of preservation. The axe-head, which is square in section at the mouth, has at one side the remains of a loop. The gouge has lost portion of its socket. They were found together at Boa Island, Lough Erne, Co. Fermanagh, by Mr. F. Johnson.

[1] The alleged finding of a bulla (now in the Academy's collection) with portion of a bell-shrine of eleventh-century date on the shore of the River Bann may also be mentioned. (See Reeves, Journal Roy. Soc. Antiqq., Irel., x, pp. 353–356).

IX.

A BRONZE-AGE BURIAL NEAR GALBALLY, CO. TYRONE.

By PROFESSOR R. A. S. MACALISTER, Litt.D.

[Read May 22. Published August 2?, 1922.]

Toward the end of March last I received a letter from Rev. P. McNelis, c.c., of Galbally, near Donoughmore, Co. Tyrone, informing me of the discovery of certain ancient graves in his neighbourhood, and inviting me to visit them. I was not able immediately to accept the invitation, but on the 25th of April I made my way to the place, and was guided to the site by Father McNelis, whose kind offices in the matter I wish cordially to acknowledge.

The graves, two in number, are situated on the top of slightly rising ground, in a field on the townland of Camoghy. They are cists, sunk in the ground, the cover-slabs being only just under the surface. These were frequently struck by the plough, of which they bear the marks, and were supposed by the farmer to be rock-outcrops; but this year in digging the field in order to set potatoes they were found to be movable slabs, and on raising them the graves were discovered below. Father McNelis was soon on the ground; and after he heard from me the first time, naming the date when I should visit the site, he instructed the farmer to watch the field to prevent intruders from interfering with the remains. This the farmer did at the cost of some trouble; but the remains as I saw them were not quite so perfect as when they were first uncovered. One of the urns was badly injured; several of the bones had disappeared, and, especially, a considerable number of the teeth were extracted from the skulls. I understand that there is a local belief that to extract the teeth of a skull with one's own teeth is either a cure for, or a prophylactic against, the agonies of toothache; and that this odd item of folk-medicine is responsible for the despoiled condition of the jaws of these very interesting specimens.[1]

Of the two cists, one, which I call *A*, was built of well-squared and close-fitting slabs. Its internal dimensions were 3 feet 4 inches by 1 foot $6\frac{1}{2}$ inches and 2 feet in depth. It was covered with a rather irregular

[1] Mr. W. G. Strickland has referred me to a parallel, described in *Journal*, R.S.A.I., xxii (1892), p. 187.

flat slab, 5 feet 2 inches by 3 feet 6 inches in dimensions. The long axis of the cist lay north and south. It contained the skeleton of a man, young or in quite early middle age, with at his head a food-vessel. This was broken when found, but the meddling of curious visitors had reduced it still further, and only the bottom was forthcoming when I arrived. When I saw the skull it struck me at once as being singularly brachycephalic for a Bronze-Age Irish skull; the jaw also seemed to me to be unsymmetrical, probably for some pathological reason. However, when I returned to Dublin I submitted the bones to Professor A. Francis Dixon, and obtained from him a report upon them, which I append.

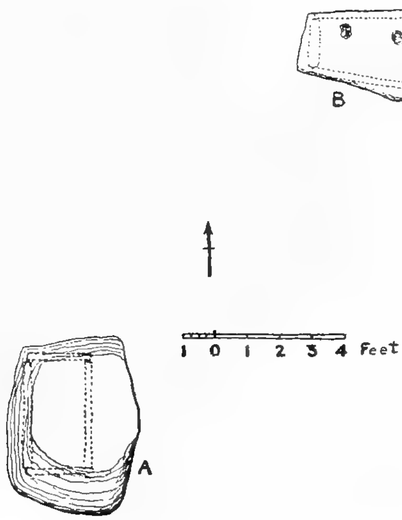

FIG. 1.—Plan of Cists.

The second cist, *B*, was 10 feet north-east of *A*. Unlike *A*, it lay east and west, and was not built with the careful regularity of *A*. On plan it was wedge-shaped, 2 feet wide at the broadest (eastern) end, tapering to 1 foot 6 inches at the other; the length was 3 feet 6 inches. The cover-slab was 2 feet 10 inches at the eastern end, tapering to 1 foot 8 inches at the western end; its length was 4 feet. Inside the cist was the skeleton of a girl of sixteen or seventeen years of age. The epiphyses of the joints had not yet adhered to the bones to which they belonged, and the wisdom-tooth was only just sprouting. At the head had been placed a well-made and well-ornamented food-vessel, apparently of rather late type. No other deposits were found in either cist.

On the cover-slab of cist *B* there were two cup-shaped depressions, one circular, the other a rather irregular oblong; but I could not satisfy myself that either of these was artificial.

As the material for studying ancient Irish osteology is still lamentably scanty, I purchased the contents of both cists from the farmer, and have now the pleasure of handing them over to the custody of the Academy. The farmer at first expressed his intention of removing the cists out of the way of his tillage, but after a little persuasion he at least promised to consider the possibility of filling them in, leaving the side stones in position, and removing the cover-slabs only.

The following are Professor Dixon's notes on the bones:—

A—A young adult male. *Skull* brachycephalic; length, 180; breadth, 150; cranial index, 81·8. All the sutures open. Parietal and frontal eminences prominent. A distinctly pentagonal outline presented by the skull when viewed from behind. The mastoid processes, which contained large air-cells,

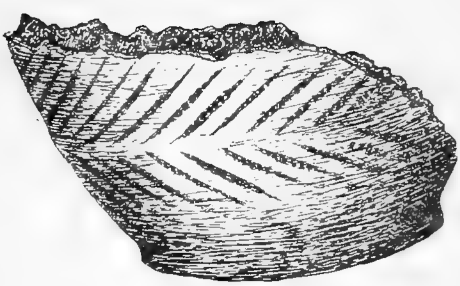

FIG. 2.—Food-vessel in Cist *A*.

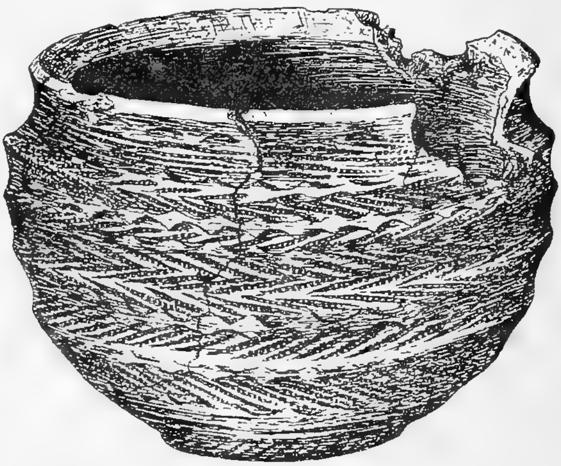

FIG. 3.—Food-vessel in Cist *B*.

are broken off. The muscular ridges of the occipital region and the temporal lines are not very well marked. The supraciliary ridges are moderate in development, and the supra-orbital triangle in the region of the zygomatic process of the frontal bone is well marked and flat. The lower part of the frontal region is nearly vertical, and the glabella is not marked. The fragment of the right maxilla contains the two right bicuspids and the first and second molars. The third molar has fallen out; judging from the socket, it must have been small in size with undivided root. The bone near the anterior nasal opening is missing. *Mandible*—Poorly developed; the ramus is rather small and narrow from the front backwards. The mandibular notch is deep. The basal part of the jaw is not well developed. On both sides the second premolar has been lost during life. The first on each side has fallen out and is missing, and the third molars have not erupted.

Portion of Dowris Hoard (below $\frac{1}{4}$).

Femora—The left femur is nearly perfect, but a part of the medial condyle is broken off. The length is 462 mm. (the average European length is 450–460). On the basis of the principle that the femur is 0·275 of the stature, this gives a stature for the subject of 1680 mm. (about 5 feet 6 inches). The diameter of the head is 44 mm., which is small for a male. The shaft is nearly straight, flattened in the upper part, and has a well-marked lateral flange; there is a small ridge in the upper part of the gluteal line. *Tibiae*—The length, omitting the spine and malleolus, is 366 mm.; the bone is flattened laterally, the anterior-posterior diameter being 30 mm., the transverse diameter 20 mm, at the level of the nutrient foramen. Owing to the broken condition of the lower end, the presence or absence of the squatting facet cannot be determined. The index of proportion between tibia and femur $\left(\frac{T \times 100}{F}\right)$ is 85·7; the average European index is 83; the tibia is, therefore, longer in proportion than in a normal European The *humerus* has lost its upper end. There is a well-marked epitrochlear foramen.

B—A young subject, most probably female, under twenty years of age—probably about seventeen. *Skull*—Bones thin, all the sutures open, and simple in character. The basilar synchondrosis is open; the mastoid process is small, the forehead vertical, with well-marked frontal prominence, but no superciliary ridge. There are grooves for the supraorbital nerve on the frontal bone. The muscular impression and lines are feebly marked. The palate is rather long and narrow, with no crowding of the tooth sockets. All the teeth of the upper jaw are lost except the third molar, which is still in its crypt. The length, as nearly as can be measured, is 175, the breadth 136, giving an approximate cranial index of 77·7. The *mandible*, unlike that of the man, is strongly developed, the ramus being wide from before backwards; the notch is shallow and wide. The mental eminence is small. The teeth as a whole are well developed and not much worn; the third molar is still in its crypt. *Right humerus* exhibits upper end of diaphysis; the epiphysis, which is not united, is missing; lower end imperfect. Of the *left humerus* only the shaft is preserved. The upper ends of the *femora* are broken off; the lower ends show that the epiphyses had not united to the shafts. We thus have no material for estimating the stature of this subject.

In a letter to me Professor Dixon says:—"I feel that the form of the [male] cranium is rather surprising. The lower jaw of the female is of the type one would expect in a prehistoric Irish skull; that of the male is not. The vertical forehead in both skulls is striking."

X.

THE SIGNS OF DOOMSDAY IN THE SALTAIR NA RANN.

By ST. JOHN D. SEYMOUR, B.D., Litt.D.

[Read November 30, 1922. Published January 26, 1923.]

It was held in medieval times that the coming of the Day of Doom would be announced to mankind by a series of awe-inspiring portents, "wonders in the heavens and in the earth," on the fifteen days preceding the *Dies Irae.* This belief was widespread throughout Europe. Miss L. T. Smith, in her *Commonplace Book* (the Book of Brome), p. 70, says that "a Greek acrostic, which was embodied by Lactantius in his *Divina Institutio*, and translated by St. Augustine into Latin hexameters, seems to be the original source of the narration of the fifteen definite signs of Doom." Frequently these signs are attributed to St. Jerome, who is said to have found them in the "Annals of the Hebrews." Lists of these signs are to be found in numerous manuscripts. Mr. J. E. Wells, in his most helpful *Manual of Middle-English Writings* (Oxford and Yale, 1916), p. 328, distinguishes six groups, which he terms :—Augustinian-acrostic (Migne, P. L. xli, col. 579); Bede (P. L. xciv, col. 555); Comestor (P. L. cxcviii, col. 1611); Aquinas (St. Thomas Aquinas, *Liber Sententiarum* (Venetiis, 1586), lib. iv, dist. 48, quaest. 1, art. 4); Old French; Miscellaneous. Of these the Augustinian is the least important, except in so far as it is supposed to be the *fons et origo* of all the others. Bede and Comestor are closely related. The Old French group, which is said by Wells to go back to a twelfth-century French poem, differs considerably from these, and is much fuller. An example of it may be found in the fourteenth-century Northumbrian poem *Cursor Mundi* (ed. R. Morris, Early English Texts Soc., p. 1283). Aquinas seems to stand midway between the Bede-Comestor groups and the Old French. Of the group which Wells terms "Miscellaneous" he does not give an example.

But there is another group of signs, seven in number, to which we must now turn our attention, for it is of extreme importance to us, as an example of it occurs in early Irish religious literature, namely, in the *Saltair na Rann.* That poem properly consists of 150 cantos, in imitation of the Biblical Psalter. But added on to the end of it are twelve additional cantos, in a different metre. Through ten of these the seven signs are distributed, with the natural result that some of them are curiously misplaced. Miss Mary E. Byrne, B.A., has very kindly translated these ten cantos for me. She quotes Dr. Whitley Stokes's remark that in these poems the sense is so completely sacrificed to metrical requirements that the meaning is very obscure and unintelligible. This, unfortunately, seems to be only too true. So I shall now only give briefly the salient points in each of these ten cantos, i.e., Cantos CLIII–CLXII, for Cantos CLI–CLII are merely religious poems of no particular interest.

Canto CLIII (lines 8017–8052).—First day. Sunday before Doom. There will be a warlike (?) din, with horrible cries. There will come a red fiery cloud from the north, which will spread over the earth, out of which a bloody rain will fall on the world. At tierce this shower begins, and does not cease till mid-day. Then come lightnings, thunders, and hail. From mid-day to nones there is a shower of thick blood. There are earthquakes. The sea with all its living things crosses over its ramparts.

Canto CLIV (ll. 8053–8076).—Second day. Monday. Hosts will be agitated. Heaven will tremble around the earth. The waves of the sea beat against the coasts. Beasts and monsters roar. There is wailing and lamentation throughout the world. Robbers will strike off palms off hands. No restful peace.

Canto CLV (ll. 8077–8100).—Third day. Tuesday. The Lord will press in [check or arrest (?)] the circuit of His elements. The foundations of the world will melt. Stones will tremble, and be broken up. There are red fiery clouds going round the world. A stream of sulphur-fire comes from the corners of the earth. The world will be a mass of flame from East to West. A slanting (?) mist of vapour will fill every constellation.

Canto CLVI (ll. 8101–8148).—Fourth day. Wednesday. Wailing, which shakes the whole earth. The sea rises up, and gives a shout. The sea-monsters bellow as they are left high and dry. The sea subsequently goes back again. Winds uproot the woods, and carry them up into the air. Flocks of birds swoop down upon the food of the earth. There are showers of hail and blood. Men declare, "Better for us is death than life." Heaven will be bent, and will be crushed against the earth.

Canto CLVII (ll. 8149–8176).—Fifth day. Thursday. Great thunder. The stars will be destroyed. Every created thing is sad. Hosts of stars will fall down from their seats. The sun and moon will be quenched. There is hideous weeping, intense gloom, and showers of hail.

Canto CLVIII (ll. 8177–8200).—Sixth day. Friday. Every living creature will die. There will be hail and lightning. The doors of Heaven will be opened. "The holy ones and the holy angels in the swift wide flame, as regards every fair cause they are free as fish in the sea."

Canto CLIX (ll. 8201-8225).—Seventh day. Saturday. The world trembles. There is lightning (?). The streams dry up. The mountains will be overthrown, and will be shattered to pieces. Some obscure incident occurs, perhaps an earthquake, as a result of which "there will be no habitations among the living and the dead."

Canto CLX (ll. 8226-8280).—Eighth day. Sunday. The Archangel calls to the race of men, who arise in the following order:—(1) The Apostles. (2) The Prophets. (3) The Confessors. (4) The Martyrs. (5) The hosts of Holy Ones. (6) Virgins, Penitents, and infants after baptism. (7) The rest of mankind. The seven heavens will be bowed [folded up (?)], and will be aflame from East to West. Christ will appear with His bloody cross at His back.

Canto CLXI (ll. 8281-8302).—Eighth day (continued). Sunday, *after* the Resurrection. The devils come out of Hell, and fill the whole world. The idols fall. The foundations of the world are moved.

Canto CLXII (ll. 8303-8392).—Ninth day. Monday of Doom, i.e., the Judgment Day. The angels give battle to the devils, and defeat them. Judgment is passed. The righteous go to Heaven, the sinners to Hell.

In Anglo-Saxon literature there is a seven-sign list which closely resembles in subject the above cantos of S, as I shall term it for convenience sake. This is to be found in one of the Blickling Homilies[1] (hereafter termed B), a series of religious writings, the unique MS. of which was written in the year 971. I shall now give this briefly, and shall put in italics the portions that correspond to passages in S. It will be noticed that the order of events is not identical in both, and where a difference occurs I shall indicate the position of the corresponding portion in S by putting S 1, S 2, etc., as the case may be, after the sentence in italics.

First day.—*At mid-day*, a great *lamentation of all creatures* (S 2, S 5), and men shall hear *a great noise* in Heaven *as of an army being gathered together. Then shall ascend a bloody cloud from the north*, and cover all this heaven, and *after the cloud shall come lightning and thunder* all day. *And in the evening there shall be a bloody rain* (also in S 4).

Second day.—There shall be heard in Heaven a sound of *the arraying of armies. Earth shall be moved out of its place* (S 8). Heaven shall be open at its eastern quarter. At evening a great host shall come from the open end, and obscure the heaven. *A bloody*, fiery *rain shall fall* (S 1, S 4). *The heaven*

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[1] R. Morris, *Blickling Homilies* (E.E.T.S.), pp. v, 90.

shall fall to the four corners of the earth (S 4), and the earth shall be overwhelmed with darkness at the eleventh hour of the day.

Third day.—The North and East parts of the earth shall speak to each other. *The Deep will rage* (S 1), and will devour the earth. All the powers of the earth shall be changed, and *there will be great earthquakes* (S 1).

Fourth day.—*There are mighty thunders in Heaven* (S 5). *All the idols fall* (S 8). *The moon shall be quenched* (S 5). *Darkness shall come over all the world* (S 5). *The stars all day shall run across our sight* (S 5).

Fifth day. *The Heaven shall burst* (S 6) from the East to the West. Angels will look through the opening at mankind, who will run and hide themselves.

Sixth day.—*The world will be filled with evil spirits* (S 8), who will endeavour to take men's souls. Afterwards Michael *will slay them* (S 9).

Seventh day.—Michael has the four trumpets blown for Resurrection.

S and B are closely related in date. The latter, as we have seen, assumed its present form in 971. The main portion of the *Saltair na Rann* does not appear to be later than the year 1000; while from the style of the language it would seem that the twelve additional cantos were written not many years after that date. It is clear that S and B are also closely related in subject. There are some slight differences indeed between them. The order of events is not the same in both. S has transferred some of the signs to the period after the Resurrection. The two distinct showers of bloody rain in S 1 are apparently based on the similar incidents in the first and second days of B. These are minor details, however, and do not affect the conclusion that there is a close connexion between our documents.

Is the one derived from the other, or may both be referred back to some common source? The latter seems most probable, for there is in existence a much older seven-sign list, which may have furnished an origin for both of these. This is the obscure *Apocalypse of Thomas,* which dates from at least the end of the fifth century, and which has come down to us in several manuscripts, though always in an incomplete form. I make use of the text of this which Dom. Bihlmeyer has published in *Revue Bénédictine* (July–October, 1911), pp. 270–282. It will be necessary, for purposes of comparison, to translate the greater portion of it here—no easy task, as the Latinity is strange. The passages in it which correspond to parts of S I have, as before, put in italics. I shall hereafter refer to this Apocalypse as A.

First day. *Third hour.—There will be a great and strong voice* in the firmament. *A bloody cloud arises from the North. Great thunder and lightning* follow it. *The cloud will obscure the whole sky* [spreads over the whole world, S 1]. *A bloody rain* [and fire] *will fall* on the whole earth.

Second day [no hour given].—There will be a great voice in the firmament. *The earth will be moved from its place* [earthquakes, S 1]. The gates of Heaven will be opened in the firmament from the East. The smoke of a great fire will burst through the gates of Heaven, and will cover the entire sky till evening. *There will be fear and trembling in the world.*

Third day. Third hour.—There will be a great voice in Heaven. The abysses of the earth will groan from *the four corners of the world. The wings of the firmament will be closed* [*reading* operientur. This seems to correspond to the passage in S about the Lord checking the circuit of the elements]. *All the air will be filled with columns of smoke.* There will be an evil stench of *sulphur* until the tenth hour. *Men will say, "We deem the end is near, that we may perish"* (S 4).

Fourth day. First hour.—*The abyss* on the East of the earth (?) *will become liquid* (S 3), and will bellow. [*Or, according to another reading,* the earth on the East speaks, and the abysses groan.] Then *the entire earth will be moved* [by wailing, S] by the virtue of the earth. In that day *the idols* [adornamenta, *another reading is* idolas] *of the nations will fall* (S 8). *All the buildings of the earth will be moved* (S 7) by the virtue of the earth.

Fifth day. Sixth hour.—*A great thunder in Heaven,* and the virtues of light. *The disk of the sun will be obscured* [*reading* operietur]. There will be *great darkness* till evening. The air will be sad *without sun or moon. The stars will cease from their ministering.* In that day all peoples will see it so, as in a bag (?), and they will despise the life of this age.

Sixth day. Fourth hour.—There will be a great voice in Heaven. *The firmament will be split* from the East to the West, and the angels will look through the aperture at the earth. All men will see the hosts of angels, and will fly to the tombs to hide themselves from the sight of the holy angels, and will say, "Would that the earth might open, and swallow us up." [Here follows in Bihlmeyer's text a long interpolated passage. Christ comes. At His coming the fire which encloses Paradise will be released. (Is the passage in S 6 dealing with the angels in the flame based on this?) It is an everlasting fire, which consumes the earth and all the elements of the world. The spirits and souls come forth from Paradise, and return to their bodies, and each will say, "Here was placed my body." When their voice is heard *the earth will be moved* (S 7), and by the virtue of the earth there is *movement over the mountains* (S 7), and *the rocks are split* (S 3) from below. The bodies of the dead are raised, and are clad in garments made of a cloud of light. For a cloud descends from the higher kingdom of Heaven, and surrounds with its beauty all the souls that believe in Christ. Then they are clad with it, and go rejoicing to Heaven. But it is important to note that in one of the MSS. which Bihlmeyer uses this passage stands at the end of the eighth day.]

Seventh day. Eighth hour.—There are voices in the four corners of Heaven. All the air will be moved, and will be filled with holy *angels, who make war among themselves* (i.e. the good with the evil, as in S 9) the whole day. The elect will seek in that day from the holy angels with respect to the destruction of the age.

Eighth day. Sixth hour.—A sweet and gentle voice is heard in Heaven from the East. Then the angel who has charge over the holy angels will make manifest (or announce publicly), and with him will go all the angels sitting on chariots of clouds to set free the elect.

From what has been already said it can be seen that the writer of S knew and used the Blickling Homilies. Apart from the general resemblance, there are certain passages in S which are found in B, but not in A. For example:—The raging of the sea in S 1 and B 3; the heaven falling against the earth in S 4 and B 2; the coming of the demons out of Hell, their spreading over the world, and their subsequent defeat in S 8 and 9 and B 6. On the other hand, it may safely be said that S also knew and used A. Three arguments support this. (1) The many points of coincidence between the two documents, more especially in the events of the first, third, and fifth days, which are nearly identical in both. (2) There are certain points in S which are found in A, but not in B. For example:—The sulphur-fire, and the mist of vapour filling the sky in S 3 and A 3; the statement made by mankind in S 4 and A 3; the absence from the sky of the sun and moon in S 5 and A 5, whereas the moon only is quenched in B 4. (3) The *Apocalypse of Thomas* was known in Anglo-Saxon England. It is admitted by those competent to speak on the matter that the Blickling Homilies show numerous traces of its influence, as does also a Hatton MS.; while it is said that what is practically a version of the *Apocalypse* is contained in the Vercelli Book.[1] Now when we bear in mind the numerous points of connexion there are between Irish and Anglo-Saxon religious and homiletic literature, it may safely be said that if the *Apocalypse of Thomas* was known in England in the latter half of the tenth century, it would also have been known in Ireland about the same date. Thus we may conclude that the writer of the additional cantos to the *Saltair na Rann* had a first-hand knowledge of the *Apocalypse*. Had he not been so hampered in his desire to fulfil the metrical requirements, we might have been able to find other points of resemblance between the two documents.

[1] Dr. M. R. James has kindly given me a reference for the last two, viz., Max Förster, *Studien zur Engl. Philologie* (Halle, 1913). Heft 1. *Der Vercelli Codex*, cxvii.

But something more may be said. Leaving out of consideration Canto CLX, the writer of S distributes his signs over *nine* days, and so makes some of these appear *after* the Resurrection, whereas one would naturally expect that they would occur earlier as precursors of that event. Why does he adopt this curious order? I would venture to put forward the following suggestion as an attempt to solve this problem. The writer of S had before him a version of the *Apocalypse* in which occurred the long interpolated passage dealing with the coming of Christ, the fire of Paradise, and the robes of light; but this stood, not after the events of the sixth day, but at the very end of the document, after the events of the eighth day, as is actually the case in one of the manuscripts which Bihlmeyer uses. This interpolation contains items which might be classed as "signs," two of which the writer of S uses in his seventh day, and another perhaps in his third day. So the existence of such a long passage in such a position in his original may have suggested to the mind of the writer of S the idea of lengthening out his signs over two extra days. If this be correct, it may be said that not only did the writer of S know at first hand the *Apocalypse of Thomas*, but that he made use of a version of it in which the long interpolated passage stood at the end of the eighth day. And this conclusion, I believe, adds a further item to our knowledge of the extraneous literature read in the schools of Ireland nearly a millennium ago.

But this does not conclude our examination of the subject. There is matter in S which is not to be found either in A or in B. Such is:—The roaring of the beasts and monsters (S 2); the uprising of the sea, leaving its inhabitants high and dry till its return; the bird-flocks assailing the food; the winds uprooting the woods (S 4); and perhaps the breaking of the stones (S 3). But it is remarkable that, with the exception of the action of the bird-flocks, which resembles a passage in Aquinas, all these find more or less close parallels in the Old French group of fifteen signs, which is said to go back to a twelfth-century French poem, and of which the *Cursor Mundi* affords an example. Indeed, the latter group contains signs which occur in our seven-sign group (viz., A, B, and S), but not in any of the other fifteen-sign groups. Such are:—The bloody rain, the detailed destruction of the stars, the extinction of both the sun and moon, the opening of Heaven, and the escape of the devils from Hell. I am not competent to deal with so vast a question as the relationship between the seven-sign and the fifteen-sign groups. But this much at least may be said. The Old French (*Cursor Mundi*) group of fifteen signs is closely connected with our seven-sign group, not merely in subject, but in the arrangement of the signs, i.e., it has, as a rule, *several* events occurring on each day, while Bede, Comestor, and Aquinas have, as a rule, only *one* event occurring on each day. Thus it would seem to me that the origin of all the groups of fifteen signs may be referred, not so much to the Augustinian acrostic poem as to the obscure *Apocalypse of Thomas.* Our Irish list of signs in the additional cantos of the *Saltair na Rann* is of peculiar interest, in that it seems to serve as a connecting link in subject, and perhaps in time also, between the seven-sign and the fifteen-sign groups. And at this stage I must leave the problem for others to elucidate.

For completeness' sake I may add the following. The fifteen signs were well known in Ireland, as one would only expect. Miss Byrne has translated one for me from the *Liber Flavus Fergusiorum*, i, 12r. This follows Comestor. Another list is embodied in the modern recension of the *Ever-New Tongue* (*Revue Celtique*, xxviii, pp. 304–5). This follows Bede. A third has been published by Dr. Whitley Stokes (*Revue Celtique*, xxviii, pp. 308–323). This seems to follow Aquinas, with many items from the Old French. But it is of interest, in that it has also made use of the signs in the *Saltair na Rann.* Its ninth day before Doom is clearly based on S 1; in its seventh day before Doom it mentions "the streams of fire from the flanks of the earth," as in S 3; it gives the list of the various resurrections, and mentions the Seven Heavens, and the cross on Christ's shoulder, as in S, Canto CLX. Another document in *Liber Flavus*, ii, 32 [42] v, commences with eight quatrains on the Day of Judgment, in which the description of the battle on the Monday of Doom between the angels and demons is almost word for word with the matter in Canto CLXII of S.

A list of signs is to be found in the Lismore version of the *Ever-New Tongue*, published by Dr. Whitley Stokes in *'Eriu*, vol. ii. From the style of the language its editor thinks that it may be ascribed to the tenth or eleventh century. If so, it is even earlier than S. The signs occur on pp. 137 and 139. The writer of them is not concerned to give a formal list of the same, in consequence of which he makes no mention of definite days, while he interpolates matter not altogether relevant (sects. 127, 134). I give the signs here briefly in sections as in the original:—

122 *The bursting of* 365 fiery *mountain-ranges* (S 7).
123 *The tottering and crashing of the* five *heavens at bowing them to earth* (S 4).
124 The rising and roar of the seven fiery winds out of the poles of heaven at the noise and approach of *thunder and lightning* (S 1).
125 *The falling of* 3,375 *stars* (S 5).
126 *The moon* turns to blood. *The sun's light fails* (S 5).
(127 Only God can reckon the host of heaven at Doom.)
128 *Forests* and mountains *levelled by a* fiery *tempest* (S 4).

129 *Beasts and living creatures cry* (S 2).

130 The hurling down of fire on every land.

131 *The birds* (S 4) scream at the streams of fire.

132 *The roaring of sea-monsters and fish at the ebbing of the ocean* (S 4), and before the heating of the fire.

133 *The nine orders of angels come* (S 8). There is shouting and chorusing of the souls as they go to meet their bodies in the clay.

(134 The too-late repentance of sinners.)

135 The shout of the dwellers in Hell [the devils] at casting forth souls to the assembly for judgment (cf. S 8).

136 *The crashing of the seven heavens at being thrown down through blasts of fire* (S 8).

137 *The shaking of the earth at being turned up and over* (S 8).

138 Sinners and devils are locked in Hell.

This contains many points of connexion with S, which I have italicized. In form it also agrees with it in that it puts two of the signs (sects. 136, 137) *subsequent to* the coming of the angels, these two corresponding to those in S 8; while the section (135) dealing with the dwellers in Hell may be an echo of the passage in S 8. In sect. 133 the shouting of the souls, and their going to the place where their bodies lie, seem to indicate that the writer was acquainted with the interpolated passage in the sixth day of the *Apocalypse of Thomas*. To the moon being turned to blood, the fall of a definite number of stars, and the allusions to the fiery winds there are parallels in the *Fifteen Tokens* published in *Revue Celtique*, xxviii, p. 308, already mentioned.

There is a list of seven signs given by Wright in his *Poems of Walter Mapes*, p. 347, which dates, he says, from the first quarter of the fourteenth century. It is not of much importance. There is another seven-sign list, probably late, which I have been unable to consult. It may be found in Suchier, *L'enfant sage* (Dresden, 1910), p. 272. This reference I owe to Dr. M. R. James.

There is but one list of three signs known to me, which is not without interest. It occurs in a series of fragments attributed to the Priscillianist heretics; these have been published in *Revue Bénédictine* (July, 1907), p. 325. It runs as follows:—

First day.—Snow and hail come on the earth, with great thunderings from the terrible trumpet, and the dead arise.

Second day.—The sea will be dried up.

Third day.—Heaven will be opened from the East to the West. Sinners will fly, and will ask the hills and mountains to fall on them and hide them. Then Christ and the hosts of angels come.

One of these Priscillianist fragments was certainly known in Ireland, as it seems to have furnished the original from which were taken the descriptions of the Seven Heavens so frequently found in Irish literature.[1] It is also possible that this three-sign list was known to the writer of S, and may have suggested to him the drying up of the streams in his seventh day, as well as the shower of hail, which last item he introduces no less than four times.

[1] This has been dealt with by me in an article in *Zeitschr. für Celt. Phil.*, xiv, 18-30.

XI.

PLACE-NAMES AND ANTIQUITIES OF S.E. COUNTY CORK—BARONY OF BARRYMORE.

Part III.

By REV. PROFESSOR PATRICK POWER.

[Read April 12, 1920. Published February 5, 1923.]

Owing to the present expense of printing, &c., it has been necessary to reduce considerably the matter originally embodied in the present paper. Dunbullog, for instance, though the largest and, from our present point of view, most interesting parish in the barony, is entirely omitted. Dunbullog, however, does not form portion of the historical Barrymore; traditionally and ethnologically it is part of Muskerry, from which, for purposes of assessment and civil administration, it has been cut off within the last hundred years.

Parish of Dungourney.

The parish name, which is not of ecclesiastical origin, signifies Guairne's Fort. Almost certainly the dun site was on the partly isolated rock, subsequently occupied by a castle. This is on Castlequarter, where the later stronghold of the Barrys was strategically pitched upon the summit of a rock, now partly cut away by the public road. Neither dun nor castle has left any appreciable remains. As regards its place-names and antiquities, the parish is well up to the average in interest. Lioses and dallans are numerous; there are a few holy wells, the site of an ancient castle, and at least one cillín site.

Eight townlands of the parish lie within the neighbouring Barony of Imokilly, under which they will be found treated.

The ancient church has left no remains; it stood, no doubt, on site of the present Protestant church, in the small, uninteresting cemetery which surrounds the latter. Some ruins of the church survived in 1774 (Brady, "Records of Cork, Cloyne, and Ross," under Dungourney).

TOWNLANDS.

BALLYDONAGHBEG, Baile Dhonnchadha Beag — "Donnchad's Little Homestead."

Ballydonaghe (Inq. Jas. I).

On Edmond Colbert's farm is a fine lios, with double rampart, in rather good preservation but the inner ring is more or less obliterated. The outer rampart is about 5 feet high. Area, 177 A.

S.D. Bothar na Sop—"Road of the Wisps." This is a name of rather frequent occurrence. I imagine it is applied because in narrow roads, overhung by hedges, wisps of hay, straw, &c., get pulled out as laden carts come through at haymaking and harvest seasons.

BALLYDONAGHMORE. See last.

By side of main road, on Kelleher's farm, there stands a noble lios of unusual size and strength. It has three lines of concentric rampart, and two intermediate trenches, each 15 feet wide, all enclosing a central court, about three-fourths of an acre in extent. Two of the enclosing ramparts are about 12 feet in thickness by 4 to 6 feet high, but the outermost has, unfortunately, been almost entirely levelled. Area, 438 A.

S.D. Seana Mhuileann—"Old Mill."

BALLYMARTIN, Baile Mhártain—"Martin's Homestead." On Staunton's farm there is a small circular lios, single-ramparted, about 8 feet high. There is also a holy well and a cillín site. Area, 569 A.

S.DD. Tober na Killeen (O.M.), Tobar a Chillín—"The Little Church Well." This is the holy well above alluded to. It is a small stone-lined basin, by side of a stream at bottom of a glen, on Richard Daly's farm. Overhead, on branches of an aged ash-tree, hang various votive offerings of the usual kind. There is, however, neither trace nor tradition of the name-giving cillín. The chief day of devotion is August 15th.

Bárr a Bhaile—"Top of the Village"; a sub-division of 160 A.

An Coimín—"The Commonage"; a cross-roads.

Loch Ruadh—"Red Pool"; a pond—not constant.

Bóithrín na Sliogán—"Little Road of the Shells."

Crosaire an tSaighdiura—"The Soldier's Cross-roads."

Seana Bhaile—"Old Homestead"; a field.

BALLYNAGAUL, Baile na nGall—"The Foreigner's Homestead." Area, 109 A.

Ballingulla (Inq. Jac. I); Ballingaule—D.S.

BALLYNACOLE, Baile Niocóil—"Nicol's Homestead." Area, 320 A.

S.DD. Seana Bhaile—"Old Homestead"; a sub-div. of about 20 A.

Ceathramha an Tighe Mhóir—"Great-House Quarter"; another sub-div.—110 A.

Bárr and Bun a Bhaile—Top and Bottom, respectively, of the Village.

Boithrín Gheata na Laidhre—"Fork-Gate Little Road"; an old, very narrow road, running north and south over hill.

Field names:—Páirc a Leasa, Páirc an tSuaig (the Rope Field), Páirc a Chlampair (Field of the Law Suit).

BALLYNONA, Baile Inneone; etymology unknown. Inneone may possibly be na Inneona (of the anvil); but I think the equation very unlikely. The only antiquities are three wells—one with legendary, the other with devotional, associations. Area, 110 A.

Ballynony—D. Survey.

S.DD. Ladywell (O.M.), on S. boundary. "Rounds" were made on Aug. 15th, on which day also a pattern was held. The assembly finally degenerated into an occasion of faction fighting, &c., and this abuse led to its suppression. The well is in an unenclosed patch of waste ground, quite by the roadside, and some 2 feet or 3 feet below the level of the roadway. A few votives still hang from branches of the alder-tree which overshadows the well.

Tobar Ghuirt na gCros—"Garden-of-the Crosses Well." A place named Gortonocros, site of a cemetery, is mentioned in the "Rotulus Pipae Clonensis"; but it does not seem to be identical with the present.

CASTLEQUARTER, Ceathramhna an Chaisleáin—Idem.

Castlene Cally Quarter (Deps. 1652).

There are two good lioses on the farm of Edmond Aherne. One—the most westerly—has been partially levelled; it was of moderate size and single-ramparted. The second lios, also of moderate size, has a double rampart, 6 feet high. As its name suggests, the townland was also the site of a castle. Only insignificant remains of the latter survive. It was built on the summit of a cliff, some 30 feet or 40 feet high. Around the base, on two sides, flows a stream, and a modern road cuts through portion of the rock. Area, 311 A.

S.D. Ceathramha na bPréachán—"The Rooks' Quarter"; sub-div. of 50 acres, so called from presence of a rookery there.

CORBALLY. See townlands of the same name under Parishes Ardnageehy, Ballydeloher, &c., *antea*. The O.M. records one square lios of medium size, but this does not now exist. Area, 324 A.

Ballincoalig als Corbally—Ancient authority quoted by Field Book, Ord. Survey.

S.D. Páirc na Faidhrach—"Field of the (natural) Trench"; compare Firies, Co. Kerry, &c.

Cottstown, Baile Chotaigh—"Cott's (or Codd's) Homestead."

Cottstowne (D.S.).

There is one circular lios of medium size on John Griffin's holding. A well on the same farm is reputed holy, and "rounds" were formerly made at it. Area, 198 a.

Dungourney, Dún Guairne—"Guairne's Fort." The name-giving fort, I have little doubt, was the dun upon which the castle (Castlequarter) was subsequently built.

Dungorn—Tax. Pope Nic., 1303; Dun Gorney (D.S.).

On Colbert's farm was a chambered lios, now obliterated. Area, 303 a.

S.DD. Affane, Áth-Mheadhon—"Middle Ford"; a sub-division embracing about 180 a.

Bóthar na Naomh—"Road of the Saints."

Abha Óguilte: name of a stream; I cannot interpret it.

Páircín a Chúigir—"Little Field of the Five Persons"; in explanation of the name I heard again the extraordinary legend related in connexion with a similar name at Glennaglogh, Co. Waterford. ["Place Names of Decies," Power, p. 46.]

Glebe. No Irish name. The church and churchyard are on this division. Area, 14 a.

Glenbeg, Gleann Beag—"Little Glen."

There are two lioses, one each, on Kent's and O'Donovan's holding. The first is, or rather was, of medium size and circular plan, and the other is of large size and circular plan, and ramparted to height of 8 feet or thereabout. Area, 442 a.

Knockanemore, Cnocán Mór—"Great Little Hill." Area, 80 a.

Rathfootera, Ráth Fuataire—"Fuataire's Rath"; there is no trace of the eponymous rath. Area, 179 a.

S.DD. Stuaic—"Stack of Rock"; a sub-division, 96 acres in extent. The name is commonly applied to the whole townland.

Bán a tSamhaidh—"Field of the Woodsorrel."

Rathorgan, Ráth Argáin—"Argain's Rath." The name-giving monument, a fine specimen of its class, survives on Crowley's holding; it is circular in plan, over an acre in area and double-fossed, but one of the ramparts has been levelled. Area, 323 a.

Rathorgane (D.S.).

S.DD. Leaca Theas and L. Thuaidh—South and North Glenslope respectively.

Páircín a Dalláin—"Little Field of the Pillar-stone"; the field adjoins the lios, but the pillar-stone has disappeared.

Sandyhill, Cnoc na Gainmhe—Idem. The sole antiquity is a pillar-stone of conglomerate, 4 feet by 4 feet by 3 feet. Area, 325 a.

S.DD. Slievecorran (O.M.); the name is unknown locally for any part of the present townland; it is, however, applied to the cairn-crowned hill on the neighbouring Gurteen townland.

Cnocán Mor—"Great Hillock"; a sub-division of some 60 acres.

Páirc a Dalláin—"Field of the Pillar-stone," in which stands the monument already mentioned, on Mulcahy's farm.

Sheepwalk, Talamh na gCaorach—"Land of the Sheep."

S.D. Abha Beag, "Little River," a stream which flows through.

Young Grove, Garran Mhág; meaning unknown. On Turpin's farm is a pillar-stone giving name to a field. Area, 577 a.

S.DD. Coc, "Head Tuft," a hill-top.

Páirc na Cloiche—"Field of the Pillar-stone," on Dr. Turpin's farm.

Parish of Gortroe.

This is a parish of large extent, embracing a considerable area of undulating country on south side of the Bride river, as well as two or three townlands to north of latter. The parish gets its name from a townland sub-denomination, on which stands the ancient church. There is one very remarkable holy well and several cillín sites, besides the usual lioses and pillar-stones. From the well-known holy well at Garrantaggart the whole parish is popularly known as Bartlemy, and sometimes Irish speakers refer to it simply as Paróiste an Tobair.

Townlands.

Ballinterry.—I got the Irish form—Baile an Teiridhig — "Terry's Homestead"; but the more common name is Baile na Draoidheacht, which seems to signify homestead of the witchcraft or magic. Possibly the official name is derived from David and Edmund Tyrry, Archdeacons of Cloyne (1520 and 1521 respectively); Gortroe, part of the townland of Ballinterry, belonged to the corps of the archdeaconry. On the townland stands the ruined church within its ancient graveyard. Unfortunately, the ruin lacks architectural features, which would enable one to gauge its period without hesitation. Generally, it appears modern—seventeenth century (?); the dimensions are 48 feet by 20 feet. Both gables stand; but part of one (south) side wall has fallen. The west doorway has been closed up and obstructed by a vault built across it. In the east gable is a pointed (wide or flat arched) window, splaying inwards; and there are two additional windows with wide splay—one each in north and south side wall. Area, 311 A.

Ballinterry (D.S.R.).

S.DD. Gortroe, Gort Ruadh—"Red Garden"; a sub-div. of some 40 A. or so, on which is the ancient church, &c.

Leaca Ruadh—"Red Glen-slope"; another sub-div.; about 70 A.

Tobar an Easpoig—"The Bishop's Well"; the bishop was John O'Brien, of Cloyne (1748–1767), compiler of the Irish Dictionary. He lived here, presumably for security in the protection of his influential relatives, the O'Briens of Kilcor.

BALLINURE, Baile an Iubhair—"Homestead of the Yew Tree."

Ballinore (Inq. Iac. I).

On Healy's farm there is a small lios with circular rampart, about 7 feet high. Area, 304 A.

S.D. Parkaclamper (O.M.), Páirc an Chlampair—"Field of the Contention."

BALLINVARRIG, Baile an Bharraigh—"Barry's Homestead."

The O.M. indicates, near the river, a single small lios which seems to have disappeared.

S.D. Poll Cam—"Crooked Hole"; a pool in the river.

BALLYWILLIN, Baile an Mhuillinn—"The Mill Homestead." The mill, which stood down in a glen, has long since disappeared.

On the townland is a small dimidiated lios, with a semicircular rampart 10 feet high. The public road was taken through, and it cut the lios in twain, with the result that one-half has entirely disappeared.

S.D. Páirc na Cille—"Field of the Early Church Site"; this is on John Barry's farm, where outline of circular surrounding fence can still be traced.

BALLYDA, Baile Dáith—"David's Homestead."

There is a small circular lios, with rampart 3 feet high, on William Reardon's farm. Two "forts" additional have been levelled within living memory. Area, 287 A.

S.DD. Seana Bhaile—"Old Homestead"; a field.

An Reastal—"The Rake"; another field.

The Stone Field, on Leahy's farm; here is a dallan 4 feet by 2 feet.

BALLYNAKILLA, Baile na Coille—"The Wood Homestead."

Ballynakilly (Inq. Iac. I).

Here took place the tithe massacre of 1834. The well-known horse fair of Bartlemy is held on the townland. Formerly there were four fairs annually. Area, 227 A.

S.D. Knoppoge River (O.M.), Cnapóg—"Hillock," forming eastern boundary of townland.

BALLYNANELLAGH, Baile na nEallach—"Village of the Cattle." Area, 241 A.

S.D. Bóithrín a Leasa—"Little Road of the Lios."

BALLYNOE, Baile Nua—"New Homestead."

BALLYOGAHA, Baile Ó gCobhthaigh—"O'Coffeys' Homestead." In the O'Longan MSS. it is written B. O. gCatha—"O'Catha's Homestead."

Ballyogahie (Inq. Car. I).

There are two circular lioses, with ramparts 4 feet high, on Denis Shea's and Mrs. Foley's farms respectively. A large rath, with triple ramparts, has, unfortunately, been destroyed. Area, in three divs., 767 A.

S.DD. Ladhar Ruadh—"Red River-Fork."

Field names:—Páircín an Chrónaigh ("Little Field of the Funeral Dirge"); Páirc an Chumair ("Field of the River Confluence"); The Linny Field (perhaps from lín, flax); Páirc na Druinne ("Field of the Hump"), &c.

A small brake on Walsh's farm hides the site of a medium-sized lios, prostrated within the past seventy years. Area, 237 A.

BALLYONEEN, Baile Eoghainín—"Little Owen's Homestead." Area, 171 A.

Bally Ionyne (Inq. Iac. I).

S.D. The Close—a field.

BALLYROBERT, Baile an Robairdaigh—"Robert's Homestead." Two lioses recorded in O.M. have disappeared. On Ballyrobert was a small castle of the Barrys, which was captured during the confederate wars by the Earl of Castlehaven. Area, 374 A.

S.D. The Castle Field; on Michael Doherty's farm; no remains of the castle survive.

BANEENA—The Irish form, as I heard it, was Beiníní, "Little Points," but O'Donovan [Ord. Survey Field Book] makes it Báiníní, "Little Fields." Area, in two divisions, 216 A.

Binniagh (D.S. Ref.).

CAHERDESERT, Cathair an Díseirt—"Stone Fort of the Secluded Place."

On Duggan's farm, crowning an eminence, stands the name-giving cathair—a fine specimen, "The Cathair," with souterrains. All the stones have been carted away, leaving only the earthen core of the rampart.

On the same farm are also a small lios and the sites of two others. Area, 235 A.

S.DD. Knockauncaragh (O.M.), Cnoc an Chatharach—"Hill of the Cathair." Loch na Muc—"The Pigs' Pond."

Cahirduggan, Cathair Dubhagáin—"Dugan's Stone Fort." There is one small circular lios on FitzGerald's farm, besides the traces of another, while within the present demesne is site of a third. Area, 115 A.

S.D. Bán Éisc, "Fish Field," because it was on one occasion manured with decayed fish.

Clykeel, an Cladh-chóill—"The Fence Wood." So the name is written in the O'Longan MSS., *teste* Prof. O'Donoghue.

On Ned Cotter's farm is a small and now nearly obliterated lios. On same holding is a large well, formerly regarded as holy; this is overshadowed by a large willow tree, and "rounds" were made there within living memory. Area, 250 A.

S.DD. Cotter's Hole, a river pool.

Coilleadar; perhaps Coill-fhada Shior.

Bluebell Bridge (O.M.)—The name was derived from a former public-house.

Gort na Daibhche, "Garden of the Vat," a sub-div. of about 9 A.

Commons, Móin a Choimín—"Bog of the Commonage." Area, 9 A.

S.D. Corrach Doimhin, "Deep Swamp."

Cronavon; meaning unknown. The accent is on the first syllable; this, therefore, is the qualifying word.

There is a much-defaced lios near S.-W. angle of townland on Leahy's farm. This appears to have had double ramparts, but the outer fence, which was 4 feet high, has been levelled. Area, 195 A.

S.D. Corrach an Ime—"Swamp of the Butter"; a sub-div. containing about 17 A.

Curraghard, Corrach Árd—"High Swamp." Area, 106 A.

Curragh Phlibbode, Corrach Phlibóid—"Philpots' Swamp."

There are two lioses—one (medium-sized and circular, with rampart 8 feet high) on John Murphy's holding; the other (small and circular, with rampart 4 feet in height) on Donovan's. Area, 98 A.

S.D. Lisbrien (O.M.), Lios Bhriain—"Brian's Lios"; on Murphy's holding as above.

Desart, Diseart—"A Sequestered Place."

On the townland are the very interesting remains of Desart Church. Latter consisted of nave and a later chancel; total length, 60 feet by 15 feet wide. The walls are levelled nearly to the foundations, except at the N.-W.

angle, where stands a piece of quoin, 12 feet high by 9 feet long. The foundations of the chancel arch are clearly traceable. As evidenced by the remaining fragment, the masonry, at least of the nave, was somewhat peculiar—of flagstones, set on edge. In Quirke's farmyard, near by, are two magnificent pillar-stones, one (8 feet by 3 feet by 9 inches) standing; the other (nearly as tall) prostrate. In a field of the same farm stands another pillar-stone (5 feet by 4 inches), and on Egan's holding there is yet a fourth specimen, now only 3 feet by 3 feet above ground. Near the church ruin, to the east, and on verge of a bog, lies a large perforated millstone, noted also by Windele (Windele MSS., R.I.A., vol. xii, I. 3). Across the bog, and leading to the church, are the remains of an ancient causeway, the Cliadh Buidhe. Area, 296 A.

Dizerte (Inq. Car. I).

Field names:—Macha Mór ("Great Milking Place"), Páircín na gCloch ("Little Field of the Pillar-stones"), Cnoicín na Scolb ("Little Hill of Thatching Pegs"), The Church Field, An Bannsa ("The Manse or Glebe").

GARRANTAGGART, Garraidh an tSagairt—"The Priest's Garden."

On the present townland is a very remarkable holy well—St. Bartholomew's. This latter will be found at bottom of a glen, and surrounded by a wall of modern masonry, but not roofed over. Above the doorway, in a pediment, is set an iron cross, and beneath the latter is an inscribed tablet.

The basin is oval—some three yards in longer, and two in shorter, diameter. Around hang, or are deposited, votives of the usual kind, and devotions are paid on August 24th. On the townland there is also, on Arnold's farm, a small lios site. Area, 106 A.

HIGHTOWN, Baile na Mullach—"Village of the Hill-summits."

There were on the townland four small circular lioses, of which one has disappeared. Two of the surviving examples are on Dooley's farm; they are both imperfect. The fourth lios is on Barry's farm; it is perfect, with rampart 6 feet in height. On Dooley's farm are also a couple of Folacht Fiadhs. Area, 404 A.

HOLLYHILL, Cnoc an Chuillinn—Idem. Compare the alternative old name of the parish, *antea*, scil. Inchicollin.

There are some slight remains of an old castle. Area, 111 A.

S.DD. Sheelaboonaskeane's Castle (O.M.). Caisleán Sighle Bhuidhe na Scian—"Yellow Julia of the Knives' Castle." The remains are on Daly's farm; they stand about 8 feet high. The building, which was neither of great size nor of strength, was square in plan. Locally it is believed to have been occupied, in the seventeenth century, by the female leader of a band of outlaws.

Páirc a Dalláin—" Field of the Pillar-stone," on Arnold's farm ; the stone has, unfortunately, been removed.

KILLAMURRAN, Cill Átha Muirín—" Church of Muirin's Ford."

The name-giving Cill, or Early Church site, will be found on Jer. Murphy's holding, as marked on Ord. map. The cill is a circular enclosure, half an acre or so in area, within which are distinctly traceable the foundations of a primitive church, 27 feet by 15 feet. To south of this last are a bullán and some traces of another building. The O.M. likewise records a large circular lios, but latter has been recently levelled. Area, 333 A.

KNOCKNABOOLY, Cnoc na Buaile—" Hill of the Mountain Dairy." Area, 142 A.

S.DD. The Thunder Field, a field in which are two cavities—one believed to have been made by a thunderbolt, the other by collapse of a limestone cavern.

Bóithrín Glas—" Little Green Road" ; a disused roadway.

KNOPPOGE, Cnopóg—" Little Knoll." Area, 11 A.

LACKABEHA, Leaca Beithe—" Birch-clad Glen-slope."

The O.M. shows two small lioses, both of which have now been levelled. One of these was on Roche's holding, the other on Arnold's. There was also a third lios (rampart, 4 feet high) on Smith's holding. Area, in two divisions, 223 A.

S.DD. Flesk River (O.M.), Abha na Fleisce—Meaning unknown. Compare River Flesk, Co. Kerry.

Liosnamoinbra (O.M.) The Irish form appears to be Lios na Móin Bréagha, which name the Field Book, O. Survey, inconsequently explains by stating that the lios was reputed to be haunted, and that the bog sometimes appeared to be a sheet of liquid fire.

LISURLA, Lios Oiriolla (for Oiliolla)—" Oilill's Lios."

The townland is now commonly known as Fort Richard.

There were two lioses, but one of them has been prostrated ; the other, on Cashman's holding, is of medium size and circular in plan. There is also on Cashman's a well, with a certain local reputation for sanctity. Area, 173 A.

S.DD. Aughnacloghfinnia (O.M.), Áth na Cloiche Finne, " Ford of the White Stone" ; on S. boundary.

Abhainín na gCaorach—" Little River of the Sheep."

MELLIFONTSTOWN, Baile Mhíleamhótair—Idem.

Mallefontstowne (Inq. Car. I).

In a field on Hegarty's farm is a pillar-stone of clay slate, 43 inches by 43 inches by 21 inches, but probably originally taller. Area, 566 A.

S.D. Ciopán, "Little District," a sub-div., of about 100 acres.

Monanig, Móin Eanaigh—"Bog of the Quagmire." Area, 713 A.

Peafield, Cúl na Pise—"Corner of the Peas." Area, 22 A.

Rathaneague, Ráth an Fhiadhaigh—"Rath of the Hunting."

The townland is rich in antiquities of minor importance. On Sullivan's holding are three small circular lioses, a fine pillar-stone (7 feet by 3 feet), as well as a smaller specimen (48 inches by 34 inches by 13 inches), and a small dolmen, while on Leahy's is a pillar-stone (8 feet by 4 feet). Area, 360 A.

S.DD. Leaba Diarmuda; the dolmen on Sullivan's farm.

Cnoc Mór—"Great Hill"; a small sub-div.

Lios an Uisge—"The Water Lios."

Páirc a Dalláin—"Field of the Pillar-stone."

Móin Ruadh—"Red Bog," now a pond, covering a couple of acres, on the hill-top.

Rathcobane, Ráth Ghobáin, "Goban's Ráth."

See under Templebodan par. Area, 21 A.

Parish of Inchinabacky.

Inchinabacky is an ecclesiastical division of very small extent, containing only six townlands. The parish name, which is not shared with a townland, seems to signify Island or River-holm of the (River) Bend (Inse na Baice). The ruined church, on the townland of Churchtown, is one of the very few fairly preserved ecclesiastical ruins in Ballymore. It is a simple oblong structure, without division into nave and chancel; total length, 48 feet, by about 21 feet wide. The original walls stand almost entire. A single doorway (pointed), in the south side wall, gave access to the sacred place. This side wall also contains a single pointed window, and, on the inside, a pointed piscina, and a second similar alcove, rectangular-headed. A breach in this wall has nearly effaced a second window. In the west gable, which stands entire, is a defaced window, and, in the east gable, another (two-light) window, pointed, widely splaying, and 5 feet high, and probably of the fourteenth century.

The church belonged to the Abbey of Chore (Middleton); it appears as Capella de Inchenebaky in the Taxation of 1303; and as Inchybacky in the Down Survey. "Inshiensbackie" was one of the 220 "towns and villages" which were "burned and spoyled" by Tyrone and Desmond in 1599.

TOWNLANDS.

BILBERRY, Cnoc na bhFraochán—"Hill of the Whortleberries."

In the townland (on Garde's farm) there was formerly a pillar-stone; but it stands no longer. Area, 609 A.

CHURCHTOWN, Baile an Teampuill—Idem.

On this townland stands the ruined church; at Mrs. Kelleher's house was a bullán, but it has been removed or destroyed. Area, 105 A.

CLASHDUFF, Clais Dubh—"Black Trench."

On Kelleher's farm stood a dallan in a field named from it, Páirc a Dalláin; the monument has met the usual fate. Area, 237 A.

HARRISGROVE.—No Irish name. The place is locally regarded as part of Bilberry. Area, 38 A.

ROXBOROUGH, Inse na Baice—Meaning, as above. Area, 124 A.

S.DD. Dunsfort (O.M.), Scairbh mhic Choitir—"MacCotter's Stony Ford."

Springfield (O.M.), Cillín na Manach—"The Monks' Little Church."

STUMPHILL, Cnoc a Smutáin—Idem. Area, 360 A.

S.D. The Twig Yard; a field.

PARISH OF KILLASPUGMULLANE.

This is a small parish (Diocese of Cork), containing only five townlands, but, thanks to its position—off main roads and remote from towns—it is much richer in local names than the last. Lioses abound; but otherwise—beyond a couple of ancient church sites—there are no antiquities. The name, which is not shared with a townland, is, of course, ecclesiastical, signifying "Bishop Mullane's Church." It appears as Killasputmullan in the Taxation of Pope Nicholas (1303). The church appears to have been on the present townland of Coolnacaha, where there are some rather modern-looking ecclesiastical ruins.

TOWNLANDS.

BALLINGOHIG, Baile an Cobhthaig—"Cowhig's Homestead."

Ballynegohugh (Inq. Iac. I).

Prof. O'Donoghue thinks the name may be B. 'O gCathaig ("O'Cahys' Homestead"). There was one circular lios of medium size on Delaney's farm, but it was demolished about forty years since. Area, 387 A.

S.D. Sruth Fhinghín—"Fingin's Stream."

BALLINVINNY, Baile an Mhuine—"Homestead of (in) the Shrubbery."

The O.M. records no fewer than six lioses; but all of these, with two exceptions (on Cashman's and Macauley's farms respectively), have disappeared. In James Cashman's garden is a well to which particular virtue is attributed. Area, 590 A.

S.DD. Páirc na Saighdiuri—"The Soldiers' Field."

Páirc a' Chrochaire—"The Hangman's Field," in which a man strangled himself.

Other field names:—Seana Bhaile, Páircín an Phúna ("The Pound Field"), &c.

COOLNACAHA, Cúil na Cáthadh—"Corner of the Winnowing."

It is pretty evident that the present townland was formerly a sub-division of Ballyvinny. On it are the remains of the ancient parish church, already referred to. These are confined practically to a ruinous tower, some 30 feet high, probably added, in comparatively recent times, to an older church. Area, 132 A.

S.DD. Tobar na gCat—"The (Wild) Cats' Well."

Páirc an Iubhair—"The Yew Field."

KILRUSSANE, Cill Rossáin, Russan's Church; possibly from St. Russan, of Spike Island. Site of the name-giving church will be found on Michael Cashman's farm. It is marked on the O.M.; but not the slightest token is now left to indicate the spot. The large circular surrounding fence was thrown down within the last half century. Area, 241 A.

Kilbrishane and Kilrushane (Inq. Iac. I).

S.D. Seana Cill—"Old Church." The name is applied to a sub-div. (about 105 A.) of the townland.

TRANTSTOWN, Baile an Tranntaigh—Idem.

Of the three lioses marked on the O.M., only one (on Grady's farm) survives. This is a splendid specimen—large, double-ramparted, and commanding a varied and extensive view. There are also a holy well and site of a late castle or mansion. Area, 500 A.

S.DD. St. Valentine's Well (O.M.), near east boundary. Stations were made here; but they have been discontinued now for nearly a century.

Castle in ruins (O.M.); no remains survive.

Ráth Mór—"The Great Rath," as above.

Old Court—Site of Lady Pepper's mansion.

Lady Pepper was simply Mrs. Pepper, wife of Michael Pepper, of Bigod, Essex. She was daughter of Sir R. FitzGerald, of Ballinshinny; and her mother was a Trant. She occasionally resided at Trantstown till her death in 1842.

'Ath an Chomhnuidhe—"The Rest Ford."

PARISH OF KILQUANE.

Our present parish is one of three bearing the same name in Co. Cork. The parish name, derived from the townland on which is the ancient church, signifies Cuan's Church. Stations or "rounds" at the holy well took place on June 23rd, but there evidently has been a transfer of the original patronage, almost certainly under Anglo-Norman influence.

TOWNLANDS.

AGHADUFF, Achadh Dubh.—"Black Field." Area, 148 A.

S.D. Páirc na mBullán—"Field of the Bowls (or the Bullocks)."

BALLYLOOHANE, Baile úi Locháin—"O'Loughane's Homestead." Area, 290 A.

BALLYNAGAUL, Baile na nGall—"Homestead of the Foreigners."

Ballyngaule (D.S. Book).

There are two lioses—one is circular and of medium size, with rampart 5 feet high, but now nearly destroyed; the other is smaller, and its rampart about 8 feet hight. Area, 305 A.

S.D. Leaba Luinge—"Ship's Berth"; a hollow (in centre of a field), shaped like a ship. Folk-etymology supplies an explanation to the effect that by some means a ship came in from Queenstown, and remained here for years!

BALLYNANEELAGH—See under place of same name, Gortroe Parish.

Ballyneleagh (D.S. Ref.).

The lios, marked on O.M. as on Hogan's farm, has disappeared. On Gleeson's farm there was a second lios, which also has been long since improved away. Area, 433 A.

S.DD. Bán na gCloch—"Field of the Pillar-stones"; on Gleeson's farm. Only a single dallan now survives; this stands about 4 feet by 2 feet.

BARNETSTOWN, Baile an Bharnánaigh—"Barnet's Homestead." Area, 360 A.

S.DD. Brazier's Pond, a patch of cut-away bog.

The Burning Mountain.

CLASH, Clais a Cheannbháin—"The Cotton-grass Trench," from a spot on which is now a pond surrounded by a patch of partly reclaimed bog. Area, 97 A.

COOLQUERISK, Cúil Giorruisg; meaning unknown. *Giorruisg* is an epithet applied to a short-sighted person.

Cowllegerrish (Inq. Iac. I).

The O.M. records one circular lios of moderate size. Area, 300 A.

GOGGANSTOWN, Baile an Ghogánaigh—" Goggan's Homestead."

The O.M. gives a circular lios of medium size. Area, 278 A.

S.DD. Clais a Tóiteáin—" Trench of the conflagration."

Páircín na bhFotharach—"Little Field of the House Ruins."

KILLEENA, Cillíneach—" Early Church site."

O'Donovan, who, presumably, never heard the name from a native of the district, makes it Cill Einne. I could discover neither trace nor tradition of the name-giving cill.

There were two lioses up to sixty years ago, but both have been since levelled. Area, 528 A.

S.DD. Bóthar Dubh—" Black Road." The road, which enjoyed the reputation of being haunted, is now partly closed up.

Pairc na gCloch—" Field of the Pillar-stones." The name-giving dallans have unfortunately all disappeared.

KILQUANE, Cill Chuain—Cuan's Church.

Eccl. de Kylcan—Tax. Pope Nicholas (1303).

There are no remains of the ancient church, which, indeed, was a complete ruin at beginning of the seventeenth century (Royal Visitation, 1615, R.I.A.). It consisted of nave and chancel (*ibid.*). The cemetery in which the church stood is about an acre in area.

To north of graveyard, in side of a glen, is the holy well, covered over by a structure of masonry, with a narrow, square-headed doorway, 3 feet by 1½ feet. Here " rounds " are still made on St. John's Eve. Area, 269 A.

S.DD. Páirc na Cloiche—" Field of the Pillar-stone " ; on Hogan's farm. The pillar, which still survives, measures 4 feet by 1½ feet by 3 feet.

KNOCKANEFINOGE, Cnocán na Fionóige—" The Raven's Little Hill." Area, 72 A.

KNOCKRAHA, Cnoc Rátha—" Rath Hill."

Cnock-Rahy Mory (Inq. Iac. I).

The O.M. records three lioses, all of which have disappeared. One of these was a very large specimen. Here, according to Windele, lived Dr. Thos. Wood, the antiquary, author of the " Enquiry," &c. Area, in two divs., 453 A.

S.DD. Ahalig Bridge (O.M.)—Áth a Liaig (O'D.)—" Ford of the Flag-stone."

Gleann na mBríce—" The Brickworks Glen."

Lisheenroe, Lisín Riabhach—" Grey Little Lios."

The name has been improperly Anglicised.

There is one small circular lios on Sheehan's farm, and a second similar monument has disappeared. Area, 116 a.

Meeleen, Maoilín—" Little Hill."

O'Donovan makes it Meillín, dim. of Meall, which it is not. Area, 361 a.

S.D. " The Chapel Field " (Páirc an tSéipéil), on Duggan's holding.

Mitchelsfort. I failed to find the ancient name ; the present name is derived from a former owner.

Four small circular lioses are marked on O.M. ; but of these, two have been destroyed, another, with a rampart 10 feet or 12 feet high, has been partially demolished, and the fourth stands to height of a few feet. Both the surviving forts are on Fell's farm. Area, 903 a.

S.DD. Bóithrín Widdlim. This was an old road which ran in direction of Ardnagehy.

Páircín a Chríu (" Little Field of the Withered Thing ").

Moonaneaghe, Muine an Fhiaidh—" The Deer's Thicket."

O'Donovan wrongly makes it Móin an Éaga.

Cowland, als. Moneineige (?) (Inq. Iac. I).

On Maurice Walsh's holding is the site of a demolished lios which had souterrains. Area, 163 a.

Moonatooreen, Móin a Tuairín—" Bog of the Cattle Field."

There were no fewer than six lioses, one of them of unusually large size, but they have been all destroyed. Area, 182 a.

Pigeo nHill, Cnocán a' Cholúir—" The Pigeon's Little Hill." Area, 52 a.

S.D. Áth na hÓinsidhe—" The (Female) Idiot's Ford."

Rathfilode, Ráth Mhiolóid—" Milot's Rath."

Rathmilode (D.S. Map).

On Cashman's are three lioses or lios sites. The largest lios covers an acre of ground, and has a rampart about 10 feet high. Area, 301 a.

Rupperagh, Ropaireach — " Rapparee (or Robber) Abounding Place." Area, 252 a.

S.D. Páirc na Riastála—" Field of the Sod-lifting (for burning)."

Shanballyreigh, Sean Bhaile Riabhach — " Old Grey Homestead." Area, 422a.

Parish of Kilshanahan.

This is an ecclesiastical division (Diocese of Cork) of about average size, having the Bride River for its northern boundary. Its name, which it takes from Senchan, presumably founder of the church, it does not share with any townland. Unfortunately there is nothing by which we can identify this particular Senchan.

The church stood on the townland of Ballinaltig, and, like the generality of Barrymore churches, it has left no remains. The old graveyard, about an acre in extent, has had its surface much elevated by interments; there is no monument or inscription of special interest, if, perhaps, we except one (a table-tomb), which commemorates the original Father Prout (1757–1832), a man who won fame without doing anything to deserve it.

The Irish form of the parish name seems to be Cill Séanacháin.

Townlands.

Ballinaltig, Baile an Fháltaig—Faltach or Altach seems a family, or personal, name.

Ballynaltigge (Inq. Car. I).

The single, small, circular lios recorded by the Ordnance Survey has disappeared. Area, 316 a.

S.DD. Páircín a' tSalainn—"Little Field of the Salt."

Bóithrín a' Phiobaire—"The Piper's Little Road."

Bushy Park, Scairt an Arbhair—"Thicket of the Corn."

On John Daly's holding, in a field called "The Fort Field," is a small circular lios, with its rampart about 6 feet high. In the same field was formerly a second lios. Area, 296 a.

Coolquane, Cúil Úi Chuain—"O'Quann's Corner."

There is one small fort, nearly demolished, on Barry's farm. A second fort, on same farm, has been quite destroyed, as has a third (on another holding), inside of which a house has been built. Area, 459 a.

S.D. Carraig Eoghainín—"Little Owen's Rock."

Condonstown, Baile a' Chondúinaigh—Idem.

There are three lioses, all of medium size and circular plan. One is on P. Condon's farm; this, which is now partly destroyed, had ramparts 10 feet high, and it is said to have been used as a Mass place in the Penal days. The remaining two forts are on Twomey's and Lord Barrymore's farms respectively. Each of these lioses has ramparts about 3 feet high, and Lord Barrymore's has souterrains. Windele (MSS. R.I.A., vol. xii, I. 3) refers to a rock basin "about two fields from Dr. Barry's house."

S.DD. Vinegar Hill, a sub-div.

Bóithrín Cnoic Duibh—"Little Road of the Black Hill."

Páirc an Riain—"Field of the Water-course." *Rian* is ordinarily a track, but here it is applied to an irrigation channel. The word occurs elsewhere in Ireland, and it is Anglicised Rhine, and applied to streams of considerable volume. Compare the A.-Saxon *ryne*, a water-course.

COOSANE, Cuasán—"Small Cavity." Area, 331 A.

S.D. An Corach Bán—"The White Marsh," a very well-known sub-div., containing about 120 A.

MT. CATHERINE, Tornóg—"Limekiln."

The O.M. gives an "abbey in ruins." There are some nondescript remains at the spot (James Cotter's farm), but evidence is entirely wanting that they are the remains of an abbey. Beside the alleged monastic remains are some insignificant traces of a small castle. Local tradition asserts that neither monastery nor castle was ever occupied or perhaps finished. On Barry's farm was a circular lios, of medium size, now demolished. Area, 319 A.

S.DD. Corach Dubh—"Black Marsh."
Seana Chúirt—"Old Court."

SCARTBARRY, Scairt an Bharraigh—"Barry's Thicket."

There was a large circular lios, now completely improved away, on John M'Carthy's holding. That there was also another lios is indicated by a Páirc a Leasa, in which there are now no traces of such a monument.

S.D. Páirc a' Dalláin—"Field of the Pillar-stone." There were, as a matter of fact, two pillars, each about 6 feet high, but they have been both destroyed.

SKAHANAGH, Sceathánach—"Abounding in Whitethorn Bushes."

The O.M. records four lioses, of which three—all circular in plan—still survive. Two of these—of medium size, and with ramparts 5 feet high—stand on Ed. Barry's and Michael Reardon's holdings respectively. The third, on Michael Keeffe's, is a more ambitious specimen; it is of large size, and its rampart is 9 feet in height. There were two further (unrecorded) lioses, of which no traces now remain. There was also, on Barry's farm, a stone alignment, consisting of three great dallans; but, very unfortunately, this also has been destroyed. Area, in two divs., 1,352 A.

S.DD. Carraig an Fhiadhaigh—"Rock of the Hunting"; a sub-div.
Cnocán a tSeabhaic—"Little Hill of the Hawk"; another sub-div.
Beal na Creiche—"Pass of the Cattle Spoil."
Droichead Sheain Úi Mhurchadha—"John O'Murphy's Bridge."
Áth na Cloch nDubh—"Ford of the Black Stones"; the present Blackstone Bridge.

PARISH OF KNOCKMOURNE.

Only a small portion (four townlands) of the parish lies within the present barony. Three of the four townlands form a detached fragment (island) within Barrymore. The Irish form is Cnoc Mughdorna, "Mughdorn's Hill."

Townlands.

Ballyda—See under Castlelyons Parish, *antea*. Area, 123 a.

Ballymurphy, Baile Úi Mhurchadha—"O'Murphy's Homestead."

Ballyworrughowe—In list of places burned by Tyrone, 1599.

There are four lioses, scil.—two of moderate size, and nearly demolished, on Toole's holding, and two smaller specimens—one nearly levelled and the other standing to height of 6 feet—on Cotter's. Area, in two divs., 526 a.

S.D. An Faithche—"The Green."

Ballynella, Baile Úi Niallaigh.

The O.M. records a very small lios, which exists no longer. Area, 169 a.

S.DD. Bealacoon Ford (O.M.), Beal Átha Chuain — "Conn's Ford-mouth."

The Spaniel's Cross-road (O.M.), Crosaire na Spaniel—Idem.

Ligín; probably this is *Luigin*, dim. of *Log*, a hole.

Douglas River, Dubh-glaise—"Dark Stream" river.

Inse Riabhach—"Grey River Holm." Note that the genitive case of *Inis* is also used as nominative.

Ballyrobert—See under Castlelyons Ph., *antea*. Area, 133 a.

Parish of Lisgoold.

Lisgoold is a hilly parish of less than average interest archæologically. Lioses abound, it is true, but there is little beside in the way of antiquities. There are no remains of an ancient church, save a few cut stones used as grave-marks in the churchyard, otherwise devoid of interest. The parish name is derived from the townland, *q.v.*

Townlands.

Ballyleagh, Baile Liath—"Grey Homestead." Area, 118 a.

Ballynaskeha, Baile na Sceithe—"Homestead of the Whitethorn."

The O.M. gives one lios of circular plan and moderate size, but this has been levelled. Area, 186 a.

Ballysallagh, Baile Salach—"Miry Village."

The O.M. records no fewer than five lioses, but most of these have been thrown down within the past half century. Area, 198 a.

Carrigane, Carragán—"Little Rock." Area, 188 a.

Corbally—See under Ardnageehy, Ballydeloher, Dungourney, &c., *antea*. Area, in two parts, 460 a.

Corbally (D.S. Ref.).

There is a large lios on Regan's farm. Area, 236 A.

S.D. Tobar an Úcaire—"The Fuller's Well"; once reputed holy.

Lios a Chúigir, "Lios of the Five Persons," i.e., a man, his wife, and their unborn triplets. The following legend—evidently of great antiquity—is told in explanation:—A man travelling with his wife is asked by the latter for meat. Having none to give, he cuts off sole of his foot, and hands the bloody morsel to her. Still unsatisfied, she asked for more, whereupon he cut off and gave her the other sole. Again she demanded more, when he, in a fit of anger, killed her. After her death the woman was found to have been pregnant of triplets, and one of the triplets, which had got no meat, had its tongue hanging out as if through hunger or thirst. A variant of this strange piece of folk-lore is quoted under Dungourney.

Beal na dTrí nÁth—"The Triple-ford Mouth."

Áth na Saileach—"Ford of the Willows."

Cúilín—"Little Corner."

CORBALLYBANE, Corra Bhaile Bán—Meaning doubtful: see last.

On Murray's farm is a circular lios of medium size, with fence about 7 feet high. Area, 241 A.

CLASH, Clais—"A Trench."

There is a single lios (on Buckley's farm) with rampart, where perfect, about 3 feet high.

S.D. Clais Dubh—"Black Trench," a field, from which probably comes the townland name.

GLENGARRIFF, Gleann Garbh—"Rough Glen."

There are three lioses, each with its rampart about 7 feet high, on the holdings of Collins, Broderick, and Donovan respectively; a fourth specimen has been destroyed. Area, in two divs., 364 A.

LEAMLARA, Léim Láraigh—"Mare's Leap." Séan na Ráithíneach, however, writes it Leim Lára. Area, 38 A.

S.D. Baile Bhileóga—"Wood-sorrel Homestead"; the name is now applied to a well.

LISGOOLD, Lios Gúl; meaning uncertain. O'Donovan makes it Lios Gabhail—"Lios of the River Fork," which it is not.

Lyskul (Tax. Pope Nicholas); Liscowel (Visitation, 1591); Liscoill (Visitation, 1615); Liscoel (Visitation, 1627); Lisgowle (Inq. Car. I).

The O.M. shows no fewer than eight lioses, and there were, at least, two others, but there is nothing to show which, if any, of these was the eponymous structure. Of the four marked on Lisgoold N. only one, a small circular example, on Reardon's farm, survives. Similarly, of the four recorded as standing on Lisgoold E., only one (on Buckley's holding) remains. On Lisgoold N. there were two further lioses—large specimens—on Barry's and Coleman's farms respectively.

The "great" fair of Lisgoold was held on June 24th—Aonach Láe Sheaghain. In addition to farm-stock, all sorts of things demanded by country folk were for sale here: brogue-makers of Cloyne, with their wares, the makers of wooden ploughs, from Ballinacurra, the loom-weavers, with their bundles of frieze, from Kilworth, &c., gave the fair the appearance of an Eastern bazaar. In a field of Reardon's is the site of a Penal days' chapel. Area, in three divs., 905 A.

S.DD. Parkadaliss (O.M.), Páirc a Dá Lios—"Field of the Two Lioses."

Baile Mhóintín—"Little-Bog Homestead"; old name of a sub-div., on which stands Lisgoold Church.

Páirc a Mhúta. *Múta* signifies a ruin and a moat, also a tree-stump, &c.

Baile ó bhFiagh—"Homestead of the Ui bhFiadh"; a well-known sub-div., locally regarded as a submerged townland.

Cúinne na Smólaighe—"The Thrush's Corner," a bend in the road.

"The Stone Field," on Barry's farm; so called from presence of a dallán, 8 feet by 3 feet by 3 feet.

Páircín na Muc—"Little Field of the Pigs"; that portion of the Fair Field at south side of the main road; here fat pigs were exposed for sale.

Pound Quarter, An Púna—"The Pound." The name-giving pound was of the baronial kind—to secure straying cattle, &c.; it was situated at north-east angle of the townland.

Parish of Little Island.

This small parish (Diocese of Cork) is coterminous and co-extensive with the island of same name in Cork Harbour. The sloblands on north side of the island were reclaimed by the Burys about 1830. [J.C. in Cork Arch. Journal, 1815, p. 62.] Beyond scant remains of the old church and a small castle there are practically no antiquities. The name appears as "Eccia. de Insula" in the Taxation of Pope Nicholas, as "Insula Parva" in the Diocesan Registry, 1582, and as "Ecclesia Sti Lapani de Insula" in the Visitation of 1591. Three Lappans are enumerated in the Irish Martyrologies, but which, if any, of these is our Lappan of the Island we have nothing to indicate. At present there is no Irish name beyond Oileán Beag.

Townlands.

Ballytrasna, Baile Trasna—"The Homestead Across." Area, 382 A.

S.DD. Ballinderrig, Baile na Daraighe—"Oakwood Homestead"; a sub-div. of about 130 A.

Clais a' Bhodaig—"The Churl's Trench"; another sub-div.; about 120 A.

Baile na Carraige—"Homestead of the Rock"; a sub-div.

CARRIGRENNAN, Carraig Grianáin—"Rock of the Sunny Chamber" (or "Grianán's Rock"); but I got also Carrig Úi Ghrianáin (I suspect that frequently, at any rate in East Cork, the genitive article masculine is, by association, transformed into úi in popular usage). Area, 80 A.

CASTLE VIEW.—No Irish form. Area, 122 A.

COURTSTOWN, Baile na Cuirte—Idem. Area, 574 A.

There was a castle, all traces of which have disappeared.

"The Giant's Hole"; a well.

Páirc a Chrainn—"Field of the Old Tree," in which was a lios, now destroyed.

HARPER'S ISLAND, an islet now joined to the mainland by a bridge and causeway. This appears as Harperstowne in the 1652 depositions. Area, 69 A.

INCHERA, Inse Thiara—"Western Isle," a peninsula. Area, 84 A.

Insheragh (Inq. Car. I).

WALLINGSTOWN, Baile Bheire.

Wallingstown (Inq. Iac. I).

On this townland, within a demesne, where it could be more easily preserved in decent order, stands the ancient church with its graveyard, in a sadly neglected condition. The walls, which are of great thickness (4 feet), stand to their original height. There is trace of former division into nave and chancel. In the south side wall is the pointed doorway of cut stone, chamfered. A pointed window lighted the building from the east, but this has been modernised. In the south wall is a second pointed window, also modernised.

On the townland, but not close to the church, is a reputed holy well, at which "rounds" were formerly made. It is now known as "Betty's Well," on Mr. Martin's lands.

Within a few paces of the church stands a small castle or peel-tower in a good state of preservation. This appears to have belonged in the mid-sixteenth century to one Christopher Lombard, by whom or by whose ancestors it was probably erected. From the Lombards it passed to the Sarsfields (from whom the place was named Sarsfieldstown), and from the latter again to the Wallings or Walshes. Area, 377 A.

Parish of Mogeesha (Part of).

Seven-eighths of the parish lie within the present barony; the remainder belongs to Imokilly. Included in the parish area are the small islands or peninsulas, known, respectively, as Brown and Brick Islands, on which are prehistoric remains of great importance. The other antiquities of the parish are of the usual character—site of the ancient church, remains of a castle, some lioses, and a few pillar-stones. The name Mogeesha (Magh Gaoise) is evidently territorial; it is not taken from the townland on which stood the ancient church.

Townlands.

Ballintubrid, Baile an Tiobraid—" Village of the Well." The name is derived from a well of singular character, which lies in a field reached by a laneway towards north side of the townland. The well, which has no proper name other than " An Tobar," is at bottom of a pit about 30 feet deep, and descent is by a series of thirty-one stone steps down a sloping gallery lined overhead with great flags. The *tout ensemble* rather suggests one of the sloping passages within the Great Pyramid. To illuminate the depths there are two light shafts. The well may be of considerable antiquity; at any rate, the place was "Ballintubrid" in the reign of Elizabeth as to-day. On John Collins' farm is a lios, small and circular, with rampart 5 feet high, bisected by a road. Area, in two divs., 758 a.

Balynetuberidroyhtrighe—List of villages burned by Tyrone, 1599.

S.DD. Brown Island (O.M.), an islet or promontory, on which is a small prehistoric shell-mound. See under Rossmore below.

Poll a' Ghabhair—" The Goats' Cave," a natural cavern within an artificial enclosure.

Poll Buidhe, "Yellow Hole," a pond.

Ballyannan, Baile Úi Anain—" O'Hannon's Homestead."

On this is the site of the parish church and graveyard. There are absolutely no remains of either, and nothing but the name to indicate their former place. Its proximity to the mansion of the Brodericks led to demolition of the ruin, and, as the funerals of the poor country people were deemed a nuisance by the noble owners, the burial-ground was closed up and tilled. The Tudor mansion is now, in its turn, a ruin, its tall chimneys and great broken windows standing sentinels over erstwhile gardens and pleasure-grounds. From the ornamental gardens here were, I believe, transferred the statues and fountains which Milliken has immortalized in " The Groves of Blarney."

In an extraordinary autobiography, "The Life of John Carteret Pilkington," published in London, 1761, we get a curious and very intimate peep at social life in Ballyannon nearly two hundred years ago. Area, 363 A.

S.DD. Cé Mór—"Great Quay," a sub-div. of some 40 acres, &c.

The Devil's Elbow, a bend in the strand.

Broderick's Stone, a rock in a wood.

The Relig.—The church and graveyard site—on David Toomey's.

"The Forge Field," one of those eerie places where people are led astray at night by some supernatural agency, &c.

Ballyvodock, Baile Bhodaigh—Apparently *Bodoch*, a churl, but I imagine Bodach is a personal name—Hodnett.

Ballyvodig (D.S. Ref.).

On the townland are the very scant remains (only a small shapeless mass of masonry) of an ancient castle, and (on O'Brien's farm) an early church site. There were also two lioses, but they have disappeared. Ballyvodick Castle was one of the 220 places in Ballymore raided by Hugh O'Neill in 1599. Some years later the castle was leased by William and John Hodnett to Louis O'Cahill, of Rathgobbane, who later lost his all in the Confederate Wars. At this latter period, or shortly afterwards, the castle was destroyed—apparently by gunpowder. Windele (mss., R.I.A., xii, I. 3) refers to two ancient *claidhes* (dykes) which ran through the townland. Area, in two divs., 932 A.

S.DD. "Lady Well," now closed; so named from a lady of the Broderick family.

Áth an Eisc—"Ford of the Fish"; the name is applied to a sub-div., containing approximately 150 A.

Baneshane, Bán Sheaghain—"John's Bawn." Area, 249 A.

S.D. Páirc na mBile—"Field of the Old Trees."

Garryduff, Garraidhe Dubh—"Black Garden." Area, 233 A.

Knockgriffin, Cnoc Ghrifín—"Griffin's Hill." Area, 36 A.

Knockangriffin (Inq. Car. 1).

Rossmore, Ros Mór—"Great Shrubbery."

S.DD. Brick Island (O.M.), Oileán na Bríce—Idem; an island at high water only. Here are the remnants of what must have been a kitchen-midden of prodigious size. At present the shell-mound is only a couple of hundred feet long by 10 or 15 yards wide, but originally it was over a thousand feet in length and of unknown width and height. The river channel has been eating into the mound for centuries, and the materials have been carted away for brick-making and road-mending. The pile consists mainly of oyster shells, but there are also cockle, whelk, and mussel shells. No implements have been found, beyond a few sharpening stones and some large rounded pebbles bearing marks of hammer strokes. [See Journal R.S.A.I. for January, 1873.] Area, 384 A.

Páirc na Cloiche—" Field of the Pillar-stone" ; also called "The Stone Field," in which stands a dallan 3 feet by 3 feet by 6 inches.

Póinnte na mBo—" The Cows' Point," i.e., where the cattle stand to cool themselves in hot weather.

An Gaibhlín—" The Inlet."

Foill Dearg—" Red Cliff."

Cnoc na Saighdiuir—" The Soldiers' Hill."

Páirc na Leacht, " Field of the Grave-piles," in which one great stone-heap still remains.

PARISH OF RATHCORMACK.

This is one of the three very large parishes of the barony, its area running to nearly 14,000 acres, about two-thirds of which is mountain. The antiquities are not important. Early church sites are rather numerous, and lioses and pillar-stones occur with average frequency. The parish name is not ecclesiastical, but derived from the townland on which stood the ancient church. Of this last, by the way, not a stone remains upon a stone. It appears as Rathcrum in the Taxation of Pope Nicholas, 1303.

TOWNLANDS.

AUNAMIHONAGH, Áth na mBitheamhnach—" Ford of the Thieves." Area, 88 A.

BALLINAHINA, Baile na hOighne; meaning somewhat doubtful; *oighean* signifies a flat dish. Area, 890 A.

Ballynyheyhy (Inq. Iac. I).

S.DD. Seana Bhaile—" Old Village," a sub-div. containing 30 acres.

" Red Farm," a field.

Tuairín—" Little Cattle Field," a sub-div.—about 20 acres.

Carragán—" Little Rock," a small sub-div.

An Bhiolarach—" The Water-cress Place," a boggy field.

An Ros, " The Shrubbery," a field.

An Faithche—" The Hurling Green."

BALLYBROWNEY, Baile an Bhrúnaigh—" Brown's Homestead." Area, in three divs., 585 A.

S.DD. Loch an Chláirín—" Pond of the Little Board (Bridge)."

Páirc an Phoill—" Field of the Hole," from a limestone cavity.

BALLYGLISSANE, Baile Úi Ghliosáin—" O'Gleason's Homestead."

On Tom Curtin's farm is a partly prostrated lios, half an acre or so in area, with circular rampart, about 5 feet high. On the same farm is a pillar-stone, 4 feet by 1½ feet by 6 inches. Area, 203 A.

SDD. Tobar a tSúsa—" Well of the Blanket."

Móin na Mine—" Bog of the Flour."

BALLYNAGORE, Baile na gCórr—Meaning doubtful. Area, 83 A.

BALLYREIDY, Baile Úi Riada—" O'Ready's Homestead."

Of the two lioses marked on the O.M., only one survives, and this is at present being excavated as a sand pit; it is of moderate size, circular in plan, and has a single rampart about 7 feet high. Area, 383 A.

S.DD. The Toors, Tuair—" Night Field for Cattle," a sub-div.—25 A.

Curraheens, Coraichíní—" Swampy Places," a sub-div.—5 A.

The Revauns, Réidh Bhán—" White Mountain"; another sub-div.—80 A.

Cnocán a' Reithe—" Little Hill of the Ram."

Lios na Fola—" Lios of the Blood," a field in which there is now no lios.

BEHERNAGH, Beithearnach—" Birch-abounding Place." Area, in two divs., 275 A.

S.D. Poillín a' Mhóid—Meaning doubtful; probably Mód = woad, for dyeing.

BRIDGELAND—No Irish form, so far as I could learn. Area, in two divs., 90 A.

COOLIA, Cuaille—A stake or pole. Area, 218 A.

S.DD. Cnoc an Áird—" Hill of the Height."

Cnoc na Sceithe—" Hill of the Whitethorn," on summit of which is a cairn.

COOLNAKILLIA, Cúil na Coille—" The Wood Corner."

There were several lioses, all of which have been levelled. Area, 1155 A.

S.DD. Sean Abhainn—" Old River"; observe use of dative.

Carraig an Aifrinn—" The Mass Rock," on meeting-place of three parishes.

CURRAGHPOEVIN, Corach Phréibhín—" Previn's Swamp."

Curraghphrevin (D.S. Ref.).

There are three lios sites, two on John Barry's holding and one on Buttimer's, but the lioses have been levelled. There is also a well, formerly regarded with reverence, but no "rounds" are now made. Area, 503 A.

S.DD. Tobairín na Fuinnséoige—" Little Well of the Ash-tree," the pseudo-holy well above alluded to.

Páirc an Oidhche—" The Night Field," a field of the class variously called tuar, bawn, púna, close, &c.

Curraghateemore, Corach a Tighe Mhoir—"The Great House Marsh." Area, 120 A.

Craftimore—Deps., 1652.

S.D. The Badgers' Field.

Dromruagh, Drom Ruadh—"Red Ridge." Area, 26 A.

Garrynacole, Garraidhe Niocóil—"Nichol's Garden." Area, 116 A.

S.D. Páirc a tSalainn—"Field of the Salt."

Gearagh, Garthadh—"Wooded Glen." Area, 167 A.

Gaehry (Inq. Iac. I).

S.D. Páirc na gCloch—"Field of the Pillar-stones"; no dallán now.

Glanakip, Gleann a Chip—"Glen of the Tree-stump"; *ceap* may also be a patch of tillage ground. The O.M. marks a medium-sized lios near north boundary, but I failed to find it. Area, 678 A.

Gleannagaul, Gleann na nGall—"Glen of the Foreigners." Area, 1320 A.

S.D. Páirc na gCloch—"Field of the Standing Stones"; the "stones" have all disappeared.

Glenreach, Gleann Riabhach—"Grey Glen." Area, 23 A.

Gneeves, na Gnímh. The Gníomh was an ancient Irish land measure of about 10 acres. Locally the townland is better known as *Bothair Buidhe* (Yellow Road). Area, 70 A.

S.D. Tobar a Chaipín—"Well of the Little Cap."

Kilbrien, Cill Bhriain—"Brian's (Brianit's) Church."

Killbryanitt (Inq. Iac. I; Killinbrianitt, Inq. Car. I).

Site of the ancient church is in a field called Folacht Fiaidh ("Prehistoric Cooking-place") on Collins's holding. There are, however, no traceable remains. Area, 217 A.

Kildinan, Cill Daighnín—Dinan's Church.

The townland is all demesne, and the early church site is on Cahill's farm in adjoining townland (Shanbally), formerly, no doubt, part of Kildinan. Dinan may be the name, not of the church founder, but of some more recent owner of the land. Area, 748 A.

S.D. Páirc Fodhaile—"Field of the Division."

Kilshannig, Cill Seanaigh—"Senach's Church." Seven different saints of the name are recorded in "Mart. Donegal."

The O.M. marks site of ancient church and graveyard immediately in front (north side) of present mansion. There are no remains, if we except a small pile of stones beside a pair of whitethorn bushes. On Mulcahy's farm is a circular lios with perfect ring, enclosing about half an acre. Area, in two divs., 361 A.

Kilshanach (Deps. 1652).

S.DD. Lisín Daraighe—Lios of the Oak.

The Old Warren.

KNOCKADROLEEN, Cnoc an Dreoilín—"The Wren's Hill." Area, 43 A.

S.D. The Ash Hole.

KNOCKANDUFF, Cnocán Dubh—"Little Black Hill." Area, 215 A.

KNOCKANACORRIN, Cnocán a Chaorthainn—"Little Hill of the Rowan Tree." Area, 120 A.

LISNAGAR, Lios na gCarr—"Lios of the Cars." Area, 459 A.

S.DD. Clais na gCon—"The Dogs' Trench."

Clais Dearg—"Red Trench."

LOUGHAPHREAGHAUN, Loch a Phreacháin—"The Crow's Pond," from a pond half an acre in area, by the roadside on east boundary of townland. Area, 80 A.

MAULANE, Meallán—"Small Rounded Hill." There was a large circular lios, close to site of present chapel, but this has disappeared. Area, in two divs., 411 A.

S.DD. Bóithrín na Sailighe—"Little Road of the Willow."

The Chapel Field, a triangular enclosure to north-east of present cross-roads, on which stood a former chapel, predecessor of the present.

The Pond Field, also called "The Safe."

MOANDANIEL, Móinín Domhnaill—"Daniel's Little Bog."

There were two large lioses, both polygonal in plan, near east boundary. Area, 602 A.

S.DD. Shanowen River (O.M.). Sean Abhainn—"Old River" (dat. case).

Aughlea (O.M.), Achadh Liath—"Grey Field."

Clais a Mhadradh—"The Dog's Trench"; the name is applied to a sub-div. containing about 200 A.

MOANLAHAN, Móin Leathan—"Broad Bog." Area, 522 A.

MULLENATAURA, Muilleann an tSamhraidh—"The Summer Mill." Area, 955 A.

S.DD. Cnocan Ramhra—"Thick-set Hill."

Réidh Dhubh—"Black Mountain."

PORTDUFF, Port Dubh—"Black Bank." Area, 162 A.

PRAP, An Phrap—"A Cluster (of Houses)." Area, 180 A.

RAHEEN, Ráithín—"Little Rath."

The small, name-giving lios, which stands in mountain surroundings, is now nearly destroyed. Area, 107 A.

RATHCORMAC, Ráth Chormaic—"Cormac's Rath." Area, 202 A.

There is a large, well-kept cemetery, in which are many inscriptions dating from the eighteenth century. The oldest I found was dated 1710:—

HERE LYETH THE BODY
OF MARY BARRY
WHO DEPARTED
THIS LIFE Y 30th 7BR
AGED 52 ANNO
DOMINI 1710

Rathcormick (Deps. 1652).

RATHCORMAC MOUNTAIN. Area, 481 A.

S.DD. Reidh Dóite—"Burnt Mountain," a sub-div. of somewhat indefinite extent.

Tobairín Domhnaill—"Donal's Little Well," a holy well, partly covered by a stone cap. Devotional "rounds" are still made—ordinarily on Mondays and Fridays—and there are votives of the usual kind.

SHANACLOGH, Seana Chloch—"The Old Stone Building," so called from an ancient castle of which there are scant remains. The castle was small, rectangular in plan, and furnished with solid flankers, on top of which doubtless were towers with loopholes. The structure appears late. Area, 88 A.

SHANAVAGHA, Seana Mhacha—"Old Milking Place." Area, 226 A.

SHANBALLY, Seana Bhaile—"Old Village."

On this townland is the site of Kildinan Church, in a field by north side of road. The cillín, half an acre or so in area, is roughly circular, now planted and surrounded by a low fence. Area, 97 A.

S.DD. Gleann Caol—"Narrow Glen."

Cumar Chúil—"River-Confluence Corner."

TERRAMOUNT. I could find no Irish form. Area, 127 A.

TOBBERANEAGUE, Tobar an Fhiaidh—"The Deer's Well." The well from which the townland is named is on Coffey's farm. Area, 286 A.

S.DD. Páirc na Scailpe—"Field of the Sod-covered Hut."

PARISH OF ST. MICHAEL.

This division contains four townlands only. Site of the ancient church is recognizable, but there are no remains. The walls were still standing in 1700, and they showed the building to have consisted of nave and chancel. Shanbally is a synonym for St. Michael's. Under the former name the church appears in the Taxation of Pope Nicholas, and it is called Shanbally, also Shanavallie, in the Royal Visitation [MS., T.C.D., E. 3. 14].

TOWNLANDS.

BALLYNAMADDREE, Baile na Madraidhe—"Village of the Dogs (Wolves ?)." There were two lioses, on the respective farms of Hanlon and Walsh, but both have been improved away. A small segment of a third fort survives near the western boundary of the townland. Area, 470 A.

S.DD. Ballaghmire (O.M.), Beal Átha Maghair—"Maghair's Ford-mouth."

The Pedlar's Grave. A gentleman (?), whose dogs killed and ate a pedlar, buried the skeleton here.

BALLYSKERDANE, Baile an Sciardáin—"Village of the Wind Blast." There is one lios of medium size on the farm of Andrew Cotter, about middle of townland. Area, 162 A.

S.D. Ladhar a Dá Abhainn—"Fork of the Two Rivers."

BALLYTHOMAS, Baile Thomais—"Thomas' Homestead."

Ballythomas (Inq. Car. I).

There is a small lios, with fence, about 5 feet high, on Mrs. Foley's farm. Area, 128 A.

S.D. Páircín a Ruisín. *Ruis,* of which the qualifying term here seems to be a diminutive, is the elder-tree.

TEMPLEMICHAEL, Teampul Mhichil—"Michael's Church."

The "Church in Ruins" of the O.M. is merely a circular mound, about 1 foot in height and an acre in extent. It is called the Teampuilín. On the townland was one circular lios of moderate size near the north boundary, but this too has been improved away. There is also a dallán 5 feet by 3 feet on Jennings' farm.

S.DD. The Teampuilín, as above.

The Graff, a field; the name comes from graffán, the adze for skinning land.

Páirc an Fhásaigh, "Field of the Wild Growth."

Cnoc na bhFear—"Hill of the Men"; a field for hurling, &c.

PARISH OF TEMPLEBODAN.

The name comes from the ancient church which was named, in its turn, from its founder, Buadan—perhaps Buatán—whom I cannot further identify. The church is named Drummor in the Taxation of Pope Nicholas, and later documents show that its rectory was impropriate in the Abbey of Bridgetown. Besides minor antiquities, the parish has an ancient graveyard, two early church sites, a holy well, and an ogham-inscribed stone.

Townlands.

Ballincurrig, Baile an Choraigh—"Homestead of the Marsh." Area, 418 a.

Ballincurrig (Inq. Car. I).

S.DD. Tobar na bhFaithne—"Wart Well."

Cuinne a Chaim—"Corner of the Hollow," in river.

Carraig Liath—"Grey Rock."

Poll a Chleibh—"Hole of the Basket," in river.

Ballyerra—Meaning unknown.

On this townland are two small lioses. That on the south boundary is still in a good state of preservation, with rampart 8 feet high. Area, 299 a.

S.D. Poll na Muc—"The Pigs' Pool," in river.

Ballyoneen, Baile Eoghainín—"Little Owen's Homestead." Area, 108 a.

There is a single small lios near south-west angle. Two fine pillar-stones stand on Adams' farm; these measure 7 feet 6 inches by 3 feet 9 inches by 2 feet and 7 feet by 6 feet by 2 feet respectively.

Ballyrobert. Baile an Roibeardaigh—"Roberts' Homestead." Area, 28 a.

Cahir Duggan—See under Gortroe, *antea*. On the townland is an old ruined mansion of the Pynes. Area, in two divs., 208 a.

Dundullerick, Dún Dolaraic—"Dolarac's Fort." Area, in two divs., 536 a.

Dundullericke (Inq. Car. I).

S.DD. Screathan—"Coarse Land"; a sub-div., containing 50 acres.

Carraig na Claise—"Rock of the Trench."

Dúinín Ruadh—"Little Red Fort," a field.

An Gniomh; G.—a well-known old Irish land measure. The name is here applied to a field.

Other field names:—Páirc na Cloiche (Field of the Pillar-stone; no dallán now). An Cnoc (The Hill; on this is a fallen dallán, 6 feet long), The Stone Field (on this is a dallán, 8 feet long, and now prostrate).

Monaing, Móin an Eanaigh—"Bog of the Quagmire." Area, 67 a.

Old Court, Seana Chúirt—Idem. Here was a castle of Barrymore's. The place was held in the seventeenth-century wars by the Confederates, who, in its neighbourhood, inflicted a considerable defeat on the Parliamentarians under Lords Broghill and Barry. There were formerly seven lioses, all of which are said to have been levelled by a single individual. By the roadside, set in the old demesne wall, is a milestone of peculiar type. Unfortunately the inscription is almost obliterated; it seems, however, to indicate half the distance from Cork to some place the name of which begins with a *C* and ends in *n*, perhaps Cappoquin. Area, 470 A.

S.DD. Bealach na Leacan—" Roadway of the Glen Slope," a sub-div. of small size.

Site of church and burial-ground (O.M.); this is a cillin; there are no remains.

Peafield, Cúl na Pise (also Gort na P.)—" Corner (also Garden) of the Peas." Area, 1,153 A.

On Lomasney's farm are two lioses—one, very large and double ramparted, and the other, a diminutive specimen. Two further lioses, partly levelled, are on John Kelleher's and John Murnane's farms respectively. On Lomasney's there were likewise two pillar-stones, which have disappeared.

S.DD. Móin a Lín—" Bog of the Flax"; a sub-div. containing about 200 acres.

Bóthar a Bhodaigh—" The Churl's Road"; a sub-div., about 100 acres.

Seana Mhacha—" Old Milking Place"; another sub-div., about 100 acres.

Seana Droichead—" Old Bridge"; there is only a low causeway now.

Páirc a Dalláin—" Field of the Pillar-stone."

Portavarrig—" Barry's Bank." Area, 145 A.

Rathcobane—See under Gortroe, *antea*.

Rathgobbane (D.S. Ref.).

There were formerly five or six lioses. Besides, there are the remains of a castle, an ogham-inscribed stone, and the site of an early church. The most important of the lioses is on Cullinane's farm; this is double ramparted and of large size. On M'Grath's and Chas. Cullinane's holdings respectively are two other lioses, the latter partly destroyed. On P. Aherne's farm again are two or three further specimens, of which one is unusually large and nearly perfect. Of the castle, only a featureless fragment, 12 feet in height, survives. The building was, I am inclined to believe, erected on site of the name-giving rath. This castle was occupied in the seventeenth century by one Daniel O'Cahill, who, as an innocent Papist, escaped transplantation and loss of estate. Area, 558 A.

S.DD. Seana Cill—Early church site; on Cullinane's farm; no remains.

Páirc an tSéipéil—" The Chapel Field"; adjoins last.

Páirc na Cloiche—" Field of the (Pillar) Stone." The name-giving stone bears two ogham inscriptions, one of them modern; the other, on left hand angle of the block, reads: " Loga Magi Sdambi."

Páirc a Dallán—" Field of the Pillar-stone"; no stone now.

Riesk, Riasg—" Morass." Area, 383 A.

S.D.D. Boherduff (O.M.)—" Black Road."

Loch a Chéid (?) a small lake on a hill summit.

Poll a Chléibh—" The Basket Hole," in river.

Páirc an Riasca—" Field of the Marsh."

TEMPLEBODAN—" Bodan's Church."

There is one large circular lios, known as Lisnabrock; it has one perfect rampart, 10 feet high, and part of a second. There is also the site of the ancient parish church in its churchyard, and, besides, an early church site, on Tim Connell's farm, and a holy well. The holy well is surrounded by a low wall, and inside are some rudely carved figures and many votive offerings. " Rounds " are made chiefly on Aug. 29th (beheading of St. John Baptist).

S.DD. Liosnabroc (O.M.), Lios na mBroc—" The Badgers' Lios."

Seana Chill, early church site, as above.

PARISH OF TEMPLENACARRIGA.

The parish name is derived from the ancient church (completely destroyed), which stood on a rocky ridge named independently Cargokenaughe [MS., T.C.D., E. 3. 14], Carrig O Keanath [*ibid.*], or Carrigokenagh [R.V. 1634]. From the Visitation of 1615 it would appear that this church consisted of a nave and chancel.

TOWNLANDS.

BALLYEDMOND, Baile Eamoinn—" Edmond's Homestead." Area, 398 A.

S.DD. Bóithrín Dorcha—" Dark Little Road."

The Maoghneas Wood.

Crosaire an Leacht—" Cross-roads of the Grave Monument."

BALLYMACSLINEY, Baile Mhic Sleighne—" MacSliney's Homestead."
Bally M^c^Slenye (Inq. Eliz.).

On Spillane's farm (E. boundary) was a circular lios of medium size, now demolished. Area, 341 A.

S.D. Páirc a Chrainn—" Field of the Tree."

BALLYTRASNA, Baile Tarsna—" The Homestead Across (the Glen)." Area, 297 A.

S.D. Gleann a Mhuillinn—" Glen of the Mill," a sub-div. containing about 100 acres.

CARRIGOGNA, Carraig Ó gCionáith—" The O'Kinney's Rock." Here we have the Carrig O'Keanath, &c., of the Visitations. On the farm of Tim Kelly is a well-preserved lios of moderate size and oval in plan, with a rampart 6 feet high. Area, 272 A.

CARRAGHCONDON, Corach an Chúndúnaigh—" Condon's Marsh." The O.M. records one circular lios of medium size. Area, 158 A.

Glenreagh, Glen Riabhach—"Grey Glen." The place is, however, more commonly called Baile Úi Ríóghbhárdáin (O'Reardon's Homestead"). Area, 71 a.

Glenwillin, Gleann an Mhuillinn—"The Mill Glen." Area, 114 a.

There is one large circular lios, with souterrain and chambers, in which two ogham-inscribed pillar-stones were found. One of the stones has been transferred to the Museum of University College, Cork; it bears a double inscription, scil.—

1. Brusco Magi Dovalesci.
2. Colomagni *avi* Duc*agni*.

The second stone has been re-erected in the field as a scratching-post! Its legend runs—

Lodimani.

S.DD. Beal Átha an Aifrinn—"Fordmouth of the Mass."

Míolta ?—a field. M. means beasts or lice (perhaps woodlice).

Páirc a Dalláin, the field in which the ogham-inscribed pillar stands.

Knockaneshane, Cnocán Sheaghain—"John's Little Hill." Area, 66 a.

Knocknamourah, Cnoc na mBuarach—"Hill of the Spansels," an ancient milking-place. Area, 168 a.

S.D. Bóithrín na gCaorach—"Little Road of the Sheep."

Leadington, Baile na Luidean—"The Lydons' Homestead." Area, 454 a.

Ballyneledan (Inq. Car. I).

S.D. Páirc na gCloigeann—"Field of the Skulls," on John Barry's farm.

Old Court, Seana Chúirt—Idem. Area, in two parts, 293 a.

On John Barry's holding were two small circular lioses with souterrains; both have been destroyed.

S.D. Seana Bhaile—"Old Village."

Rathgire, Ráth Gadhair—"Hound's (or Gadhair's) Rath."

Rathgaire (D.S.).

The eponymous lios was a small specimen, now destroyed. On Ned Stack's holding is a well, formerly reputed holy. "Rounds" were made there, and votive offerings were in evidence up to twenty years ago. Area, 143 a.

S.DD. Cúl Úi Mhurchada—"O'Murphy's Corner"; a small sub-div.

The Leacht (Grave Monument), at meeting-place of three roads.

Shanavougha, Seana Mhacha—"Old Milking Place." Area, 174 a.

Templenacarriga, Teampull na Carraige—"Church of the Rock."

On Ned Stack's holding is a very fine circular lios in perfect preservation; this splendid monument has a strong rampart, 8 feet or 9 feet high, and there are souterrains. Area, in two divs., 380 A.

S.D. The Cladderach; meaning unknown; perhaps "Hard Place"; a rocky recess on a hill-top, and also the stream at its base.

WALSHTOWN, Baile na mBreathnach—"The Walshes' Homestead."

There are two small lioses of no great importance; one of these—a half-demolished specimen—is on Ring's farm; the other is on Walshtownmore West. Area, in three divs., 1,775 A.

PARISH OF TEMPLEROBIN.

This division embraces the eastern half of the Great Island, together with the islands of Spike, Haulbowline, &c., in Cork Harbour. Besides some scant remains of the ancient church there are the usual lioses, some cairn sites, a primitive shell-mound, several early church sites, the remains of two ancient castles, &c. Templelyra was another name for the parish (Windele's "Cork," 1st ed., p. 154), and the form Capla Robin also occurs (Visit. 31, Eliz., MS. E. 3. 14, T.C.D.).

TOWNLANDS.

ASHGROVE, Baile Mhic Sheaghain Ruaidh—"Red John's Son's Homestead."

A small late castle of the Barrys still stands in the grounds of Ashgrove. This consists of a single square tower, with the usual loopholes and crenellated battlements. The tower was used as a pigeon-house till recently. Area, 177 A.

BALLYBRASSIL, Baile Úi Bhreasail—"O'Brazils' Homestead." On Corcoran's farm is a circular lios of moderate size. Area, 229 A.

S.DD. Móinteán na gCoinneal—"Little Bog of the Candles (phosphorescent lights)."

Reddington (O.M.); the famous academy of Fr. Harrington, wherein Daniel O'Connell received part of his education. The house still stands in good repair.

Cabhán an Mháirnéalaigh—"The Mariner's Cove."

Pointe na Sagart—"The Priests' Point."

Strialander; this strange name is applied to a path up the cliff face; entrance to the path, from below, was through a natural arch, which has since fallen.

BALLYDANIEL, Baile Dhomhnail—"Daniel's Homestead." Area, in three parts, 470 A.

S.DD. "The Palatines' Corner," a place where Palatine planters were buried.

Geata Buidhe—"Yellow Gate"; a cross-roads.

BALLYDULEA, Baile Úi Dhúin Shleibhe—"O'Dunlea's Homestead." Area, 146 A.

BALLYELLANE, Baile Ghолláin; meaning doubtful. Area, 169 A.

There is one small lios, of circular plan, on D. Ahern's; the rampart stands about 6 feet high.

S.DD. Gleann a Phúca, G. a Chuillinn and G. na mBocht—Glens of the Pooka, of the Holly, and of the Poor respectively.

BALLYMORE, Baile Móre—"Great Village."

Ballimore, als Greatetowne (Inq. Iac. I).

Here is the site (there are hardly any recognizable remains) of the ancient church, within a very large graveyard. In the latter are many ancient monuments, densely lichen-covered, and difficult to decipher. One such gravestone covers the remains of Fr. Harrington, O'Connell's preceptor; another marks the last resting-place of Chevalier J. P. Leonard, "an honest man, a lover of Ireland, and a friend of France."

A plain standing stone is inscribed:—

Hic Iacet Reverendus Ioannes
Sinnigh qui obiit decimo
tertio die Decembris sex
agesimo anno suae aetatis
et vicesimo Septimo anno
officii sui pastoralis in
Paroecia de magna
Insula, et anno Domini
1721.

Beside Father Shinnick reposes the body of his successor:—

I.H.S.
Here lyeth the body of the
R[d]. Garrett Stack w[o]
departed this life the
17th day of May in
68th year of his age
1751.

A table-tomb, close to the south fence, has the following:—

Here lieth the body of Matthew Mac
Kenna, in hopes of a happy Resurrection
Doctor of Sorbonne, Pastor of this place
for many years; Bishop of Cloyne & Ross
twenty-two years. Born in the year six,
and died June 4th, 1791.

S.D. Clais a Bhéiceacháin—"The Crying-Fairy's Trench."

Ballynatra, Baile na Trágha—"Homestead of the Strand."

The O.M. records a single moderate-sized lios of circular plan. Area, 83 a.

S.DD. The Gamhnach. G. = a "stripper"; the name is applied to a well.

Glenmore Stream (O.M.), Gleann Mór—"Great Glen."

Ballywilliam, Baile Liam—"William's Homestead."

BallymWilliam (Inq. Car. I).

There is one lios on the south boundary line—the monument lying mostly within adjoining Carraignafoy. Area, 156 a.

S.DD. An Linn Beag—"The Little Pool," a well.

An Púna—"The Pound"; still standing, but not used. See Cork Hist. and Archaeol. Journal, 1914, p. 36.

Bellgrove, Cill Bóchra—"Bóchra's Church." Area, 334 a.

Bóchra, mother of SS. Laidcenn, Cainnach, and Accrobrán, is honoured in the Martyr. of Gorman on Nov. 28th. Site of the ancient church lies on west side of Belgrove House, but there are no visible remains.

S.DD. The Moat (O.M.)—This was an artificial mound—probably Norman—which stood on summit of Eastgrove Hill; the Irish form is Cnoc an Mhóta.

Leacan Gadhair Gallda—"Glen Slope of the Foreign Dog."

Baile an Charrúnaigh—"Carew's Hamlet," a sub-div.

Tobar an Chuillinn—"Well of the Holly."

Carraig a Róin—"The Seal's Rock."

Bóthar na Naomh—"The Saints' Road." The name suggests that the road was used by the early Christian missionaries. Thence, by the way, would lie the shortest route from Cloyne to Finbarr's School of Cork.

Carrignafoy—I think the old name is Carraig-an-eich-Bhuidhe—"Rock of the Yellow Horse," from figure of a yellow horse painted on a cliff.

Coraneboy (D.S. Ref.); Carraghneboy (Inq. Car. I).

Castle Oliver, a sub-div. containing 50 or 60 acres.

Cnoc na Cathrach—"Hill of the Stone Fort."

Kilgarvan, Cill Garbháin—"Garvan's Church." Site of the early church is now occupied by part of Queenstown. At a later date the name Kilgarvan came to be applied to the union of Clonmel and Templerobin parishes. The name appears in the Down Survey as Kilgarvane.

Currabally—O'Donovan generally translates this name, which is of fairly frequent occurrence, as "Odd town," and in this I venture to think he is incorrect. Canon Lyons insists (Cork Historical and Archæol. Journal, vol. iii, p. 65) that *coradh* is in this and such connexions the surrounding wall of a homestead. See under Lisgoold, *antea*.

On summit of a hill stood a tumulus, destroyed about sixty years since. On Michael Houlahan's holding is a prehistoric shell-mound of kitchen-midden type. There is also a partially levelled lios called Cnocán na Síogán. Area, in two parts, 297 A.

S.DD. Tobairín na Trágha—"The Strand Well," a quarter of a mile from the strand. The well was regarded as holy, or, at least, as possessing peculiar healing qualities. There are a few votive offerings still.

An Clampar—"The Dispute," a field.

Cushkinny, Cuas Chionaoith—"Cionath's Haven." Area, 91 A.

Coshainny (Inq. Car. I); Quosquinny (Inq. Gul. et Mar.).

S.DD. Kitchen Cove (O. M.), Cuan na Cistin.

Carraig Ruadh—"Red Rock," a small sub-div. on which is a field frequented by a spirit.

Fanick, Fánach—"Sloping Place." Area, 86 A.

Fannagh (D. S. Ref.).

Haulbowline (island)—Etymology doubtful. An English (nautical) derivation is claimed for it. Notwithstanding, however, its English look, Canon Lyons (Cork Hist. and Archæol. Journal, vol. iii, p. 85) claims for the name an Irish derivation—Ail Bó Linne ("Cliff of the Cow Pool"). Professor O'Donoghue thinks the name is Ail Bolglinne—"Swelling Water Rock." With Haulbowline is now united an islet called Rat, or Coney, Island. The Irish name of this speck of land was Oileán Cathail. It is therefore one of the islands in Cork Harbour given to Mochuda of Lismore by Cathal Mac Aodha, chieftain of Kerrycurrihy. Area, 27 A.

Rocky Island, now the naval magazine. Irish name unknown. Area, 2 A.

Rossleague—Doubtful. The *a* is pronounced long and open—Ros Láig.

Roseylig (Inq. Jac. I).

The O. M. shows three small lioses; these have been all levelled, though their sites are easily recognized. On the townland is also a martello tower, 30 feet high and 143 feet 2 inches in circumference, erected in 1815. Area, 226 A.

S.DD. Baile an tSeiscinn—"Homestead of the Fen," a sub-div. containing about 80 A.

Lios an Ghruagaigh—Grúgach (from *Gruag*, hair) was a legendary spirit, or superman, whose name signifies hairy, fierce, stern, or wrinkled. This lios was one of the three so recently destroyed.

SPIKE ISLAND—I got the name Oileán a Spíce locally, but this is evidently of modern manufacture, though O'Longan so called the place in 1798. The island is called Inis Pic in the Irish Life of Mocuda, and the forms Innys Picke and Spike Island occur in Inquisitions of William and Mary and Car. I, respectively. I would suggest that Inis Pic may be a corruption or wearing down of Inis Easpoig; but the difficulty is that the writer of Mochuda's Life should not know this. St. Mochuda of Lismore founded a religious house here in the eighth century; and the British Government ten centuries later (1847) established in its place another house of quite a different character.

WALTERSTOWN, Baile an Bháitéir—"Waters' Homestead." On Murphy's farm are traces of a demolished lios. On Michael Mahoney's holding is a holy well beside an ancient burial-ground, locally believed to have been the scene of a battle. Slightly to west of Morlogue Point are some oyster and other shell deposits, indicating a prehistoric settlement of kitchen-midden type. A natural cave in the cliff at East Ferry is believed to have been a place where Mass was celebrated in the Penal times. There is also a site, with some nondescript remains of a castle of the Waters family, later the property of the Lavallins. Area, 330 A.

S.DD. Morlogue Point (O. M.), possibly from Marl, which was dug here.

Cnocán na Croiche—"Little Hill of the Gallows," on south slope of hill. Here in a field was found a number of stone-lined graves.

Poll an Chaorthain—"Pool of the Quicken Tree," a hole or pool in the navigable channel.

Bóithrín a Ché—"Little Road of the Quay."

PARISH OF TEMPLEUSQUE.

The name signifies "Water Church." At present the site is high and dry, and the etymology seems inadmissible and physically impossible. Hence another derivation has been put forward and pretty generally accepted—Temple Loiscthe ("Burnt Church"). From traditional popular usage it is not possible to determine which is the proper form; both forms are freely used. That the correct qualifying term is *uisge* seems clear from the documents.—Templeusky (Deps. 1652); Templeoskye (Inq. Jac. I); Teampul uisge (Sean na Raithineach); Templeosce (will of Fr. Conor MacCurtin). On the other hand, the form in the 1591 Visitation Book (MS., T.C.D., E. 3. 14) undoubtedly suggests Burnt Church, scil—Clanmnoyre als Temple Losky. Of the ancient church there are no remains, and the extensive graveyard contains nothing of very special interest.

At west end of the graveyard is a vault-like, subterranean chamber, approached by a flight of stone steps, and secured by a strong iron gate. This was used as a kind of mortuary chapel, wherein bodies were deposited for a period of three weeks after death. At the end of that period the body would be useless to body-snatchers, and so it was buried.

The parish name appears as Glynmaygyr in the Taxation of Pope Nicholas, as St. Mary's of Glanmire in the Presentation of 1437 (Caulfield MSS., quoted by Brady, vol. i, p. 349).

TOWNLANDS.

BALLINDEENISK, Baile an Díonuisc; meaning unknown. Two Irish speakers of the locality pronounced the name *B. an Líniosc*; from all others I got B. an Dionuisc, as above. The Field Book, Ord. Survey, makes it Ballinleenisk. On the other hand, the Down Survey has Ballydinisk.

There are two small lioses on Fell's farm, and on the same are four remarkable dallans, of which three (one of them now prostrate) formed a group in line in "The Two-Stone Field." The two standing pillars are each about 9 feet high by 6 feet wide and 2 feet thick, but the fallen stone is not quite so massive. In a field close by ("The One-Stone Field") stands the fourth dallan, 5 feet by 3 feet by 1 foot. Area, 645 A.

S.DD. "The Barrack Field," so called from a village of labourers' houses.

Crosaire na mBastairdí—"Cross Roads of the Illegitimate Children," where some unfortunate infants of the kind named were found buried.

Páirc a tSeantóir—"The Glebe."

BALLYNAPARSON, Baile na bPearsan—"The Parson's Homestead." There was one large lios, but it has been demolished. Area, 288 A.

Field names—Páirc a Phúna (Púna here = safe enclosure), Páirc a "Safe" (same meaning exactly as last).

CONEYBEG, Cómhnúidhe Beag—"Little Dwelling." The Field Book (O. S.) gives *connadh* (firewood), which is certainly incorrect.

Conyally and Conygally (Deps. 1652).

There is a circular lios of moderate size on Cuffe's farm. Area, 449 A.

S.DD. Field names:—"The Stone Field," in which is a small dallán, 3 feet by 3 feet by 3 feet; Seana Bhaile and "The Fort Field," in which was another lios, now levelled.

COOLGREAN, Cúilín Uaithne—"Little Green Corner"; but I also got Cúil Grín, in which *grin* may be intended for *grinn*, pleasant. There is a rather remarkable holy well ("Lady's Well"); this is within, or beside, a farmyard, and is elaborately arched over and tended with some care; it is entered by a doorway, 6 feet by 4 feet. "Rounds" are made on August 15th and all during May. The "pattern" also is still kept, and there are votive offerings of the usual kind. Area, 482 A.

S.DD. "The Stone Field," in which is a dallán, 6 feet by 2½ feet, on O'Shea's farm.

Páirc na gCloch—"Field of the Stones," in which were formerly other dalláns. In another field (nameless) of O'Shea's is a small dallán, 3½ feet by 2 feet by 4 feet.

CRUSHYRIREE, Crois Raighri—"Roger's Cross (Roads)."

There is one circular lios, now nearly demolished, on John Cashman's farm; it has a rampart, where perfect, about 7 feet high. On O'Donoghue's farm is site of a completely demolished lios. Area, 334 A.

S.D. Áth na Ceárdchan—"Ford of the Forge"; applied to a bridge.

HERMITAGE, Cúil Úi Mhaonuisg—"O'Maoghnus's Corner."

The place gets its official, and fancy, name from a clochán-like structure, now very decayed, which stands within the demesne of Miss Gubbins, in a dense shrubbery by the riverside. This hut is 8 feet in diameter by 9 feet high; it was roofed on the beehive principle, and was furnished with fireplace and chimney. On Miss Gubbins' farm are also two pillar-stones in one field; these are each about 6 feet by 2 feet by 2 feet. The field in which they stand is called Páirc na Cíoiche. Area, 100 A.

KILLALOUGH, Cill a Locha—"Church of the Pond."

Minute investigation failed to discover trace or tidings of the eponymous cill. I think the present and adjoining Killydonoghue Townlands were originally one, and that the name-giving cill is that described under the latter townland. There is a well styled "Lady's Well," to which, however, no reputation for sanctity attaches. Area, 141 A.

KILLYDONOGHUE, Cill Úi Donnchadha—"O'Donoghue's Cill." See last.

The name-giving cill, or, at least, its site, is on William Cashman's farm. The former sacred spot is now tilled, and only tradition indicates its exact location. On Cashman's, too, near the cill, was a lios, now also levelled and obliterated. Area, 457 A.

S.DD. Tobairín an Bhutain—"Little Well of the Button" (?).

Tobairín na Cille—"Little Well of the Ancient Church Site."

Seana Bhaile Mór—"Great Old Homestead."

Cnoicín—"Little Hill."

Bogachín—"Little Soft Place" (a bog).

Carraig an Mhadraidh—"Rock of the Dog (Wolf ?)."

POULADOWN, Poll an Deamhain—"The Demon's Hole," from a bog-hole now drained and filled in.

There were two lioses near west boundary of the townland, but they have gone the way of most lioses. A pillar also, which gave its name to a field has disappeared. Area, 171 A.

S.DD. Screathan—"Coarse Land," a sub-div.

Cnoc na hÁtha—"Hill of the Ford."

Páirc a Tóchair ("Field of the Raised Causeway").

RIVERSTOWN, Baile Ruisín—"Homestead of the Little Wooded Bluff." Area, 449 A.

S.DD. Cúirt Úi Mhaonuisg—"O'Maoghnus's Court," a sub-div.

Cruachán Úi Orgain—"O'Horgan's Little Crested Hill," another sub-div.

Poll an Choire and Poll Cam—"The Cauldron Hole" and "The Crooked Hole" respectively; they are both in the river.

Inse na hOrna—"River Holme of the Barley"; barley was sown here but potatoes grew instead!

"Ali Baba's Rock," a ridiculous modern name.

SARSFIELD'S COURT. No Irish name.

The name-giving mansion, now entirely destroyed, stood on site of O'Neill's farmyard. The Sarsfields, who had been here for four hundred years, forfeited in the middle of the seventeenth century.

There were formerly three lioses, but all have been destroyed. One was named Lios na Mna Óige ("Lios of the Young Woman"). This had underground chambers, and was the abode of a spirit. There is also a well, Tobar Beannuighthe, to which was attached a reputation for sanctity. Area, 621 A.

S.DD. Leaca Breac—"Speckled Glenside," a sub-div.—about 10 acres.

Páirc na Bó Finne—"Field of the White Cow."

TEMPLEUSQUE—*Vide supra.* Area, 458 A.

There were three small circular lioses on Cuffe's farm, but they have been cleared away.

S.DD. Strapa an Aifrinn—"The Mass Stile," because it led to a chapel of the Penal days, situated at Ballinbriskig.

"Buck Leary's Cross." Leary was a famous bowl-thrower of his day. In '98 he became a sheriff's officer, and incurred much popular odium.

XII.

THE OFFICE OF CHIEF GOVERNOR OF IRELAND, 1172–1509.

By HERBERT WOOD, B.A.

[Read December 11, 1922. Published February 8, 1923.]

The question of the position of Chief Governor, as the King's Deputy in Ireland, is of considerable importance in considering the government of the country. The changes of policy of the English Kings were manifested in their choice of representatives, and the character of the Chief Governor had much to do with the success or failure of such policy; yet, up to the present time, no one has produced a satisfactory list of such Governors and their Deputies, with the exact dates during which they held office, nor has there been any attempt to set out clearly their powers. The various titles they held, such as King's Lieutenant, Justiciar, Governor, Custos, Deputy, &c., seem never to have suggested to the historian the necessity for clearly stating what they severally connoted. Not only the old annalists, but even some modern historians, have gone hopelessly astray in giving the Chief Governor his proper title. I hope to be able to show in the following pages that each of these titles had a distinct connotation, and was not given at hap-hazard. As to my authorities, I have found the annalists frequently wrong, the most reliable being the Laud MS., commonly called "Pembrige's Annals." Accordingly I have relied chiefly upon what I may call Government records, both because the entries were contemporaneous with the events recorded, and because they were actual transcripts of administrative acts of the Government. For this purpose the Plea or Justiciary Rolls, containing the exact dates when the Chief Governor presided in Court; the Patent and Close Rolls, containing the various writs tested by him; and the Memoranda Rolls, which contained the entries of various acts by him which it was necessary to record in the Exchequer, have been of much greater value to me than the various annals or histories. The loss of many of the Government Rolls in the past has compelled me at times to give these annalists or historians as authorities for my statements, but I have never done so without having a very strong presumption that in these cases they are right. I regret that many of my references to the Government records must be taken on trust, as the originals have been destroyed by the fire and explosion which occurred in the Four Courts on 30th June, 1922.

I intend to treat first of the various titles held by the Chief Governors, and afterwards of the powers possessed by them. There is appended a list of all the Chief Governors who held office between 1172–1509, with the names of such deputies as I have been able to trace.

I.—Titles of Chief Governors of Ireland.

(a) *King's Lieutenant.*

The title of Lieutenant of the King was the highest which was given to any Governor of Ireland. He was generally an English noble, and, in the fifteenth century, a son or relative of the King himself. Before the coming of Richard II to Ireland in 1394, there were only nine cases of the office being held by a King's Lieutenant. In 1308 Richard de Burgh, Earl of Ulster, was appointed under that title, but his tenure was short, as next day Piers de Gaveston, Earl of Cornwall, was appointed; the rest were Roger de Mortimer in 1317; William de Burgh, Earl of Ulster, in 1331; Lionel, Earl of Ulster, and subsequently Duke of Clarence, 1361; Sir William de Windsor, 1369; Edmund de Mortimer, Earl of March, 1379; Roger de Mortimer, 1382; and Philip de Courtenay, 1383. In the cases of Piers de Gaveston, Roger de Mortimer, William de Burgh, and Philip de Courtenay, Justiciars were for all or part of the time acting with them. It is curious to note that in two cases, viz. Sir William de Windsor and Roger de Mortimer, they were, subsequently to being removed from their office as King's Lieutenants, reappointed with inferior titles, Roger de Mortimer returning to Ireland in 1319 as Justiciar, and Sir William de Windsor in 1373 as Governor and Keeper of the Land.

The powers of these Lieutenants were larger than those of a Justiciar, and were set out at large in their patents. But what especially indicated their importance was that they entered into indentures with the King on their appointment, setting out the sums for which they agreed to undertake the government of Ireland. Thus, in 1369, Sir William de Windsor agreed for £1,000 a year; in 1316 the King bound himself in 6,000 marks to Mortimer; in 1380 Edmund de Mortimer was appointed on consideration of being paid 20,000 marks and permission to expend the King's revenue as he wished; in 1382 Roger de Mortimer was permitted to receive all the revenues and profits of every kind derivable in Ireland under the Crown of England, and 2,000 marks in money; in 1398 Thomas Holland, Duke of Surrey, was appointed at 11,500 marks yearly; in 1400 Thomas de Lancaster agreed to accept the post at 12,000 marks yearly for all the men retained by him, while in 1406 he was granted £7,000 yearly on the same terms; in 1414 Sir John de Talbot received £2,666 13*s.* 4*d.* a year; in 1423 Edmund de Mortimer received 5,000 marks yearly; in 1425 James Butler, Earl of Ormond, received £1,000 a year; in 1428 Sir John Sutton received 5,000 marks for the first year and 4,000 for the second; in 1442 Ormond was allowed to receive all the Crown receipts and profits, but to pay the ordinary wages of officers; while in 1447 Richard, Duke of York, agreed to take office on receiving the entire of the King's revenue and 4,000 marks the first year and 2,000 marks for the remaining nine years. With these large sums were also granted special powers, even to removing the chief officers of State. The large sums mentioned above were often given to cover the increased military costs.

There is only one case in the fifteenth century of this title being given to an Irishman, viz. the Earl of Ormond, who was appointed King's Lieutenant in February, 1442. When, towards the end of the year 1441, it was thought probable that he would be chosen for the vacant post, a vehement protest was made by the members of the Irish Parliament, who sent a deputation to the King "to ordayne a mightie lord of this yo[r] Realme of England, for to be yo[r] lieutenant of the said land, that tyme being there present the Erle of Ormond as deputie to the lord Wells then yo[r] lieutenant there . . . both the lordes spirituall and temporal, and the comons there assembled, considered in there wisedoms, that it was most expedient to yo[r] soveraine lord, to have to yo[r] lieutenant there, a lord of birthe, of this Noble Realme, whom yo[r] people there will more favour and obay, than any man of that landes birthe, for men of this Realme keepe better Justice, execute yo[r] lawes, and favour more the common people there, and ever have done before this tyme, better then ever did any man of that land, or ever is like to doe" (Statute Rolls of Ireland, 20 Hen. VI). The King did not grant this petition. It must be remembered in reading the above that the petitioners were speaking in England, to which "this Realme" refers.

The King's Lieutenant was allowed to appoint a Deputy, and in the fifteenth century Ireland was almost always governed by a Deputy, as the Lieutenant rarely put foot on these shores. The Deputy was generally an Ormond or a Kildare, and the constant hostility of the two families was the reason for the enactment of Poynings' Law.

Before the arrival of Richard II in Ireland in 1394, the King's Lieutenant presided over the King's Court as his representative. Lionel, Duke of Clarence, was termed not only "the King's son and Lieutenant in Ireland," but also "the Justiciar of Ireland."

(b) *Justiciar.*

The title of Justiciar is derived from the Latin "Justiciarius," which was applied to all Justices. So, too, the English word "Justiciar" was also applied to all Justices in the past, as we find Madox in his *History of the Exchequer* writing about Justiciars of the Bench. In Norman-French the corresponding title was "Justice." The term "Justiciar" is now only applied to the King's representative in the past. The old practice of using this word to indicate all kinds of Judges has led many historians into error, through not observing that the Chief Governor was always called "Justiciarius Hiberniae," while the others had their distinctive titles, as "Justiciarius de Banco," "Justiciarius ad assisas capiendas assignatus," &c.

The office of Justiciar was one of those Norman offices which William I brought with him to England; and when he was absent in Normandy he appointed a Justiciar in England to represent him in his absence. This practice ceased in England with Hugh le Despenser in 1272, but was continued in Ireland till long afterwards, as in 1449 we find Richard Talbot, Archbishop of Dublin, acting as Justiciar. From that time we find the title still used, but with a different signification, which I will refer to later on under the head of "Custos." The appointment of a Justiciar to represent the King is also to be found in Scotland, where two Justiciars were appointed, one for the north and another for the south; and the Supreme Criminal Court in that country is still called the High Court of Justiciary. In Wales, too, after the conquest, a Justiciar was appointed in 1328 (Rymer).

The Justiciarship, unlike the office of King's Lieutenant, was usually made without any indenture, with a fixed salary of £500 and the obligation to maintain twenty men-at-arms and twenty caparisoned horses. Possibly in some cases these forces tended to become fictitious, as in 1349, in Thomas de Rokeby's patent, the twenty men-at-arms and twenty mounted archers were to be periodically inspected by the Treasurer to prevent frauds. The Justiciar's powers were set out in his patent; and he was usually enjoined to act only with the advice of the Council. These powers were of a much more limited nature than those given to a King's Lieutenant. In early times he was obliged to give his own son or some of the children of his kinsmen or wealthy retainers to the King as a guarantee of his fidelity, and he, in turn, could claim hostages from the native chiefs.

The Justiciar was always given the custody of the land and the castles, unless a King's Lieutenant was acting with him, when the custody of the land was given to the latter.

Till the coming of Richard II to Ireland the majority of Chief Governors were styled Justiciars; but from that time they were mostly King's Lieutenants, and generally exercised their office by deputy.

(c) *Custos.*

This term or style is involved in a certain amount of obscurity, and I must be pardoned if I dwell on it at some length.

The Chief Governor was invested with the custody of the land and its castles as well as with the office of Justiciar. When the Chief Governor was a King's Lieutenant or a Justiciar, he held the custody of the land; but when they were both acting together, it was always the former who held such custody. The custody of the land was the matter of most importance, and was consequently given to the higher official; but somebody had to hold it. When in 1331 William de Burgh was King's Lieutenant, acting with Antony de Lucy as Justiciar, and was recalled to England, the custody of the land was handed over to de Lucy by the King. To prevent the land being left without a custodian, it was enacted by the Statute FitzEmpress (recited in the Act 2–3 Ric. III, c. 8) that in the case of the office of Chief Governor being void through death, surrender, or departure of a Chief Governor or his Deputy, the Council should appoint someone in his place to hold the land till the King should think fit either to confirm the appointment or choose someone else to fill the post.

This officer was called the "Custos," because he had the custody of the land; but he was also nominated to exercise the office of Justiciar.

Out of the fifteen cases of appointment of a Custos which I have found, eight of them were by the Council on the death or departure of a Chief Governor, and are easily understood under the above statute. They resemble the appointment of a Custos over the temporalities of a See on the death of a Bishop. Five appointments of a Custos were made by the King; and in four of these cases they were of a temporary nature and of short duration; but the fifth, that of Thomas de Charlton, Bishop of Hereford in 1338, lasted for nearly two years; and the only reason I can think of as to why the King only appointed him a Custos instead of making him a Justiciar is that he only intended the appointment to be temporary, but that circumstances prevented him making a permanent appointment sooner than he did. The remaining cases, those of Edmund le Botiller in 1304–5 and 1312–14, present a difficulty. Why was Edmund le Botiller appointed Custos in 1304 instead of Deputy, as Wogan remained Justiciar all the time, and writs were directed to him as such to try certain cases, which were tried by Botiller in his absence? The same difficulty meets us in his appointment as Custos in 1312, though a solution of this case may be found in the argument of Mr. Roberts. who was Ulster King-of-Arms in the time of Charles I. He says that upon the repair of John Wogan (1312) to England, Edmund le Botiller was by letters patent appointed to govern Ireland as a Lieutenant of Wogan, but refused it (as it seems) because he had been formerly Chief Governor of Ireland. "This appears by Patent Roll, 6 Ed. II, among the Rolls of the Exchequer in Ireland, where, on the margin of the Roll, at the foot thereof, and at the end of the first commission, is written *vacat, quia idem Edmundus illam commissionem noluit accipere.* And then, immediately after the said commission, follows another there enrolled, whereby he is made *Custos terrae Hiberniae*" (Carte, *Life of Ormond,* Introduction, p. lix). It may be argued from this that the office of a Deputy was considered as being inferior to that of a Custos, and that as Botiller had been appointed Custos in 1304, he refused to take an inferior post in 1312.

That there was a difference between a Custos and a locum tenens or Deputy is clear from an entry in the Justiciar's Roll, 23 Edward I (p. 50 in Calendar), where the petitioner says that he had complained before "the now Custos of Ireland, then locum tenens of the Chief Justiciar." This refers to Thomas FitzMaurice, who was first Deputy to William Dodingeseles and then Custos.

It seems to me that the office of Custos differed from that of a Deputy in that the former was an *emergency* Governor—a term which seems to indicate more clearly than any other the temporary nature of the appointment.

The last Governor to be appointed as Custos was E. de Kent in 1399, when Richard II was recalled in haste to England to meet Richard Tudor, and from that time an emergency Governor was called "Justiciarius." From this time till 1449 we find the term "Justiciarius" applied not only to a Chief Governor, but also to an emergency Governor, and great care must be taken to distinguish between the Justiciar or Chief Governor appointed by the King and the Justiciar or emergency Governor appointed by the Council.

From 1449, however, the term Justiciar only occurs as indicating an emergency Governor; and from the time in the reign of Henry VII when the statutes commenced to be made in English, this officer has been termed Justice or Lord Justice. In 1509, on the death of Henry VII, the Council elected the Earl of Kildare, who had been Deputy to Prince Henry, to be "your Justice and Governor here," as a temporary appointment till the new monarch should express his pleasure. By the Act of 33 Henry VIII (sess. 2, c. 2), it was ordered that in the cases of emergency comprehended by the Statute FitzEmpress, the Council should choose an Englishman, not being a spiritual person, if any should be found in the realm, and if not, then to choose two persons out of the Council to be Justices. We see in this the origin of the practice of appointing two or more Lords Justices, in the absence of the Lord Lieutenant, which has continued to the present time.

(d) *Deputy.*

Most Governors were entitled by their patents to elect a Deputy to govern in their absence, but the election was sometimes made by the King, as in the case of Henry, Lord Gray, in 1478, and the Earl of Kildare in 1479. In some special cases a Deputy was allowed to appoint a Deputy. This power was expressly set out in the indenture of Thomas de Lancaster. Accordingly, when his Deputy, Sir Stephen Lescrop, in 1405 and 1407, had to go over to England, the latter appointed James, Earl of Ormond, as his Deputy; he also made Sir William de Burgh his Deputy in Connaught in 1403. Henry, Lord Gray, Deputy of George, Earl of Clarence, appointed Sir Robert Preston his Deputy in 1479, and by Statute 3 Ed. IV, c. 5, Desmond as Deputy was allowed to appoint a Deputy, Thomas FitzMaurice, Earl of Kildare, so that Clarence's patent should not be invalid. On the death of a Deputy in office, it was usual for the Council to elect a Custos or Justice till the King's pleasure should be made known; but in 1454, on the death of Sir Edward FitzEustace, Deputy of Richard, Duke of York, a fresh patent was given to the latter by the King to avoid any complications. In 1423 the Chancellor refused to acknowledge the Bishop of Meath as Deputy of the Earl of March, as he had been appointed under the Earl's privy seal, and not under the Great Seal of Ireland; and in 1478 the Earl of Kildare also refused to acknowledge Gray's patent as Deputy for the same reason, as it was under the privy signet.

(e) *Various Titles.*

Though Hugh de Lacy was appointed Justiciar by Henry II in 1172, his successors in the office of Chief Governor of Ireland, up to 1185, received various titles. Thus Raymond le Gros, in 1176, and William FitzAudelin, in the same year, and Philip of Worcester, in 1184, were styled *Procuratores.* Hugh de Lacy, in 1177, was called *Procurator-General*; while in 1173 Richard de Clare was appointed *Custos Regni*, and in 1181 John de Lacy and Richard de Pec were styled *Custodes Dubliniі.* In 1374 Sir William de Windsor, who had been the King's Lieutenant, 1369-72, returned to Ireland as *Gubernator*, with the enormous salary of £11,213 6*s.* 8*d.* for one year, agreeing to stay longer at the same rate, and to receive 500 marks extra if staying at the King's command, though it is true that for this sum he had to maintain 200 men-at-arms and 400 archers for one year.

II.—The Office of Chief Governor.

The Chief Governor was appointed by the King, usually by privy seal. Henry IV was petitioned to make the appointment under the Great Seal of England, and on 28th February, 1417, he promised that when the term of service of the present Lieutenant should expire he would remedy the grievance, but the promise does not appear to have been fulfilled. The grant of office in the case of a King's Lieutenant was usually accompanied by an indenture setting out the express terms on which the grantee accepted office. The appointment was not always accepted, as in 1374 Sir Richard Pembridge refused it, and was prosecuted for so doing. It was adjudged that his refusal was strictly legal, "for that residence in Ireland, even in the station assigned to him, was but an honourable exile; and that no man could by law be forced to abandon his country except in case of abjuration by felony or by Act of Parliament" (Leland, i, p. 325, quoting Coke, *Second Institute*). The only occasions when the Chief Governor was not appointed by the King was when a vacancy occurred during the term of office of a Governor or his Deputy by death or departure from the land, or on the death of the Sovereign, for which the Statute FitzEmpress made provision. The Governor's patent of appointment laid down the conditions under which he was to govern the country. Such powers were nearly always limited by the instruction that his authority was to be executed "juxta leges et consuetudines terrae illius"; and, especially in the case of appointment of a Justiciar, that he was to be guided by the Council, and exercise his authority with their approval and assistance. Sometimes he was ordered to be guided by a special person: thus King John's Justiciar was commanded to take the advice of Hugh de Lacy, Earl of Ulster; in 1217 Henry de Londres, Archbishop of Dublin, was sent back from London to assist the Justiciar and Council in the government of the country; while in 1331 William de Burgh, Earl of Ulster, was ordered to assist the Justiciar. Indeed, in these early times the King seems to have placed little confidence in the persons whom he appointed to this important office.

The functions of the Chief Governor may be divided into (**a**) military, (**b**) judicial, and (**c**) administrative.

(a) *Military.*

One of the most important functions of a Chief Governor was that of commanding the army. As the country was, in one part or another, in a constant state of rebellion, the forces of the Government were in constant requisition, and it was the duty of the Governor to lead such forces against the Irish enemy. No sooner was it beaten in one part of the country than rebellion in another part of the country raised its head and required the attention of the unfortunate Governor. That he was a soldier is shown by many of the patents of appointment, where it was laid down that the grantee should provide twenty men-of-arms, of which he was to be one, and also that he should fight with the Royal power if necessary against all English rebels and Irish enemies in the said land, and reduce them to peace (see patent of Sir John Sutton, 1428). Even those Governors who were ecclesiastics had to face the enemy in the field. Thomas Cranley, Archbishop of Dublin, marched at the head of his troops at Kilkea, and his successor, Richard Talbot, in 1419, led the Crown forces against the enemy, in which encounter thirty of the Irish were slain. But it was not only in Ireland that he was expected to exhibit his military powers. The Kings of England made frequent calls on the Governors to come to their assistance in the numerous wars in which from time to time they were engaged. In 1254 the Justiciar was desired to come to the King's aid in Gascony with horses, arms, and soldiers.[1] A writ of 21st October, 29 Henry III, ordered payment to be made to the 3,000 foot-soldiers from Ireland who attended with the Justiciar in the King's service at Garmok.[2] John de Gray was summoned to attend the King in the Welsh campaign in 1211.[3] In 1245 Maurice FitzGerald, Justiciar, was ordered to bring troops against David, son of Llewellyn. In 1295 John Wogan was commanded to raise 10,000 foot-soldiers, in addition to horsemen, in Ireland, to assist the King in his Scottish wars. In 1322 John de Bermingham, Earl of Louth, was ordered to aid David, Earl of Athol, against the Scots. It must be remembered that the feudal lords in Ireland were not bound to supply military aid for expeditions outside Ireland; and on one occasion, when asked by the King to do so, it was expressly stated that it was not to be taken as a precedent. Nor could military summonses be issued to them to render aid even in Ireland without the assent of the nobles, as the Justiciar found to his cost in 1319, when his order was revoked for that reason. Yet, notwithstanding these hindrances, the Chief Governor often did conduct military levies across the water.

(b) *Judicial.*

When Henry II came to Ireland, he brought in his train the great lawyer, Ranulf de Glanvil. Whether he did so with the idea of having his advice in creating a Constitution for Ireland or no, it is extremely likely that he was guided by him in framing the form of government for this country. At that time in England the King presided in the *Curia Regis*, and no doubt such a

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[1] Irish Close Roll, 38 Hen. III.
Lynch's *Feudal Dignities*, p. 44.
[3] Annals of the Four Masters, 1210.

Court was established here. When, soon after, in England the Court of Exchequer was cut off from the *Curia*, it is probable that the same course was followed in this country. By the Great Charter of Henry III the Court of Common Pleas was settled in Dublin, and thus the only portion of the *Curia* still remaining in Ireland was the King's Court. Here the Chief Governor, as the King's Deputy, presided; and he and his Court, as in England, perambulated the country to give decisions in criminal matters and pleas of the Crown. These pleas consisted of pleas of high treason, petty treason, felony, &c. The Court also had cognizance of criminal matters, and of pleas relating to franchises and liberties. Writs of novel disseizin, mort d'ancestor, writs of right, writs of natives and fugitives, also came before his Court, which alone had the power to declare a man an outlaw. It also had jurisdiction in civil cases which were breaches of the peace, and therefore called trespasses. Appeals on writs of error from other Courts were heard before the Governor, and on his rolls alone could recognizances be entered. Even when the King granted away to a feudal lord the right of trying pleas of the Crown, the four pleas of forestalling, rape, arson, and treasure-trove were reserved to his Court. It will thus be seen what a power was given to the Governor in travelling through the country to administer justice. However, as he was more of a soldier than a lawyer, he was given a legal assessor in the time of Edward I, who was called *Justiciarius assignatus ad placita nostrum Justiciarium Hiberniae sequentia tenenda*, and a second Justice was subsequently added. It is interesting to call up in imagination the spectacle of the Chief Governor passing through the country in his judicial capacity. The Chancellor probably preceded him to have the writs made out for the cases to be tried. (He was not, however, allowed to issue writs to the sheriffs of the Liberties, but only to the seneschals, who issued the writs to their sheriffs. As, however, the seneschals sometimes made default, a law was passed in 26 Ed. I[1] appointing King's sheriffs in the Liberties to whom the writs should be directed in case the seneschals or their sheriffs made default.) In case the Chancellor was unavoidably absent, licence was granted to the Chief Justice or other legal officer to issue the writs.[2] The purveyor also went before to make preparations for the lodging and feeding of the Governor. With the latter came the clerks of the Court with their Rolls, the law officers and pleaders, and sometimes the members of the Council and their suite, together with a military force, an array sufficiently imposing to strike terror into the hardiest offender. An appeal from the Governor's judgment lay to the King; but, in one instance, contrary to custom, the King empowered

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[1] *Liber Niger*, Christ Church.

[2] Cal. Irish Pat. Rolls, 49 Ed. III, No. 154.

John de Bermingham, Justiciar, to cause to come before him the records and processes of all assizes and pleas held before Roger de Mortimer while he was King's Lieutenant in Ireland, and to correct the errors therein according to law.[1] With the coming of Richard II to Ireland, the King presided in his own Court, and thenceforth the proceedings were always headed "coram Rege," and the Chief Governor ceased to be present, the judicial power resting with the Chief and other Justices of the King's Bench, they being styled "the Justices appointed to hold pleas before the King in Ireland." When a King's Lieutenant and a Justiciar were both acting together, it would appear that they could both exercise judicial functions. Thus, Edmund le Botiller was trying cases at Limerick and de Mortimer at Cork in November, 1317; and, a few days after, both sat together at Cork.[2]

This Court continued on occasions to hold its venue outside Dublin; but it probably became fixed there in the time of the Tudor monarchs.

(c) *Administrative.*

The administrative authority granted to a Chief Governor depended very much on the power granted to him in his patent. These varied considerably. In the case of a King's Lieutenant the powers were more extensive than in the case of a Justiciar. The Duke of Clarence in 1462 was authorized to appoint and remove officers of the Treasury, Justices, Barons of the Exchequer, and the Keeper of the Rolls in Chancery—a power likewise granted to his successors; and Thomas de Lancaster in 1401 was allowed to make grants of forfeited lands. But these powers were exceptional. The usual powers of the Chief Governors comprised the receiving of rebels into the King's peace, the granting of general pardons to felons and outlaws, the right to receive all fines and ransoms, to present to certain void benefices, to grant custodies and wardships of the yearly value of £20 and upwards, to remove and appoint justices, sheriffs, bailiffs, and other inferior ministers, to summon Parliaments and convoke Councils generally, with the consent and advice of the Council.

The former of these he summoned by direction of the King, till the reign of Henry VI, when the confusion caused by the Wars of the Roses left the initiative with the Governor (Statutes 11 Eliz., sess. 3, c. 8). The Great Councils were summoned by him under the advice of the Council. That he did not on some occasions preside at the Parliaments is evident by the declaration of that body in 1382, that the necessity of the Chief Governor

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[1] Cal. Eng. Pat. Rolls, 1321–4, p. 43. [2] Plea Rolls, Nos. 115, 116, 119.

being present at such assemblies had always existed,[1] and protesting against his absence.

In the case of there being two Governors, viz., a King's Lieutenant and a Justiciar, both exercising administrative powers, the difference between them would appear to be that the King's Lieutenant alone could issue writs to the Chancellor to issue letters patent under the Great Seal. Thus, on the appointment of Roger de Mortimer, the King's Lieutenant in 1396, his authority was limited to Ulster, Connaught, and Meath; while that of W. Lescrope, the Justiciar, was limited to Leinster, Munster, and Louth (Uriel); but it was expressly stipulated "that all letters patent, charters, and writs, of whatsoever nature, passing under the Great Seal of Ireland, should be sealed and attested under the sole testimony of the Lieutenant, as heretofore in the time of Lieutenants of the whole of Ireland, notwithstanding the full powers granted to the said William as the King's Justiciar in the parts aforesaid." In a further grant to Mortimer in 1397 a similar clause was inserted.[2]

The right of removing and appointing the chief officers of State, viz., the Treasurer, Chief Justices, Chief Baron, Keeper of the Rolls, &c., was, as stated above, very rarely granted, as these officers, being members of the Privy Council, were a check on the Governor. In 1399 Sir John Stanley was permitted to remove the Chief Bench and the Exchequer from Dublin.

Most of the above administrative powers could be exercised by Deputy; and the right to nominate such Deputy was contained in the patents.

In conclusion, I must state that in the list of Chief Governors which I have appended to this paper there will be found frequently the dates of "testing" or attestation of writs, &c., by a Chief Governor. I have made use of these in cases where there is no evidence of the actual date when he took office or resigned, so as to furnish the nearest approximate date at which I could find him acting. The same remark applies to the notes of Governors "holding pleas." As the Rolls are imperfect, the Governors may have been holding pleas some days before or after the dates I have given; but they are useful in enabling us to fix an approximate date.

I am indebted to Dr. Goddard Orpen for most of the *data* in this list of Chief Governors for the period 1172–1216.

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[1] *Liber Niger*, Christ Church. [2] See Cal. Eng. Pat. Rolls, under date.

LIST OF CHIEF GOVERNORS OF IRELAND, 1172–1509.

1172–3. Hugh de Lacy, Justiciar, and Custos of Dublin.
He was appointed Custos (Gesta Hen., i, 30 ; Gir. Camb., v, 286) ; and Justiciar of Ireland, April, 1172 (Rog. Hoveden, ii, 34).
Summoned to Normandy, *c.* April (?), 1173.

1173. William fitz Audelin.
Appointed " Regis loco et vice," *c.* April, 1173.
Sent to transact the King's business, and remained about five months.

1173–6. Richard de Clare, Earl of Strigul.
Appointed "Custos regni," *c.* August, 1173 (Gir. Camb., v, 298, and Song of Dermot, 2904–5).
He styled himself " Vices Regis Angliae in Hibernia agens." See grant to Redelsford (Lynch, Feudal Dignities, p. 147).
Died *c.* 1st June, 1176 (Gir. Camb., v, 332).

1176. Raymond (le Gros) fitz William.
Appointed " procurator " provisionally by the King's Commissioners (Orpen, Anglo-Normans) on death of R. de Clare (Gir. Camb., v, 334).

,, William fitz Audelin.
Appointed "procurator," *c.* June, 1176 (Gir. Camb., v. 334, and Gesta Hen., i, 125).

1177. John, the King's son, Justiciar.
(See Cal. E.P.R., 1307–13, p. 161).

1177–81. Hugh de Lacy.
Appointed " procurator general " (Gir. Camb., v, 347) and Custos of Dublin, *c.* May, 1177 (Gesta Hen., i, 164).
Removed from office for marrying the daughter of King O'Conor without licence.

1181. John de Lacy, constable of Chester, and Richard de Pec, bishop of Coventry.
Appointed *c.* 1 May, 1181, "ad curam regiminis" (Gir. Camb., v, 355) or as " cutodes Dublinii " (Gest. Hen., i, 270).

1181–4 Hugh de Lacy reinstated, winter, 1181-2 (Gir. Camb., v, 356).

1184–5. Philip de Worcester.
Appointed "procurator" 1 Sept., 1184 (Gir. Camb., v, 359).

1185. John arrives. "Dominus Hiberniae" from 25 April, 1185 (Gir. Camb., v, 380), to 17 Dec., 1185 (R. de Diceto, ii, 39).

1185– John de Courcy, Justiciar.
Appointed Dec., 1185 (Gir. Camb., v, 392). Was still Justiciar when John was earl of Mortain (Reg. St. Thomas, p. 383).

c. 1192. Peter Pipard and William de Petit, Justiciars.
(See Orpen, Anglo-Normans, vol. iv, Corrigenda.)

1194.[1] Peter Pipard, Justiciar.
(See Marlburgh's Chronicle, T.C.D., ms. E. 3. 20, p. 135.)

1196–8. Hamo de Valognes, Justiciar.
So Annals of Innisfallen, to c. 1198. See Papal Letters (Bliss), vol. i, p. 3.

1199–1208. Meiler fitz Henry, Justiciar.
Appointed Oct., 1200 (see Rot. Chart., 2 John), but writs addressed to him as Justiciar from c. July, 1199 (C.D.I.). Remained in office till autumn, 1208, when he appears to have been superseded by Hugh de Lacy.

1208. Hugh de Lacy, earl of Ulster.
Probably chief governor for a few months from autumn, 1208 (Annals of Innisfallen, and Harris).

1208–10. John de Gray, bishop of Norwich, Justiciar.
Probably from winter of 1208–9, when William de Braose seems to have fled to Ireland (Hist. Guil. le Mareschal; Rot. Misae, pp. 144, 149).

1210. John, lord of Ireland, and John de Gray, Justiciar.
John visited Ireland, 20 June–25 Aug., 1210 (Rot. de Prest.), but Gray continued as Justiciar.

1210–13. John de Gray, bishop of Norwich, Justiciar.
He continued in office till July, 1213 (Mat. Paris, Historia Anglorum, t. iii, p. 122. Rolls Series).
Deputy, Richard de Tuit, when Gray was in Wales, 1211, and probably Geoffrey de Marisco during his absence in 1213 (Roger de Wendover, vol. ii, pp. 60 and 67).

1213–15. Henry de Londres, archbishop of Dublin, Justiciar.
Appointed 23 July, 1213 (E.P.R., 15 John, p. 102).

1215–21. Geoffrey de Marisco, Justiciar.
Appointed 6 July, 1215 (E.P.R., 17 John, p. 148), though apparently he was acting a few days earlier.

1221. Geoffrey de Marisco, Justiciar, and Henry de Londres, Custos.
Geoffrey was deprived of the custody of the land, 3 July (E.P.R., 5 Hen. III, m. 3), which was given to the archbishop, but he continued as Justiciar till 28 Oct.

1221–4. Henry de Londres, archbishop, Justiciar.
He was appointed Justiciar 28 Oct. (C.D.I.), on the resignation of Geoffrey, having had the custody of the land from 3 July.

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[1] Gilbert and others state that William, Earl Marshal, was Governor 1191-4, but Orpen (New Ross in the Thirteenth Century) does not think that there is any authority for this.

1224–6. William Marshall, the younger, earl of Pembroke, Justiciar.
Appointed 2 May, 1224 (E.P.R., 8 Hen. III, p. 3). Landed at Waterford 19 June, and proceeded to Dublin, where he received his office from the Archbishop (Royal Letters, Hen. III, No. 833). He surrendered office 22 June, 1226 (E.P.R., 10 Hen. III, m. 4). *Deputy*, Geoffrey de Marisco (E.C.R., 9 Hen. III, p. 1, m. 19d).

1226–8. Geoffrey de Marisco, Justiciar.
Appointed 25 June, 1226 (C.D.I.). Arrived at Waterford. Relieved of office at his own desire, 13 Feb., 1228 (E.P.R.).

1228–32.[1] Richard de Burgh, Justiciar.
Appointed 13 Feb., 1228 (E.P.R.).

1232. Hubert de Burgh, earl of Kent, Justiciar.
Appointed 16 June, 1232 (E.P.R., 16 Hen. III, m. 4). Dismissed in disgrace 29 July, 1232, but there is no evidence to show that he ever came over to Ireland (Orpen, Ireland under the Anglo-Normans). *Deputy*, Richard de Burgh (E.P.R., 16 Hen. III, m. 4).

1232–45. Maurice fitz Gerald (2nd baron Offaly), Justiciar.
Appointed 4 Sept., 1232 (E.C.R., 16 Hen. III, m. 4). In 1245 the King ordered him to bring troops to Wales. He was dismissed from office in Nov., according to Borlase (Reduction of Ireland).

1245–56. John fitz Geoffrey, Justiciar.
Appointed 4 Nov., 1245 (E.P.R.), but did not arrive till the middle of 1246. Was acting at least till 25 Feb., 1256.
Deputy, Richard de la Rochelle.

1256. Richard de la Rochelle, Justiciar.
Mentioned as such in 1256 (E.P.R. (1257), p. 561, and C.D.I., No. 552).

1256–8. Alan de la Zouche, Justiciar.
Was mentioned as Justiciar 27 March and 27 June, 1256 (C.D.I., No. 552, and E.P.R., p. 561), and continued till late in 1258.

1258–60. Stephen Lungespeye, Justiciar.
Mentioned as Justiciar 21 Oct., 1258 (E.P.R.), but 6 Nov., same year, Alan de la Zouche was still Justiciar, there being a conflict between Prince Edward and his father at the time (see E.P.R., p. 16, 14 Mar., 1259). He died in the first half of 1260.

1260–1. William de Dene, Justiciar of Prince Edward.
Appointed probably on the death of Lungespeye. He was certainly Justiciar on 2 Oct., 1260 (C.D.I.). Died 1261 (Annales de Monte Fernandi). He was alive 14 June, 1261 (C.D.I., No. 709).

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[1] Harris and Gilbert (History of the Viceroys) mention Maurice fitz Gerald as Viceroy in 1229 and Geoffrey de Marisco as his deputy in 1230: but there does not appear to be any evidence for these statements.

1261–6. Richard de la Rochelle, Justiciar of Prince Edward.
Mentioned as Justiciar 28 Oct., 1261 (E.P.R.).
Fulk de Saundford, archbishop of Dublin, was given the custody of the land 26 Feb., 1265 (C.D.I.), probably on account of Richard de la Rochelle's capture by the Geraldines. On 6 May, 1265. Richard was summoned to England by Prince Edward, and the custody of the land committed to Roger Waspail (C.D.I.), but on 10 June Rochelle was summoned to England by the King, and the bishop of Meath appointed Justiciar (C.D.I.).
Richard, however, continued to act till Mich., 1266 (Pipe Roll).

1266[1]–7. David de Barry, Justiciar.
Appointed Michaelmas, 1266. See Pipe Roll, 51 Henry III (Adlon).

1267–70. Robert de Ufford, Justiciar.
Mentioned as such 18 Nov., 1267 (Liber Niger, no. 64).
Deputy, Richard de Exeter (see his Account, Pipe Roll, March–Nov., 1270).

1270–2. James de Audeley, Justiciar.
He was acting from Nov., 1270 (see Accounts of above, Mich., '54–Mich., '56, Henry III, C.D.I.). Killed in Thomond, 1272 (Laud ms.), on the 23 June.

1272. John Muscegross.
He was sent by the King and the lieutenants of Prince Edward to preserve the peace of Ireland. All ordered to be intentive to him, 1 July, 1272 (C.D.I.).

1272–3. Maurice fitz Maurice fitz Gerald (3rd baron Offaly), Justiciar of Prince Edward.
Appointed by Edward's lieutenants, *c.* 8 Aug., 1272 (E.P.R.).
King Edward, 7 Dec., 1272, committed to him the office of Justiciar. He is mentioned as such up to April, 1273 (C.D.I.). He was taken prisoner by the O'Conors.

1273–6. Geoffrey de Genevil, Justiciar.
He is mentioned as such, 23 Aug., 1273 (E.P.R., also D. K.'s 36th Report, pp. 40, 41).
Deputy, Richard de Exeter (Pipe Roll, 3 Ed. I; D.K.'s 36th Report, p. 28).

1276–81. Robert de Ufford, Justiciar.
Appointed 17 June, 1276 (E.P.R.).
Deputies: Richard de Exeter (Pipe Roll, 8 Ed. I); Stephen, bishop of Waterford, when Robert was absent in England, 1279–80 (Laud ms. and C.D.I.).

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[1] John fitz Geoffrey is mentioned in Liber Niger, no. 118, as being Justiciar, 1266, so also Gilbert; but I think this must be a mistake for 1246.

1281-2. Robert de Ufford, Custos, and Stephen, bishop of Waterford, Justiciar.

By reason of the infirmity of the former, the office of Justiciar was conferred on Stephen, 21 Nov., 1281 (C.D.I.).

1282-8. Stephen, bishop of Waterford, Justiciar.

On de Ufford's death, Stephen continued as Justiciar, and was also given the custody of the land, 27 Sept., 1282. He became archbishop of Tuam, 1286. Died 1288 (3 July, Orpen).

Deputy, William fitz Roger, prior of Kilmainham, 1283 (Pipe Roll, 11 Ed. I), and also 29 July, 1285 (C.D.I., no. 814).

1288-90. John de Saundford, archbishop of Dublin. Custos and Justiciar.

Appointed Custos by Council 7 July 1288 (C.D.I.). He is mentioned as supplying the place of the Justiciar, 7 Nov., 1288 (E.P.R.), and as Justiciar 1 Mar., 1289 (C.D.I.), so that the King's confirmation was between those dates.

Deputies: William Dodingeseles and William l'Enfant in 1290 (C.D.I., p. 270).

1290-4. William de Vescy, Justiciar.

Appointed 12 Sept., 1290 (E.P.R.), and landed in Ireland 11 Nov. of that year (C.D.I., p. 428). Removed from office, 1294.

Deputies: Archbishop of Dublin (who was holding pleas as such, octave of S. Martin, 1290); Walter de la Haye, mentioned as deputy, *c.* Easter, 1294 (J.R. Cal., p. 231), also called "Custos of the office of Justiciar," probably when De Vescy was in England on his trial.

1294. William fitz Roger, prior of S. John of Jerusalem, Custos.

Appointed by Council as Custos and to hold the place of the Justiciar, and acted 4 June-19 Oct., 1294 (C.D.I., p. 120).

1294-5. William de Oddingeseles, Justiciar.

Appointed 18 Oct., 1294 (E.P.R.); died 19 April, 1295 (C.D.I., vol. iv, p. 121).

Deputy, Thomas fitz Maurice fitz Gerald (J.R.).

1295.[1] Thomas fitz Maurice fitz Gerald, Custos.

Appointed by Council on death of William de Oddingeseles, April, 1295, as Custos, and to hold the place of the Justiciar.

Continued in office till 2 Dec., 1295 (C.D.I.).

Deputy, Walter de la Haye, 13 Nov., 1295 (J.R. Cal., p. 73).

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[1] Walter de la Haye is given by some authorities as Justiciar, but he was only a deputy.

1295–1304. John Wogan, Justiciar.

Appointed 18 Oct., 1295, but commenced office 3 December, 1295 (C.D.I., page 161).

Deputies: Walter de la Haye, Easter, 1296 (J. R., 25 Ed. I, p. 127); Richard, earl of Ulster, *c.* autumn, 1299–spring, 1300 (J.R.); William de Ros, prior of Kilmainham, Aug. 1301–March, 1302 (C.D.I., p. 1); Maurice de Rochfort, 30 June–29 September, 1302 (C.D.I., no. 71).

1304–5. John Wogan, Justiciar, and Edmund le Botiller, Custos.

During Wogan's absence, *c.* Oct., 1304–May, 1305, Botiller had the custody of the land, and exercised the office of Justiciar (Mem. Roll., 1304, and J.R.).

1305–8. John Wogan, Justiciar.

He returned to Ireland, 1305 (J.R.).

1308[1]–9. Piers de Gaveston, King's Lieut., and John Wogan, Justiciar.

Gaveston was appointed 16 June, 1308 (E.P.R.), and returned to England 23 June, 1309 (Laud ms.), Wogan retaining the office of Justiciar; but as the latter was called over to attend parliament, and was absent most of this time, he left William de Burgh as his *deputy*. Wogan returned May, 1309 (J.R.).

1309–12. John Wogan, Justiciar.

On Gaveston's departure, Wogan regained the custody of the land. He apparently left Ireland finally *c.* Aug., 1312 (J.R.).

Deputy, William de Burgh.

1312–13. John Wogan, Justiciar, and Edmund le Botiller, Custos.

Wogan left Ireland *c.* Aug., 1312, retaining the office of Justiciar, as writs were issued to him as such as late as April, 1313 (E.P.R.), but the custody of the land was delivered to Botiller.

Deputies of Botiller: Walter de Thornbury and William Alysaundre, to hear pleas in 1313.

1313–4. Edmund le Botiller, Custos.

Theobald de Verdon was appointed Justiciar in April, 1313, but as he did not take office till *c.* June, 1314, Botiller was continued as Custos till his arrival.

1314–15. Theobald de Verdon, Justiciar.

He was appointed 30 April, 1313 (E.P.R.), but did not take office till *c.* June, 1314. He was holding pleas on 1 July (J.R.).

1315–17. Edmund le Botiller, earl of Carrick, Justiciar.

Appointed 4 Jan., 1315 (E.P.R.), and received his commission 2 March (Laud ms.); he held pleas from 4 April (J.R.).

Deputy, Hugh Canoun, holding pleas 16 Aug., 1316 (J.R.).

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[1] Richard de Burgh, Earl of Ulster, was appointed King's Lieut. 15th June, 1308, but as Gaveston was appointed next day, he probably did not take office.

1317–18. Roger de Mortimer, of Wigmore, King's Lieut., Botiller continuing as Justiciar.

Mortimer was appointed 23 Nov., 1316 (E.P.R.), but did not arrive at Youghal till 7 April, 1317 (Addl. MSS., Brit. Mus., 4792). He left Ireland in May, 1318, and Botiller ceased to act about the same time.

Deputy, Walter de Cusack, to hold pleas in Louth and Meath, (?) July, 1317.

1318. William, archbishop of Cashel, Custos.

On Mortimer leaving Ireland, he and the Council entrusted the custody of the land to the archbishop of Cashel by letters patent of 6 May, 1318 (J. R., 11 Ed. II, m. 2). He held pleas from 7 May–25 Sept.

1318–19.[1] Alexander de Bickenor, archbishop of Dublin, Justiciar.

He was appointed 11 Aug., 1318 (E.P.R.). News of his landing at Youghal reached Dublin on 1 Oct., and he entered Dublin as Justiciar on the 9th Oct. (Laud MS.).

1319–21.[2] Roger de Mortimer, Justiciar.

Appointed 15 Mar., 1319 (E.P.R.). He is found testing on 14 July, 1319. Held pleas till 8 July, 1320 (J.R.).

Deputy, Thomas fitz John, 2nd earl of Kildare, who held pleas from Sept., 1320–17 June, 1321 (J.R.).

1321. Thomas fitz John, 2nd earl of Kildare, Justiciar.

Appointed 23 April, 1321 (E.P.R.), but did not begin to act as Justiciar till between 17 June, when he was deputy (J.R.), and 24 June, when he was testing as Justiciar (I.C.R., 14 Ed. II, no. 100). Continued in office till Aug. or Sept., 1321.[3]

1321–4. John de Bermingham, earl of Louth, Justiciar.

Appointed 21 May, 1321 (E.P.R.), but did not commence acting till Aug. or Sept., 1321.[4] Continued to act till February, 1324.

Deputies, William de Bermingham (Pipe Roll, 15 Ed. II, Dep. Keeper's 42nd Report, p. 31); Walter Wogan and Roger de Berthorp holding pleas for Bermingham on 10 Feb., 1324, as the Justiciar was in remoter parts (J.R.).

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[1] Walter de Wogan and Roger de Birthorpe are given by some authorities as Justiciars in 1318, but they were only Chief Justices (E.P.R. and Plea Roll, no. 118, m. 2–3).

[2] Sir Ralph de Gorges was appointed Justiciar 1 February, 1321 (E.P.R.), but he was apparently taken prisoner in Wales on his way (E.P.R., 1321–4, m. 5, p. 596), and never acted as such.

[3] He was testing on 23 Aug., 1321 (Mem. Roll, 16 Ed. II, m. 2).

[4] He was testing on 28 Sept., 1321 (Mem. Roll, 16 Ed. II, m. 2).

1324–7. John Darcy, le neveu, Justiciar.
Appointed 18 Nov., 1323 (E.P.R.). Did not commence to act till Feb., 1324. He was testing on 19 Feb., 1324 (Mem. Roll, 17 Ed. II, m. 14).
Deputy, Roger Outlawe, prior, *c.* July–Oct., 1324 (see attestations, I.C.R., 18 Ed. II, p. 30).

1327–8. Thomas fitz John, 2nd earl of Kildare, Justiciar.
Appointed 13 Feb., 1327[1] (Rymer). Died at Maynooth 5 April, 1328 (Laud MS.).
Deputy, Roger Outlawe, prior, testing Mar.–April, 1327 (I.C.R., 20 Ed. II).

1328[2]–9. Roger Outlawe, prior of Kilmainham, Justiciar.
Probably appointed by Council on death of Kildare. He held pleas 11 April, 1328–23 May, 1329 (J.R.).

1329–31. John Darcy, le cosyn, Justiciar.
Appointed 19 Feb., 1329 (E.P.R.). Took office May or June; was holding pleas 26 June, 1329 (J.R.).
Deputy, Roger Outlawe, appointed 17 Jan., 1330 (Plea Roll, 116, m. 26), held pleas till 13 May, 1331 (J.R.).

1331. William de Burgh, earl of Ulster, King's Lieut., and Anthony de Lucy, Justiciar.
William de Burgh appointed 3 Mar., 1331 (E.P.R.), and Anthony de Lucy 27 Feb., 1331 (E.P.R.). The latter arrived May, 1331 (or 3 June, Laud MS.).
W. de Burgh was summoned to England 5 Nov., 1331 (E.P.R.), and the land committed to the Justiciar in his absence.

1331–3. Anthony de Lucy, Justiciar.
The Justiciar was given the custody of the land 5 Nov., 1331 (E.P.R.). According to the Laud MS., de Lucy was recalled to England, November, 1332, leaving Thomas de Burgh as his deputy. He acted as such till 13 Feb., 1333 (J.R.).

1333–7. John Darcy, le cosyn, Justiciar.
Appointed 30 Sept., 1332 (E.P.R.), but did not take office till 13 Feb., 1333 (J.R. and Laud MS.).
Deputies, Thomas de Burgh, holding pleas 30 June, 1333–Jan., 1334 (J.R.); Roger Outlawe, appointed 15 March, 1335 (J.R., 9 Ed. III, m. 22), and holding pleas to 23 June, 1335, also Nov., 1336–14 Oct., 1337 (J.R.).

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[1] Dr. Orpen says 12 March, but this was only the writ to be intendant.

[2] John Darcy, le neveu, was appointed Justiciar 21 Aug., 1328 (E.P.R.), but did not take office.

1337–8. John de Cherlton, the elder, baron of Powys, Justiciar.

Appointed 28 July, 1337 (E.P.R.). Came to Ireland 14 Oct., 1337 (Laud MS.), and held court next day (J.R.). Returned to England 31 July, 1338 (Laud MS.).

1338–40. Thomas de Cherlton, bishop of Hereford, Custos.

Appointed 15 May, 1338 (E.P.R.), as Custos and exercising the office of Justiciar (J.R.). Took office 31 July (Harris). He was paid up to 7 April, 1340. Returned to England 10 April, 1340 (Laud MS.).

1340–1. John Darcy, le cosyn, Justiciar.

Appointed 3 March, 1340 (E.P.R.). Apparently took office April, 1340 (10 April, Harris).

Deputy, Roger Outlawe, prior, who held pleas from 14 May, 1340–5 Feb., 1341 (J.R.); he died 13 Feb. (Laud MS.).

1341. Alexander, arch. of Dublin, Custos.

On the death of the deputy, the Justiciar being out of the Kingdom, Alexander, archbishop of Dublin, appointed Custos "et officium Justiciarii ibidem exercens" by the Council. He held pleas 23 Feb., 1341–14 May, 1341 (J.R.).

1341–4. John Darcy, le cosyn, Justiciar.

The Justiciar appointed John Morice his deputy, which the King approved of, 16 Mar., 1341 (E.P.R.), as he required Darcy's services.

Morice took office May, 1341 (Laud MS.), and acted as deputy to July, 1344 (J.R.).

1344–6. Ralph de Ufford, Justiciar.

Appointed 10 Feb., 1344 (E.P.R.). Landed in Dublin 13 July, 1344 (Clynn's Annals). Died Palm Sunday, 9 April, 1346.

1346. Roger Darcy, Justiciar.

Appointed by Council 10 April, 1346 (I.P.R., 19 & 20 Ed. III).
Surrendered to Morice 25 May (Cox) or 15 May (Laud MS.).

1346. John Morice, Justiciar.

He was appointed by the King in case of de Ufford's death and ordered over to Ireland (E.P.R., 7 April, 1346, and I.P.R., 10 April, 1346), when, in case de Ufford was dead, he was to exhibit his commission. Darcy surrendered the office to him 15 or 25 May, and he continued in office till 29 June.

1346–9. Walter de Bermingham, lord of Athenry, Justiciar.

Appointed 10 May, London, and letters patent enrolled 29 June, 1346, Dublin (E.P.R.), on which day he apparently took office (I.P.R., 20 Ed. III). He was summoned to England to a

Parliament, and left about 26 Nov., 1347. He returned in 1348, and left Ireland in Sept. or Oct., 1349.[1]

Deputies, John Larcher, prior of Kilmainham, 26 Nov., 1347 (J.R., 21 Ed. III, m. 60); John de Carew, baron Carew, from Sept. or Oct. to Dec., 1349.[2]

1349-55. Thomas de Rokeby, Justiciar.

Appointed 17 July, 1349 (E.P.R.); arrived in Ireland 20 Dec., 1349 (Cox). Left finally for England about 8 Aug., 1355 (J.R.).

Deputies: Maurice, bishop of Limerick, 1352 (Mem. Roll, 26 Ed. III, no. 477); and Maurice fitz Thomas, 4th earl of Kildare, appointed 8 Aug., 1355 (I.P.R., 29 Ed. III, no. 154, and 29 & 30 Ed. III, no. 60), as the Justiciar was leaving for England. He held pleas till 20 Aug. (J.R.).

1355-6. Maurice fitz Thomas, earl of Desmond, Justiciar.

Appointed 8 July, 1355 (E.P.R.). As the earl of Kildare, as deputy, was holding pleas on 20 Aug., and the earl of Desmond, as Justiciar, commenced to hold pleas 15 Septr. (J.R.), the latter must have taken office between those dates. He died 25 January, 1356, in Dublin Castle (Laud MS.).

1356. Maurice fitz Thomas, 4th earl of Kildare, Justiciar.

On the death of the earl of Desmond, the Council, on 26 Jan. (J.R., 30 Ed. III, m. 2), elected the earl of Kildare to hold the office till the King's pleasure should be known. The King's appointment is dated 30 March (J.R., 30 Ed. III, m. 2). He continued in office till end of October, 1356, holding pleas on 17th Oct. (Plea Roll, no. 219).

1356-7. Thomas de Rokeby, Justiciar.

Appointed 24 July, 1356 (E.P.R.). Commenced office the end of October, 1356 (J.R., Plea Roll, No. 219, where he is found testing 31 Oct.). Died at Kilkea Castle, April, 1357.

1357. Master John de Bolton, Justiciar.

Was elected Justiciar by the Council on the death of T. de Rokeby (E.C.R.), holding office from *c.* 24 April, 1357 (Pipe Roll, no. 68, m. 25), till 5 Sept., 1357 (same ref.). In patent of appointment of S. Amand, Bolton was called "vicegerent."

1357-9. Almaric de Saint Amand, Justiciar.

Appointed 14 July, 1357 (E.P.R.). Took office Septr., 1357. Left Ireland probably in the spring of 1359, as he was testing on the 15 March (Mem. Roll, 32-3 Ed. III, no. 250).

Deputy, Maurice fitz Thomas, earl of Kildare, appointed 30 Aug., 1357 (Rymer).

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[1] He was testing on 28 Sept. (M.R., 23 & 24 Ed. III, m. 13).

[2] He was testing on 5 Oct. and 12 Dec., 1349 (M.R., 23 & 24 Ed. III, m. 17d and 19).

1359–61. James le Botiller, earl of Ormond, Justiciar.

Appointed 16 Feb., 1359 (E.P.R.). Took office 14 April (Harris).

Deputy, Maurice, earl of Kildare, appointed 9 Oct., 1360, as Butler had been called to England (Mem. Roll, 34 Ed. III, no. 4).

1361. Maurice fitz Thomas, 4th earl of Kildare, Justiciar.

Appointed 16 March, 1361 (E.P.R.). Probably took office as such 30 March (see Commission, Laud MS.). Acted till arrival of Lionel in September (in E.P.R., 10 Nov., 1361, we find that he was still Justiciar on 1 Sept.).

1361–4. Lionel, earl of Ulster, King's Lieutenant.

Appointed 1 July, 1361. Arrived in Dublin 15 September. Left for England 22 April, 1364 (Laud MS.).

1364–5. James le Botiller, earl of Ormond, Custos.

On Lionel leaving Ireland 22 April, 1364, he left the custody of the land in the hands of Botiller, who acted up to Jan., 1365 (J.R.).

1364-6. Lionel, duke of Clarence, King's Lieutenant.

His appointment was made 30 Sept., 1364 (Rymer), and he arrived in Ireland 8 Dec., 1364 (Laud MS.). He left Ireland 7 Nov., 1366.

1366–7. Thomas de la Dale, Custos.

On leaving Ireland, Lionel and the Council committed the custody of the land to Sir Thomas on 7 Nov., 1366 (Mem. Roll, 40 & 41 Ed. IV, m. 7d), who held pleas from 13 Nov., 1366–22 April, 1367 (J.R.).

1367-9. Gerald fitz Morice, earl of Desmond, Justiciar.

Appointed 20 Feb., 1367 (E.P.R.). Did not take office till after 22 April. On the 27 April he summoned a parliament to meet on the 14 June (Cal. Arch. Sweteman, no. 29).

1369–72. William de Windsor, King's Lieutenant.

Appointed 3 Mar., 1369 (E.P.R.). Came to Ireland 19 June, 1369 (Laud MS.), or 23 June (Issue Roll, Eng., 44 Ed. III). Left Ireland 21 March, 1372 (I.P.R., 46 Ed. III).

1372. Maurice fitz Thomas, 4th earl of Kildare, Custos.

Took the oath as "Custos" 22 March, 1372 (I.C.R., 46 Ed. III). Was testing as Custos up to 21 July (I.C.R.).

1372–3. Robert de Assheton, Justiciar.

Probably appointed soon after Windsor's departure (Harris says 28 April), as there is an order directed to him as Justiciar 28 May (E.C.R.); but he did not arrive till July, as the earl of Kildare was testing as Custos on 21 July (I.C.R.). A commission was directed to Assheton 29 July, 1372. He was testing on 6 Aug., 1373 (Mem. Roll, 47–8 Ed. III, no. 147).

Deputy, Ralph Cheyne. He will be found testing from 10 Oct.–22 Nov., 1373 (Mem. Roll, 47–8 Ed. III, nos. 119–121).

1373-4. William Taney, prior of Kilmainham, Justiciar.
On Cheyne leaving the country without any governor, the Council appointed W. Taney as Justiciar. He held office 3 Dec., 1373–17 April, 1374, or thereabouts (I.C.R., 48 Ed. III, no. 41),[1] probably till Windsor was sworn in.

1374–6. William de Windsor, Governor.[2]
Appointed 20 Sept., 1373 (E.P.R.). Landed at Waterford 18 April, 1374 (I.P.R.), and sworn in at Kilkenny 4 May. Held pleas 8 May, 1374, till 20 June, 1376 (J.R.).

1376. Maurice fitz Thomas, 4th earl of Kildare, Justiciar.
Appointed 16 Feb., 1376 (Rymer). Held pleas 22 June–10 July, 1376 (J.R.). He was to supervise the country of Leinster, and Stephen, bishop of Meath, the country of Munster.

1376-9. James le Botiller, earl of Ormond, Justiciar.
Appointed 24 July, 1376 (Rymer); re-appointed 21 July, 1377, by Ric. II (I.C.R., 1 Ric. II, no. 62), and again 20 Aug., 1378 (E.P.R.). In consideration of his long service, he was released from office Mich., 1379 (E.P.R.; and I.P.R., 3 Ric. II., no. 26).
Deputy, his son James in 1379 (J.R.).

1379. Alexander de Balscot, bishop of Ossory, Justiciar.
On Ormond's resignation, as no successor had been appointed, the Council elected Alex. de Balscot as Justiciar, 13 Oct., 1379. (I.P.R., 3 Ric. II, no. 26). He was holding office on 18 Nov. (J.R.).

1379-80. John de Bromych, Justiciar.
Appointed 22 Sept., 1379 (E.P.R.). Took office after 18 Nov., on which day Balscot was still Justiciar. Was holding pleas on 10 May, 1380 (J.R.).

1380–1. Edmund de Mortimer, earl of March and Ulster, King's Lieutenant.
Appointed 22 Oct., 1379 (E.P.R.). Landed at Howth, Ides of May, 1380 (Annals of Monastery of B.V.M., MS. E. 3.11., T.C.D.). Commenced to hold pleas 25 May (J.R.), so that he took office between those dates. Died at Cork, 26 Dec., 1381.

1382. Master John Colton, chancellor, Justiciar.
Elected by Council at Cork the Thursday after Epiphany, 1382 (I.P.R., 5 Ric. II, pt. I, no. 39), and appointment confirmed by the King, 20 January, 1382. Held pleas 13 Jan.–9 Feb., 1382 (J.R.).

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[1] On Patent Roll (Ireland), 48 Ed. III, no. 41, it is stated that Taney held office for a year and a half. This must be a mistake, as Assheton was in Dublin and acting as Justiciar 6 May, 1373 (E.P.R.), at Drogheda 14 July, 1373 (Gormanston Register), and 6 Aug. (Mem. Roll, 47–8 Edward III, no. 147).

[2] Sir Richard Pembridge was appointed, but refused (Leland).

1382–3. Roger de Mortimer, earl of March and Ulster, King's Lieutenant.
Appointed 24 Jan., 1382 (E.P.R.). He was testing as late as 27 July, 1383 (I.C.R., 8 Ric. II, no. 26).
Deputy, Sir Thomas de Mortimer, 3 Mar., 1382 (I.P.R.).

1383–4. Philip de Courtenay, King's Lieutenant.
Appointed 1 July, 1383 (E.P.R.). Did not arrive till later in month.

1384–5. Philip de Courtenay, King's Lieut., and Jas. le Botiller, earl of Ormond, Justiciar.
Apparently in view of Courtenay's departure for England, Jas. le Botiller was appointed Justiciar to act with him, late in 1384. (He was holding pleas 1 Dec., 1384–28 April, 1385, J.R.). Courtenay left Ireland in the spring of 1385 (he was testing on 28 February).

1385–6. Philip le Courtenay, King's Lieutenant.
He returned to Ireland, arriving at Dalkey 6 May, 1385.[1] On 26 March, 1386 (Rymer), the King ordered him to be arrested on account of oppression.

1386. Richard White, prior of Kilmainham, Justiciar of Robert de Vere.
The King assigned to Robert de Vere his land of Ireland.
Ric. White was testing on 29 June, 1386 (I.P.R., 10 Ric. II).

1386–7. John de Stanley, Lieutenant of the Marquis.
Appointed 8 June, 1386. Landed at Dalkey, 30 Aug., 1386.
Letters patent enrolled in Dublin, 18 Sept. (I.P.R., 10 Ric. II, p. 131 in Cal.). He held pleas till 4 Nov., 1387 (J.R.).

1387–9.[2] Alexander de Balscot, bishop of Meath, Justiciar of the Marquis.
Commenced to hold pleas 13 Nov., 1387 (J.R.). On the conviction of the Marquis in 1388, the bishop was continued in office by the King, and held office till Stanley's arrival.[3]
Deputies, Richard White, prior of St. John of Jerusalem, and Sir R. Preston, Aug., 1389 (I.P.R., 13 Ric. II, no. 190).

1389–91. John de Stanley, Justiciar.
Appointed 1 Aug., 1389 (E.P.R.); further indenture, 30 July, 1390. Landed at Howth 22 Oct., 1389, and letters patent read 25 Oct. (I.P.R.).
Deputies: Robert Sutton, clerk of the Rolls, appointed by the King, 31 Jan., 1390, and holding a parliament for Stanley (I.P.R., 13 Ric. II, d. no. 202). R., bishop of Ossory, and P. de la Freyne appointed deputies to act in Kilkenny, 4 Aug., 1391 (I.P.R., 15 Ric. II, p. 149 in Cal.).

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[1] 13 July, 1385 (I.P.R.), P. de Courtenay appointed Alex., bishop of Ossory, Thomas, bishop of Waterford, James Butler, earl of Ormond, and the earl of Desmond as his deputies to continue the Council of Kilkenny: and the bishop of Ossory, John Southern, c.j., and Walter Coterell, narrator, to treat with those wishing to make fines.

[2] Thomas de Mortimer was appointed Justiciar 5 Mar., 1389 (E.P.R.), but did not take office.

[3] He was testing 22 Oct., 1389 (I.P.R., 13 Ric. II, no. 68).

1391–2. Alexander de Balscot, bishop of Meath, Justiciar.
Appointed 11 Sept., 1391 (I.P.R., 15 Ric. II, no. 43). Sworn in by Council at Trim, 3 Oct., 1391. Testing up to 4 Oct., 1392 (I.C.R., 16 Ric. II).

1392. Thomas, duke of Gloucester, King's Lieutenant.
Appointed early in 1392 (see Issue Roll, Eng., 4 May, 1392), but did not come to Ireland. Patent cancelled, 23 July, 1392, as the King might require his services in France (Cotton MSS., Brit. Mus., Titus B, xi, fol. 7^b, as given in Graves' Council Roll, Ric. II).

1392–4. James le Botiller, earl of Ormond, Justiciar.
Appointed 24 July, 1392 (E.P.R,), but the patent did not reach him till 8 Oct. (see Cotton MSS. above), and he was sworn in at the Council at Tristledermot. Further grant, 31 May, 1393 (E.P.R.). He acted up to the King's arrival. (Was holding pleas 28 Sept., 1394, J.R.)

1394–5. King Richard II arrived at Waterford 2 Oct., 1394, and returned to England 15 May, 1395.

1395–7. Roger de Mortimer, earl of March and Ulster, King's Lieut., and W. le Scrope, Justiciar.
Apparently appointed by Richard on his departure, as Mortimer was testing on 22 May, 1395 (Mem. Roll, 18–19 Ric. II, m. 43), and le Scrope is mentioned as Justiciar on 19 June, 1395 (E.P.R.). Further appointments of both were made 25 April, 1396) E.P.R.), and 25 Sept., 1396 (E.P.R.), in which Mortimer was appointed King's Lieut. in the parts of Ulster, Connaught, and Meath, and le Scrope Justiciar in Leinster, Munster, and Louth (Uriel), the King's Lieut., however, alone being authorized to attest writs under the Great Seal.

1397. Edmund de Mortimer, King's Lieut., and W. le Scrope, Justiciar.
Mortimer appointed 23 Jan., 1397 (E.P.R.), as King's Lieutenant till midsummer, and le Scrope, Justiciar, till Easter, on the same terms as above. E. de Mortimer was testing as late as 18 July (Mem. Roll, 21 & 22 Ric. II, m. 43).

1397–8. Roger de Mortimer, earl of March and Ulster, King's Lieut.
Appointed 24 April, 1397, but did not act till later, as E. de Mortimer was testing on 18 July (see above). Further appointment 24 April, 1398, for 2 years (E.P.R.). Killed at Calliston (Kelliston), co. Carlow, on 20 July, 1398.
Deputy, Ed. de Mortimer, in spring, 1398 (Mem. Roll, 21–2 Ric. II, m. 25 and 29).

1398. Reginald, lord Grey de Ruthyn, Justiciar.
Probably appointed by Council on death of R. de Mortimer. See Mem. Roll, 22 Ric. II, m. 19 and 25, where he will be found testing in Septr. Acted till arrival of Duke of Surrey.

1398–9. Thomas Holland, duke of Surrey, King's Lieut.
Appointed 26 July, 1398 (E.P.R.). Landed at Dublin, 7 Oct., 1398 (Graves, Council Roll, Ric. II).

1399. King Richard arrived 1 June, 1399, at Waterford, and left Ireland and arrived at Milford, 13 Aug., 1399.

1399. Edmund de Kent, Custos.
Probably appointed by King on his leaving Ireland (see Mem. Roll, 1 Hen. IV, m. 10, where he will be found testing, 27 Oct.).

1399–1400. Alexander de Balscot, bishop of Meath, Justiciar.
Appointed by Henry IV (Gilbert). He was acting up to March, 1400 (I.P.R., 1 Hen. IV, p. 155).

1400–1. John de Stanley, King's Lieutenant.
Appointed 10 Dec., 1399 (E.P.R.). Did not commence acting at least till March, 1400 (when he was testing, see I.P.R., 1 Hen. IV), and acted up till appointment of T. de Lancaster.
Deputy in Ulster, Sir Gilbert Halsale, appointed 8 May, 1400 (I.P.R.), and in Connaught, Sir Thos. fitz Edmund de Burgo, appointed 14 May, 1400 (I.P.R.).

1401–4. Thomas de Lancaster, King's Lieutenant.
Appointed 27 June, 1401 (E.P.R.), for six years from 18 July next. Landed at Blowyck (Bullock), near Dalkey, 13 Nov., 1401 (I.P.R.), when he took over the government from his deputy. Further appointment, 10 March, 1403 (I.P.R.). Left Howth, 8 Nov., 1403.
Deputies, Sir Stephen Lescrop, who arrived 7 July, 1401 (Wylie, Hen. IV). He handed over the government to Lancaster on his arrival in November. Was re-appointed 19 Dec., 1401, to assist Lancaster, and 7 Nov., 1403, on his departure (he made Sir W. de Burgo his deputy in Connaught, 5 Dec., 1403). Disappeared early in 1404.

1404. James le Botiller, 3rd earl of Ormond, Justiciar.
On Lescrop's disappearance, the Council elected Botiller their "Solidarius" and War Governor, 3 March, 1404, at Castledermot, but he attested as Justiciar (see Mem. Roll, 8 Hen. IV, m. 19, 9 May, 1404).

1404–5. Thomas de Lancaster, King's Lieutenant.
Appointed 1 Oct., 1404 (E.P.R.); did not come over.
Deputy, Sir Stephen Lescrop, appointed 18 or 26 Oct., 1404, and later, being obliged to go to England, he appointed James le Botiller, earl of Ormond, as his deputy (appointed 25 June, 1405 (I.P.R.), and admitted at Naas, 4 July, 1405), who died at Gowran, 7 Sept., 1405.

1405-6. Gerald fitz Morice, 5th earl of Kildare, Justiciar.
On Ormond's death, Council appointed Kildare as Justiciar, and he was acting till at least 11 June, 1406 (see Mem. Roll, 7 Hen. IV, m. 39).

1406–13. Thomas de Lancaster, King's Lieutenant.
Appointed 23 Sept., 1405 (E.P.R.), and 1 Mar., 1406 (E.P.R.). Did not come to Ireland till July or Aug., 1408, being sworn in 2 Aug. (Graves' Council Roll, Ric. II); left Ireland, 1409.
Deputies, Sir Stephen Lescrop, who came to Ireland *c.* Aug.,[1] 1406 (see E.P.R., ships ordered to bring him over), and was acting as deputy till autumn, 1407.[2] He appointed James, 4th earl of Ormond, as his deputy, who was acting as such 18 Dec., 1407, and held parliament, spring, 1408. Lescrop died at Castledermot, 4 September, 1408 (Harris), of the plague (Gilbert). Lancaster arrived in Ireland, Aug., 1408, and appointed as his deputy Thomas le Botiller, prior of S. John of Jerusalem (4 Mar., 20 June, and 1 June, 1409, I.P.R.). On Lancaster's departure in 1409, he left Thomas as his deputy, and he continued to act as such till 25 Sept., 1413. On Nov. 20, 1412 (Eng. Close Roll, 14 Hen. IV, 25d), order to Butler to be in London by 2 Feb., 1413, and calling on Ch. Justice to see that his place as deputy was adequately filled.

1413-14. John Stanley, King's Lieutenant.
Appointed 8 June (E.P.R.), 1413, for 6 years. Landed at Clontarf, 25 Sept., 1413 (Gilbert). He was testing on 28 Sept. (I.P.R., 1 Hen. V, pt. 1, d., no. 36). Died 18 Jan., 1414.

1414. Thomas Cranley, archbishop of Dublin, Justiciar.
Elected by Council on death of Stanley (I.P.R., 9 Hen. V, p. 221), and was acting on 18 Jan. (I.P.R., 1 Hen. V, pt. 1, d.). He continued in office till 13 Nov.
Deputy, John Bermingham, Judge of the K. Bench (Wylie), and Chr. Holywood, Sir E. Perers and Jenico Dartas, War Governors (I.P.R., 1 Hen. V, pt. 1, d., no. 37).

1414-20. John Talbot, of Halomshire, Lord de Furnival, King's Lieut.
Appointed 24 Feb., 1414 (E.P.R.). Landed at Dalkey 10 Nov., 1414 (Marleburgh, 219), and received by late Justiciar on 13 Nov. Left Clontarf 7 Feb., 1416 (I.C.R.); returned later in the year, and was holding Parliament Jan., 1417 (Statutes, p. 567); left Ireland in 1417 and returned 14 April, 1418; left Ireland finally in middle of 1419.
Deputies, Thos. Cranley, archbishop of Dublin, who took the oath 8 Feb., 1416, and continued to act, during Talbot's absences, till April, 1418; Richard Talbot, archbishop of Dublin, from middle of 1419 (22 July, according to Harris), till March, 1420.

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[1] Harris gives October as the month.

[2] Ed. Perers appointed deputy 28 June, 1407, from Mich. next (E.P.R.), but does not appear to have acted.

1420. Richard Talbot, archbishop of Dublin, Justiciar.
Appointed 6 Mar., 1420, and sworn in 9 March (Wylie). Acted till April.

1420–22. James le Botiller, earl of Ormond, King's Lieutenant.
Appointed 10 Feb., 1420 (E.P.R.). Arrived at Waterford, 4 April, 1420 (Carte, Life of Ormond); sworn 10 April (Harris). Acted till spring, 1422.

1422. William fitz Thomas, prior of S. John of Jerusalem, Justiciar.
Elected by Council shortly before death of Hen. V (see I.P.R., 3 & 4 Henry VI, no. 52). William was testing May, 1422, and continued for 40 days after the King's death.

1422–3. Richard Talbot, archbishop of Dublin, Justiciar.
Appointed 4 Oct., 1422 (E.P.R.), and took office on or about 11 Oct.; held office till Sept. or Oct., 1423 (I.C.R., 2 Hen. VI, pt. 1, m. 1).

1423–5. Edmund Mortimer, earl of March and Ulster, King's Lieut.
Appointed 9 May, 1423 (E.P.R.). Arrived in Ireland 1424; but cut off by plague Jan.,1425, at Trim (Harris).
Deputies, Edward, bishop of Meath from Sept. or Oct., 1423 (I.C.R., 2 Hen. VI, pt. 1); James le Botiller, earl of Ormond, in 1424 (I.P.R., 5 Hen. VI, p. 243), on 9 May, according to Harris.

1425. John, lord de Talbot, Justiciar.
Probably appointed by Council on death of earl of March.
He held office from about 22 Jan. (I.C.R., 3 & 4 Hen. VI, no. 2) till April, 1425. On 10 April he made an indenture with Donatus Obryn (I.P.R., 3 Hen. VI, no 113).

1425–6. James le Botiller, earl of Ormond, King's Lieutenant.
Appointed from 13 April, 1425, on 1 Mar. (E.P.R.).

1426–7. James le Botiller, Earl of Ormond, Justiciar.
Appointed 15 April, 1426 (I.C.R., 5 Hen. VI., pt. 1), and exonerated from office, 31 July, 1427 (I.C.R., 6 Hen. VI.).

1427–8. John de Grey, lord Grey, King's Lieutenant.
Appointed 15 March, 1427 (E.P.R.). Arrived in Ireland, 1 Aug., 1427 (Gilbert says that he arrived at Howth, 31 July, and was sworn in 1 Aug.).
Deputy, Edward, bishop of Meath (I.P.R., 6 Hen. VI), and acting from 22 Dec., 1427, till at least 6 April, 1428 (Statutes, 8 Hen. VI, art. 13), and probably till Sutton's arrival.

1428–30. John de Sutton (baron Dudley), King's Lieutenant.
Appointed 19 March, 1428, from 30 April (I.C.R., 7 Hen. VI, d. no. 22). Left Ireland Oct. or Nov., 1429.[1]
Deputy, Sir Thomas Strange, from Oct. or Nov., 1429,[2] till April or May, 1430.[3]

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[1] He was testing 13 Oct. (Mem. Roll, 8 Hen. VI, m. 9).
[2] He was testing 11 Nov., 1429 (Mem. Roll, 8 Hen. VI, m. 9).
[3] He was testing 26 April, 1430 (Mem. Roll, 8 Hen. VI, m. 17).

1430–31. Richard Talbot, archbishop of Dublin, Justiciar.

He was testing 11 May, 1430 (Mem. Roll, 8 Hen. VI, m. 17), and acted till Stanley's arrival, 30 Sept., 1431.

1431–7. Thomas Stanley (baron Stanley), King's Lieutenant.

Appointed 29 Jan., 1431 (E.P.R.), from 12 April next.

Indenture, 10 Hen. VI, no. 34. Sworn into office before Richard, archbishop of Dublin, Justiciar, 30 Sept., 1431 (I.P.R., 10 Hen. VI, no. 16). Left Ireland 1433, and returned autumn, 1434; left Ireland again Oct. or Nov., 1435, and returned autumn, 1436, and left Ireland finally soon after.

Deputies, Sir Christopher Plunket, who was testing from autumn, 1433, to June, 1434; Richard Talbot, who was testing from Nov., 1435, to Aug., 1436, and again Feb.–20 May, 1437.

1437–8. Richard Talbot, archbishop of Dublin, Justiciar.

He was testing as such 25 May, 1437 (M.R., 16 Hen. VI, m. 17), and continued to May, 1438; he was testing on 20 May, 1438 (M.R., 16 Hen. VI, m. 21).

1438–42. Lord Leo de Welles, King's Lieutenant.

Appointed 12 Feb., 1438 (E.P.R.). Took office end of May or beginning of June. He was testing 5 June, 1438 (M.R., 16 Hen. VI, m. 20), and continued till summer of 1439 (M.R., 17 Hen. VI). Returned May or June, 1440, as he was testing 12 June, 1440 (I.C.R., 20 Hen. VI, no. 7), and continued till March, 1441 (I.C.R., 20 Hen. VI, no. 49).

Deputies, William Welles, testing 1 Oct., 1439, to 11 May, 1440 (I.C.R., 20 Hen. VI, m. 29 and 38); James, earl of Ormond, from March, 1441 (I.C.R., 20 Hen. VI, no. 31), until he was appointed King's Lieutenant.

1442–4. James le Botiller, earl of Ormond, King's Lieutenant.

Appointed 27 Feb., 1442 (E.P.R.). Recalled to London Aug., 1442 ("the archbishop to abide" Privy Council, Nicolas). Held parliament 25 Jan., 1443 (Statutes, 28 Hen. VI, a. 29). Recalled to London, Nov., 1444 (Graves' Council Roll).

Deputy, Sir Richard Nugent, baron of Delvin, 7 Oct., 1444 (Mem. Roll, 24–5 Hen. VI, m. 26).

1444–6. Richard Talbot, archbishop of Dublin, Justiciar.

Held parliaments Feb., 1445, and Mar., 1446. He was testing 15 Oct., 1446 (Mem. Roll, 25 Hen. VI, m. 14).

1446–7. John Talbot, earl of Shrewsbury, King's Lieutenant.

Appointed 12 Mar., 1445 (E.P.R.), but did not come over till end of 1446.[1] Held parliament Jan., 1447, and council Oct., 1447 (Statutes, 27 Hen. VI, p. 151).

Deputy, Richard Talbot, arch. of Dublin (Mem. Roll, 28 Hen. VI, m. 14 d).

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[1] He was testing 18 Nov., 1446 (Mem. Roll, 26 Hen. VI, m. 10).

1447–57. Richard, duke of York, King's Lieutenant.

Appointed 9 Dec., 1447 (E.P.R.), for ten years. Regrant Dec., 1454, on account of death of his deputy (E.P.R.). Did not actually arrive till July, 1449 (5 July, Harris). Returned to England about Sept., 1450 (Temperley).

Deputies, Richard Talbot, archbishop, to beginning of 1449; Sir Rich. Nugent, baron of Delvin, held parliament Mar., 1449; James, earl of Ormond and Wiltshire, held parliament Nov., 1450, also 1451–2; Sir Edward fitz Eustace, held a parliament and councils, 26 May, 1453,[1] June or July, 1454, died 25 Oct., 1454; Thomas fitz Maurice, 7th earl of Kildare, appointed Justiciar[2] by Council on death of fitz Eustace, and appointed deputy by Richard in spring, 1455, held councils and parliament, April and October, 1455, and Nov., 1456.

1457–60. Richard, duke of York, King's Lieutenant.

Appointed 6 Mar., 1457 (E.P.R.), from 8 Dec., 1457. On being attainted, arrived in Ireland Oct., 1459, or a little later. Held parliament 1460. Returned to England, June, 1460, and killed at Wakefield, 31 Dec., 1460.

Deputy, Thomas fitz Maurice, 7th earl of Kildare. He held parliaments Feb., 1458, and Feb., 1459; re-appointed June, 1460.

1461–2. Thomas fitz Maurice, 7th earl of Kildare, Justiciar.

Appointed by Council on death of Duke of York, and confirmed in his office by Ed. IV, 30 April, 1461 (I.P.R.).

1462–5. George, duke of Clarence, King's Lieutenant.

Appointed 28 Feb., 1462 (E.P.R.), from 6 March next.

Deputies, Sir Roland fitz Eustace, lord of Portlester, appointed 16 May, 1462 (E.P.R.), took oath 12 June (I.P.R., 1 Ed. IV, no. 62); William Sherwood, bishop of Meath, succeeded him in same year (Gilbert); Thomas, earl of Desmond, appointed 1 April, 1463 (Statutes, 3 Ed. IV, s. 63), and confirmed 15 April (E.P.R.); Desmond had as deputy Thomas fitz Maurice, earl of Kildare (see Mem. Roll, 6 Ed. IV, m. 9, where he is found testing 12 July, 1464).

1465–70. George, duke of Clarence, King's Lieutenant.

Appointed 10 May, 1465 (E.P.R.).

Deputies, Thomas, earl of Desmond, till October, 1467; Tiptoft, earl of Worcester, landed at Howth, 9 Oct., 1467 (*Liber Albus*, f. 1), and acted till March, 1470.

1470. John Tiptoft, earl of Worcester, King's Lieutenant.

Appointed 23 March, 1470 (E.P.R.). Attainted.

Deputy, Sir Rowland Dudley (testing May and June, 1470; M. Rolls, 9 Ed. IV, m. 24, and 10 Ed. IV, m. 16).

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[1] On 12 May, 1453 (E.P.R.), Ormond was appointed King's Lieutenant, and he appointed John, archbishop of Armagh, his deputy on 25 June (I.P.R.), but they did not act for long.

[2] See Mem. Roll, 36 Hen. VI, m. 24 and 30, for evidence of Kildare being Justiciar.

1470–1. Thomas fitz Maurice, earl of Kildare, Justiciar.
Appointed apparently by Council on attainder of Tiptoft. He was testing 13 Oct., 1470 (*Statutes*, p. 815); held parliament end of Nov., 1470, and also Nov., 1471, which was prorogued by him on 10 Dec., 1471.

1471–7. George, duke of Clarence, King's Lieutenant.
Appointed 18 Feb., 1471 (E.P.R.), from last Michaelmas. Attainted, Feb., 1478.
Deputies, Thomas fitz Maurice, 7th earl of Kildare, who prorogued parliament Mar., 1472, and held parliament March, 1474; William Sherwood, bishop of Meath, held parliament July, 1475, and also one Dec., 1476, which continued to Nov., 1477.

(?) 1477–8. Thomas, earl of Kildare, Justiciar.
Apparently appointed by Council on Sherwood leaving the country; died April, 1478.

1478. Gerald, 8th earl of Kildare, Justiciar.
Elected by Council on death of his father. The King ordered him to cease from the office of Justiciar (*Statute Roll*, 18 Ed. IV). Notwithstanding, he held a parliament at Naas, May, 1478.
[John de la Pole, duke of Suffolk, King's Lieutenant.
Appointed 10 Mar., 1478 (E.P.R.). Apparently never took office.]

1478–9. George, the King's son, King's Lieutenant.
Appointed 6 July, 1478 (E.P.R.). Died 1479.
Deputy, Henry, lord Gray; opened parliament at Trim, Nov., 1478. He had as deputy Sir Robert Preston (14 Jan., 1479, see Christ Church Deed, No. 1014, and 6 Feb., 1479, see Chartulary of St. Mary's Abbey, vol. ii, p. 14).

1479–83. Richard, duke of York, King's Lieutenant.
Appointed 5 May, 1479 (E.P.R.).
Deputy, Gerald, earl of Kildare, 1479 (E.P.R.), to 1482 (Christ Ch. Deeds). The King confirmed his deputyship from 5 May, 1482.

1483–4. Edward, the King's son, King's Lieutenant.
Appointed 19 July, 1483 (E.P.R.).
Deputy, Gerald, earl of Kildare.

1484–6. John de la Pole, earl of Lincoln, King's Lieutenant.
Appointed 21 Aug., 1484.
Deputy, Gerald, earl of Kildare.

1486–94. Jasper of Hatfield, earl of Pembroke, duke of Bedford, King's Lieutenant.
Appointed 11 March, 1486 (E.P.R.): a new patent, 1490.
Deputies, Gerald, earl of Kildare, confirmed in his deputyship by Henry VII; Walter fitz Simmons, archbishop of Dublin, 11 June, 1492 (Harris);[1] Sir Robert Preston, lord Gormanston, 1493 (6 Sept., Harris), and William Preston, his son, same year.

[1] Kildare resigned deputyship and agreed with Ormond that it should be transferred to the archbishop of Dublin till the King should settle their rights (Annals Four Masters, iv, p. 1197).

1494–1509. Prince Henry, King's Lieutenant.
Appointed 12 Sept., 1494.
Deputies, Sir Edward Poynings, landed at Howth, 13 Oct., 1494; recalled January, 1496; succeeded by Henry Deane, bishop of Bangor, appointed 1 Jan., 1496 (E.P.R.). Gerald, earl of Kildare, appointed 6 Aug., 1496, and arrived in September[1]; Walter, archbishop of Dublin, April, 1503; Gerald, earl of Kildare, Aug., 1503, and continued till death of Henry VII.

ABBREVIATIONS.

C.D.I., . . .	Calendar of Documents relating to Ireland.
Cal. Arch. Sweteman,	Calendar of Archbishop Sweteman (Lawlor).
Ch. Ch. Deeds, .	Christ Church Deeds, in P.R.O.
Clyn, . . .	Clyn's Annals.
Cox, . . .	Cox's Hibernia Anglicana.
D.K.'s Reports, .	Reports of the Deputy Keeper (Ireland).
E.C.R., . . .	English Close Rolls.
E.P.R., . . .	English Patent Rolls.
Gilbert, . . .	History of the Viceroys (Gilbert).
Gormanston Ch., .	Gormanston Chartulary (R.S.A.I.).
Graves, . . .	Council Roll of Ireland, Richard II (Graves).
Harris, . . .	Works of Sir James Ware, revised by Walter Harris.
I.C.R., . . .	Irish Close Rolls.
I.P.R., . . .	Irish Patent Rolls.
Just. Rolls or J. P., .	Justiciary Rolls in P.R.O.
Laud MS., . .	In Bodleian Library, published in Chartulary of St. Mary's Abbey, &c., vol. ii (Gilbert).
Leland, . . .	History of Ireland (Leland).
Lynch, . . .	Feudal Dignities (Lynch).
Lib. Nig., . . .	Liber Niger (Christ Church).
Mem. Rolls, . .	Memoranda Rolls, Exchequer, in P.R.O.
Orpen, . . .	Ireland under the Normans (Orpen).
Privy Council, . .	Acts of the Privy Council (Nicolas).
Royal Letters, . .	Royal Letters, Henry III (Rolls Series).
Rymer, . . .	Rymer's Foedera.
Song, . . .	Song of Dermot and the Earl (Orpen).
Temperley, . .	Henry VI (Temperley).
Wylie, . . .	Histories of Henry IV and Henry V.

[1] A week before Michaelmas (Annals of Ulster).

XIII.

CHARLES WILLOUGHBY, M.D., Fellow of the King and Queen's College of Physicians.

By T. PERCY C. KIRKPATRICK, M.D.

[Read January 22. Published March 7, 1923.]

In the Proceedings of this Academy for 1857 (vol. vi), Sir William Wilde published a MS. written in 1690 by Dr. Charles Willoughby dealing with the Climate and Diseases of Ireland. This MS., which was printed in full, had been found among a collection of papers belonging to Archbishop King, and it was, Wilde tells us, preserved in the Library of Trinity College. No trace of the MS. can now be found in the Library, and we are dependent for our knowledge of it on the printed version in the Proceedings of the Academy. Some further information about Willoughby has recently come to light, as well as a commentary on his paper by Archbishop King, which form an interesting supplement to the paper of Sir William Wilde.

Little is known of the early history of Dr. Charles Willoughby, although he belonged to a family of some note in Ireland during the seventeenth century. His father, Sir Francis Willoughby, was a Major-General in the army of Charles I, and he had been knighted on October 10, 1610, at Dublin Castle, by the Lord Deputy, Sir Arthur Chichester. Sir Francis was a member of the Provincial Council of Munster, and in 1636 he was appointed Governor of Galway at a salary of 5/- per diem.[1] In 1641 he resigned that charge to his son, Captain Anthony Willoughby, who in turn received the honour of knighthood at Oxford on February 4, 1645/6. Another son, Colonel Francis Willoughby, afterwards lived in poor circumstances at Dunbro, in the parish of St. Margaret, Co. Dublin, where he died in 1679.[2] Sir Francis Willoughby died in 1659.

It has been stated that Charles Willoughby was born in Cork, but we have not been able to ascertain the date of his birth. Probably he entered Trinity College, but the date is uncertain, as no names are recorded in the Entrance

[1] "Hist. of Galway," Hardiman, pp. 98, 108.
[2] "Southern Fingal," F. E. Ball, 1920, p. 75.

Book between the years 1644 and 1652, and his name does not appear in the published roll of graduates of the University. Most probably, like many others, he left Trinity College during the troublous times of the Civil War; and we find him, described as "of Trinity College, Dublin," admitted to the degree of B.A. at Oxford on December 18, 1649, and in the same year he was elected a Fellow of Merton College. On November 18, 1652, he proceeded to the degree of M.A., on which degree he was incorporated at Cambridge in 1655. Soon after he went to Italy to study medicine, and he was admitted to the degree of M.D. at Padua on March 29, 1663/4. Just a year later he was incorporated at Oxford on his Padua degree.[1]

Probably after his incorporation as M.D. at Oxford, Willoughby returned to Dublin, and in 1667 he was nominated by Charles II as one of the Fellows of the College of Physicians in the Royal Charter granted to that body. It is possible he was at the time a member of the Fraternity of Physicians, which in 1654 had been established in Trinity Hall, under the presidency of John Stearne, but of this we cannot now be certain. His promotion in the College was rapid. On September 24, 1676, he signed as President, so that we may conclude that he had been elected to that office on the previous feast of St. Luke. He continued as President till October, 1677, when he became Treasurer of the College—an office which he held till April 25, 1683.

By that time Willoughby had attained a place of note among men of learning in Dublin. In October, 1683, at the formation of the Dublin Philosophical Society, he was elected *Arbiter Conventionis,* or "Director," and he was one of the four members chosen to draw up the rules for that Society. To its Proceedings he contributed two papers—" On a Mirage seen at Rhegium, in Italy; and on Winds," and " On Lines of Latitude and Longitude."[2]

In addition to taking a prominent part in the scientific work which was being done in Dublin, Willoughby appears to have enjoyed the favour of the Court. In 1682 we hear of him attending Patrick Sheridan, Bishop of Cloyne,[3] who died on November 22 of that year. On May 19, 1683, the Earl of Arran, who was then Lord Deputy, had written to the Duke of Ormond introducing Willoughby, and recommending him for the post of Physician at the Royal Hospital, Kilmainham, which was then being built. Sir Patrick Dun was also a candidate for that post. To that letter Ormond replied: "The pretensions of the Doctors Willoughby and Dun will be best determined by employing the Surgeon-General of the Army, at least, till an army marches

[1] Foster, "Alumni Oxonienses."

[2] Dub. Quart. Journ. Med. Science, vol. i, p. vii.

[3] Ormond MSS., N.S., vol. vi, p. 445.

[4] *Ibid.*, vol. vii, p. 32.

and requires his marching with it, and I conceive if Fountain be alive, he is so antiquated that Thompson may with his consent officiate for him. This will be the thriftiest way, and the Governors are in conscience bound to be as good husbands for the Hospital as they can be, that the charity may extend as far as the fund will reach."[1] Arran agreed that the appointment should be given to the Surgeon-General, "because the work might be well enough done by him and with a less salary."[2]

This plan was eventually adopted, and Charles Thompson, the Chirurgeon-General, was in 1684 appointed Surgeon to the Hospital at a salary of £50 a year, with a "mate" at £20 a year. On November 17, 1692, Patrick Dun was appointed Physician at a salary similar to that which had been paid to Thompson.

We lose sight of Willoughby altogether during the troublous times from 1687 to 1690. He does not seem to have been connected with the army, and his name does not appear among those of the Physicians mentioned by Sir Patrick Dun as attending the wounded soldiers either in the camp or at the Royal Hospital. Possibly he left the country for a time, but he was back again in Dublin in 1690. In that year he wrote the paper which was published by Wilde, and sent it to his friend William King, Bishop of Derry, who in reply sent him the following letter :—

Londonderry, May (19) 169(1)

Sr

I received yours with your observations on the Bills of mortality for wch I am much yor debtor & I believe yt you have (sd) as much as such an exhausted subject will bear. I cannot prtend to say much to ym. If these calamitys had not destroyed our church books, which were regularly enough kept in most places in the diocese, I coud have furnished you with countrey observations (but) yn the diseases are not specifyed nor the age of the persons, some parishes have yet yr books, & I have ordered ye ministers to make extracts out of ym, as soon as I get any I will send ym to you. There is a thing called the viewing of parishes, in order to know ye value of tiths. ye master of each familys name is in one column, the number of acres of oats yt he plows, likewise of wheat, barl(ey) &c together with ye number of cows, sheep &c in others, these are taken in each parish every year very ex(act). Now if they were collected together, with a little addition of a column or two more, for ye number of males & females, under 16 and above 16, in each family; I believe it might be of better use yn the bills of mortality, for 1st it woud give exactly the (num)ber of the people 2dly it woud distinguish the serviceable from the unserviceable 3 it woud show exactly the increase & decrease of ye numbers 4thly it woud exactly distinguish the riches of (every) place, & in wt commoditys they abounded 5 it woud inform the government in all applotments, how to tax every parish & where to find men, cows horses,

[1] Ormond MSS., N.S., vol. vi, p. 150. [2] *Ibid.*, p. 147.

sheep meal &c when they had occasion for ym. 6ly It woud be a rule for merchants where to find the commoditys they want & to vent those they have. This compared with the custom house books woud determine the fertility and comparative bareness of soils, for if it were found yt suppose a 1000 cows &c in the north maintained so many men &c & sent off so much butter &c, whereas in another place a like number of cows & acres maintained so many more, the excesse must arise from the fertility or some other like cause, which might admit of many usefull observations.

I suppose youll inquire, why I do not im̄ediately set about this, since it may so easily be done, & may be so usefull. I answer, I am yet too young in my employment to meddle out of my own busyness, and I wou'd not meddle in any thing yt may procure me censure, but when I think it proper I may perhaps look farther into it. Tho I am afraid that the particulars are so materiall, yt many may think it yr interest yt they shoud not be known perhaps it may be dangerous to publish ym where we are not very sure of the government; for as they are the best means for (mana)ging a good government so they capacitate an ill designing government to do great mischief, & this I take to be the reason yt very few are willing yr governours shoud know the number strength & riches of their subjects. The reason yt bils of mortality have bin so readily kept & communicated I take to be from peoples not apprehending yt they might give light into these things.

I observe in your paper you say, bils of mortallity have not bin kept in Dublin above 10 years, this is a mistake, I remember ym before I left ye College, I thing one Johnson distributed ym 18 years ago.

In the discourse of feavours, you suppose ye town was thinner yn formerly in 1689, but yt is a mistake. it was never more populous. King James his court and parlement were in it. Yt year great numbers of the plundered English & creaghting Irish came into it, in some places whole houses full of ym besides often 10m of the army with ye doxys garsons &c, & in as much as there were most men and women, & had ill attendance yerefore ye number of those that dyed above (16) is encreased.

You observe in the head of males and females yt Ravenous beasts do not multiply so fast as sheep &c tho they have many in a litter and impute it to promiscuous copulation, but yt is not the reason for the females generally admit but one yre is no forcing with ym, ye tru reason is the want of certain and easy food & ye unseasonable destruction they meet with, we kill ym (as) we can find ym when young & wn with young, we take all advantages of ym & never let ym come to a head, & if they do they must Starve, as no doubt many do, for perhaps the whole kingdom cou'd not find constant food, in yr destroying way, for 100m wolves for one year therefore they cannot subsist beyond a certain number, no more yn sheep beyond a certain number can live on 100 acres of land, taking away yerefore the over plus is ye prservation of the whole, & yt is the care of man.

As to wt you say of the clergy they are not in this kingdom the 400th part of mankind, but I believe they are ye 10th of those, yt can prtend to be maintained in a gentile way by other mens labour. Now tho in generall yr may be 14 males for 13 females, yet amongst those yt can prtend to such a maintenance as this, the case is quite otherwise perhaps there are 4 women to 1 man, all the daughters of familys are of (ye) same rank, but not all the sons; tho mankind have more (sons) yn daughters, yt gentlemen have not, by reason of yr intemperance. The case of Fluxes seems to me not very difficult. Generally change of air drink and diet cause ym. Ye dissolving Juices in the stomack not concocting ym right at first when drink in Ireland was rare, meat ill boyled & lean, bread ill baked, & beds & houses not so convenient & warm as in England, every one yt came out of it had a flux, but lately very few came out of it in proportion, & those yt came, took care of ymselves. They found ye drink meat and accommodation mended, & to be had for money. No wonder therefore they escaped the flux, but wre multitudes came from England, & are ill accommodated, ye flux is as common as ever. The number of bogs drained is so very few, yt they cou'd make little alteration in the air. Perhaps ye number of houses & multitude of fires might: for I observe here burning ye heath on the mountains causes winds immediately & sensibly alter ye weather.

What you hint of imploying an army, in time of peace, to drain bogs, is a dangerous point. It touches yr ease & pleasure; & they had rather make a war yn have yse invaded, but when all is done, this wou'd be the best use they coud be put to; & it wou'd really make ym more usefull in war, as appeared from ye Roman armys, who whilst thus imployed conquered ye world, but came to nothing, when they became too gentile to work.

You say in the beginning of your paper yt ye new built houses in Dublin were filled with inhabitants, as soon as finished, without any decrease of Rent. Yt is a very great mistake, for the rents in Castle street skinner row &c fell very near half of what they had been, generally a third; & I am of opinion, ye number of inhabitants did no way increase in proportion to ye buildings.

In May 1690 ye minister of Dublin, by order, returned ye number of protestant men in the city and libertys, from 16 to 80 & they amounted to 8300, & some odd persons. Consider how that will agree with Sir Wm Pettys proportions.

Worthy sr I am ashamed to have so little to add to your observations, & yet to have been so tedious: I hope you will take these in good part, & believe yt I am

Your affectionate humble sert.

Will: Derry.

Endorsed To Dr Willoughby (May) 19 1691.

The whole subject of "Political Arithmetic," or, as we should now call it, "Vital Statistics," was at that time exciting much interest on account of the writings of Sir William Petty and Captain John Graunt. Willoughby's paper does not throw much new light on the subject; but King's letter is interesting, and it shows how two hundred and thirty years ago the suspicions of the country people made the collection of reliable statistical information as difficult as it is at present.

The three following letters, written by Willoughby to King, are preserved among the King correspondence in Trinity College, and have not been hitherto published. The first is chiefly of medical interest, being the considered opinion of a physician on the diagnosis and treatment of a patient's sickness, about which he had been consulted. The second and third letters are of more general interest:—

Sr.,

Dr. Dun is right in his guesse yt ye distemper is a sort of rickets but I feare it is such yt ordinary purgers will hardly prove effectuall ye greatnesse of ye distemper may be concluded from hence yt it has ye same effect upon bones yt are almost adult yt it uses to have upon children at a time when their hardest bones are not above one degree removed from gristles & some but newly gellied. I believe these symptomes will hardly determine ye controversy between Glisson [1] and Mayow [2] whether the rickets owe their originality to the alogotrophy of ye bones or ye atrophy of ye muscles for I suppose this to be a corrosive venome whose first degree softens and makes spongy but next step calcines ye bones such as have been sometimes observed after long confirmed veneriall distempers. I pray let the Dr. know yt my opinion is some purge made of mercury remedies ought to be prescribed I think pulvis corallium [3] with mercurius dulcis might be a good purge [4] there is an author I once read of Dr. Duns Harris pharmacologia antiemprica[5] a preparation of Antimony wch. I think they call halfe rosted[6] Dr. Needham[7] used it much sent me a quantity of it. I used a little

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[1] Francis Glisson (1597–1677). A graduate of Cambridge, and Regius Professor of Medicine there for forty years. He published the original and classical account of infantile rickets in 1650. In 1654 he was the first accurately to describe the capsule of the liver and its blood-supply.

[2] John Mayow (1643-1679). A student of Wadham College, and D.C.L of Oxford. He was a distinguished chemist and physiologist. Glisson had explained the curvature of the bones in rickets by alogotrophia, or unequal nutrition of different parts. Mayow in his essay on rickets, which was published at Oxford in 1668, opposed this view, and attributed the curvature to a deficiency in the growth of the muscles. He said "the bones are bent by the muscles just as a bow by its string."

[3] Corallium, or Red Coral, was said to be cold and dry. Culpeper writes it "helps witchcraft, being carried about one. It is an approved remedy for the Falling Sickness. Also if ten grains of Red Coral be given to a child in a little Breast Milk so soon as it is born, before it take any other food, it will never have the Falling Sickness, nor convulsions." The common dose is from ten grains to thirty. (Pharm. Lond., p. 50.)

[4] The "Purging Powder" is described in Radcliffe's Dispensatory of 1721 as follows:— "Take Mercurius dulcis six times sublim'd, six grains; Resin of Jalap, seven grains; Fine white sugar, half a scruple; mix and make a powder to be taken early with due care."

[5] Walter Harris (1647–1732). A Fellow of New College, Oxford, and of the College of Physicians, London. The book referred to is "Pharmacologia Anti-Emprica, or a rational discourse of remedies both chemical and Galenical." London, 1683.

[6] The powder referred to is probably the Kermes Mineral, invented by Glauber in 1651. The method of its preparation was kept secret, but in 1720 was purchased by Louis XIV. It was an orange-red powder, consisting of a mixture of oxide of antimony with a hydrated sulphide of the metal, and a small proportion of sulphide of sodium or potassium, according to the method of its preparation. It appeared in the Dublin Pharmacopoeia as Antimonii Sulphuretum Praecipitatum, or Sulphur Antimoniatum Fuscum.

[7] Either Caspar Needham or Walter Needham is referred to. Both were Fellows of the College of Physicians of London, and of the Royal Society. Caspar graduated M.D. Cantab. in 1657, and died in 1679; Walter graduated M.D. Cantab. in 1664, and died in 1691.

myself but found better effect of it in others who continued ye use of it longer. I think it might not be improper in this childs case. I should propose a drying dyet forbearing flesh and living on dryed and preserved fruits, raisins, almonds, sweetmeats (for I am not soe much an enemy to sugar as Dr. Willis[1] since it embalmes all putrelient juices) chocolatte and coffey dyet drinks of China, sarsaparilla[2] hartshorne & Ivorie[3] wth. ye roots of filipendula[4] & scrofula[5] the white decoction[6] made with burnt hartshorne & ( ) powder must needs be good, bathing must needs be excellent good the distemper is nervous, its seat in the very beginning & therefore no cephaliqs will be amisse. I am soe busy at present in ye accounts between Sir Henry Wemys & my nephew yt I cannot possibly contrive ye meeting of Dr. Dun but you may shew him this as my thoughts & I refere it to him to draw up directions according to this scheme. I am unwilling to put it of till next post because I perceve my answer is expected by this & ye child condition will not admit of much delay.

I am Yr affec. servt C.W.

(Endorsed by King) Dr. Willoughby about Mr. Jemmets child Dec. 1691. These for Mr. Bonnell att his office or elsewhere, from The Rt. Revd Father in God Wm. Ld. Bp. of Derry Londonderry.

June 14th, 92.

My dear Lord,

Tho a fit of ye gewte & a little feaver accompanying it were frequent visitants of yr Ldp here; and I hope your present indisposition is noe more, yet your friends cannot but be allarmed to heare you aile anything at soe great a distance.

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[1] Thomas Willis. Born January 27, 1621. Educated at Oxford, and graduated M.B. in 1646, and M.D. in 1660. He died November 11, 1675. He was one of the most noted Physicians of his time in England. His name is preserved in the "Circle of Willis." He was the first to distinguish between diabetes Mellitus and insipidus.

[2] "Sarsae Perigliae, Sarsa Parilla, roots, or Bind Weed. Somewhat hot and dry, helpful against pains in the head, and joynts ; they provoke sweat, and are used familiarly in drying diet drinks." (Pharm. Lond., p. 12.)

[3] "Unicorns horn resists Poyson and Pestilence, provokes urine, restores lost strength, brings forth both birth and afterbirth, binds, stops the whites in women, it strengthens the heart and stomach, helps the yellow jaundice, and makes women fruitful. The virtues of Hart's-horn are the same with Unicorns-horn. The bone that is found in the heart of a stag is as soveraign a cordial, and as great a strengthener of the heart as any is, being beaten into powder, and taken inwardly ; also it resists Pestilence and Poyson." (*Ibid.*, p. 49.)

[4] "Filipendulae or drop wort. The roots are hot and dry in the third degree, opening, cleansing, yet somewhat binding ; they provoke urine, ease pains in the bladder, and are a good preservative against the falling sickness." (*Ibid.*, p. 7.)

[5] "Scrofularae, Fig Wort. The roots being of the same virtue as the herb I refer you thither. Fig Wort so called of Scrophula, the King's Evil, which it cures, they say, by being only hung about the neck. If you bruise it and apply it to the place, it helps the Piles and Haemorrhoids, and (they say) being hung about the neck it preserves the Body in health." (*Ibid.*, p. 37.)

[6] "Decoctum Album. Cornu Cervicini calcinati, et praeparati P. uncias duas, Gummi Arabici P. drachmas duas, Aquae M. libros tres. Coque ad libros duas, et cola." (Pharmacopoeia Lond., 1771.)

I do in vaine wish my selfe neerer yt I might pay you ye utmost of my service and since my distance disables me from giving you any but generall directions I thinke it necessary to warne yr Ldsp of ye greatest & most prejudiciall intemperance I know you guilty of, wch is yt of over exercising your braine beleeve it my Ld tis as unlawfull an intemperance as yt of eating & drinking & rather more dangerous because its injuries are seldome discovered till they are incurable. I was in good hopes ye duties of yr function would have kept you very much in company & abroad on horseback yt it would not have permitted you to make any longer a drudge of yt head you have to much harassed but I wish a crooked irregular clergy may not have to great a share in your present disorder if soe it will (be) yr Lops remedy as tis your duty when you have done your owne part to be unconcerned for ye issue. a packet came in this morning brings word yt Namur is gone as Mons[1] went, ye confederate army looking on we have many irons in ye fire we expect suddenly to heare of a fight in ffanders and a descent into ffrance ye action of ye ffleet was really great.

My Ld. I am, Yr Lops most obliged servt.

C: Willoughby.

(Endorsed by King)—Dr Willoughby, June 14th, 1692.

(Addressed): These ffor the Right Reverend ffather in God
Wm. Lord Bp. of Derry at London Derry.

May 10th, 92.

I have recd my Deare Lord, by ye hands of Mr Bonnell your noble almes for wch I am able to make noe other returne but my humble thanks to yr Lop and my perpetuall prayers to God for your Lops health wealth & prosperity. I make no question but your Lp has long since heard of ye intended change of our Provost[2] who is by noe means satisfied therewith the Diocese of Kilmore being all wast and Ardagh lopt of to gratify another pretender and sufferer Dean Bourke.[3] he is gone into England and Dr Ash[4] landed here on Saturday. some thinke yt if he can (without disobligeing those he depends on) he will strip himself of both & endeavour to procure ye Provostship for Dr Browne[5] & resine ye Bpricke to Dr

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[1] Mons capitulated to the French in March, 1691, and Namur was taken after a siege of eight days, just before the victory of the English over the French Fleet at La Hogue on May 23, 1692.

[2] Robert Huntingdon, D.D., Fellow of Merton College, Oxford, was admitted Provost of Trinity College on September 3, 1683. In 1688, when the College was occupied by troops of King James, Huntingdon fled to England, and Michael Moore, D.D., was placed in charge of the College. After the revolution Huntingdon returned, and he continued in the office of Provost till August, 1692, when he resigned, and was appointed Rector of Stanford Rivers, Essex. In that year he was offered the See of Kilmore, but he refused it. Subsequently, on August 21, 1701, he was consecrated Bishop of Raphoe, but he died on September 2, 1701. He was a distinguished oriental scholar.

[3] We have not been able to identify this Dean Bourke.

[4] St. George Ash was elected a Fellow of Trinity College in 1679, and co-opted senior on July 25, 1686. On October 3, 1692, he was admitted Provost. In July, 1695, he was consecrated Bishop of Cloyne; translated to Clogher in June, 1697, and to Derry in February, 1716. He died February 17, 1717.

[5] George Browne was elected a Fellow of Trinity College in 1673. On July 22, 1695, he succeeded Ash as Provost. He died June 4, 1699.

Ash. I am sure if ye headship of Merton[1] College should fall in time he would play yt game & sticke there but it is tedious waiting for dead mens shooes and I am of opinion he will have a care not to loose his friends and prefermt both at once. his missing of Dr Ash whom he expected to have met by ye water side may perchance alter his measures. I am confident your Ldp has already seen Nova Dioptrica[2] I am beholden to ye Author for a present of one Volume wch obliged me to so much care in ye reading yt I have not yet finished it but finde it ye fullest of Dioptricall learning of any piece I have yet seen on yt subject tis true he quotes and seems to have consulted severall . . . my view wch makes me think . . . besides ye method of calculations . . . ray and ye solution of all problems from yt method . . . his calculations he has been very industrious and truely I thinke exact. I doe not hear yt George Tollet[3] will be here this year. his Nephew is come over from Cambridge I have not yet seen him and therefore cannot say what errand he comes on or what news he brings I am apt to thinke he intends him for his Deputy in Mr Bonnells office during his absence, the College proceeds next Thursday to an examination for schollerships and ye Wednesday following there will be a sitting for fellowships but tis thought there will not enuf sit to fill all vacancyes.[4] I hope my Ld ye Ld Liets[5] arrivall will bring yor Lop to Dublin where I may return yor Lop ye personall thanks of

yor most obliged humble servt

C : Willughby.

(Addressed) "These ffor the Right Reverend ffather in God
Wm Lord Bp of Derry at Londonderry."

(Endorsed) "May 10 Dor Willoughby."

Willoughby does not seem to have taken an active share in the reconstitution of the College of Physicians, which resulted in the granting of a new charter to the College by William and Mary on December 16, 1692. In that charter

[1] The Warden of Merton College, Oxford, at the time was Thomas Clayton, M.D., who had been appointed in 1661. He was Regius Professor of Physic at Oxford. He died in 1693, and was succeeded by Richard Lydall, M.D., who had been elected a Fellow as far back as 1641.

[2] "'Dioptrica Nova.' A Treatise on Dioptrics, in two parts. Wherein various effects and appearances of spheric glasses, both convex and concave, simple and combined, in telescopes and microscopes, together with their usefulness in many concerns of humane life are explained. By William Molyneux, of Dublin, Esq., Fellow of the Royal Society. *Ex visibilibus invisibilia.* London: Printed for Benj. Tooke, MDCXCII. 4to. 11.8, pp. 301 & 43 Plates."

William Molyneux was brother to Sir Thomas and father of Samuel Molyneux.

[3] George Tollet, a friend and correspondent of Archbishop King. He had been in negotiation with James Bonnell for the purchase of the reversion of the office of Accountant-General. At the outbreak of the revolution he had fled to England, and had obtained a post in the Tower of London. His nephew, Marcus Tollet, had graduated B.A. from Magdalen College, Cambridge, in 1691, and in 1692 he was elected a scholar and admitted B.A. (*ad eund.*) in the University of Dublin.

[4] There had been no election of Scholars or Fellows in Trinity College since 1688. In 1692 twenty-two Scholars were elected, and three Fellows—Peter Brown, afterwards Provost; Richard Mossum, afterwards Dean of Ossory; and William Carr, who was appointed Medicus.

[5] Henry, Viscount Sydney, Lord Lieutenant, arrived in Ireland on August 25, 1692, and was sworn on September 4.

he was nominated a Fellow and appointed one of the four Censors, but he did not attend till the fourth meeting of the College, on February 1, 1692/3, to take the oath. On St. Luke's Day, 1693, though absent from the College meeting, he was continued as a Censor, and on July 6, 1694, he was asked to draft a by-law "punishing such as shall come late to the meetings, and that none be obliged to stay after five of the clock." This by-law he introduced on July 17, when it was read for the first time. At the next meeting, on September 1, 1694, the by-law was read a second time, but its framer was then dead. Before concluding the business of the meeting the President and Fellows "ordered that as a mark of our respect to our honoured colleague Dr. Willoughby every one of the Fellows in town doe appear att his funeral tomorrow in a gown under the penalty of a crown for the use of the College." At the next meeting, on September 26, 1694, Willoughby's by-law was adopted as follows:—"Whereas our meetings grow troublesome to some of the practising physicians by the neglect of others to give early attendance. It is thought fit that a mulct of six pence be laid on those who do not come within one quarter of an hour after the time appointed in the monitary bill sent by the President. And to the end none may have reason to complain of the tediousness of the meetings: no man shall be obliged to continue longer at a meeting than two hours from the first date, but after that time is at liberty to depart when he pleases, altho the business of the meeting be not fully completed." For many years afterwards a fine of six pence for coming "tardy" was a common occurrence at the meetings of the College.

In his will, which was signed on August 28, 1694, Willoughby bequeathed his property, Newtown, Co. Dublin, to his niece, Katherine Willoughby, with a charge of ten pounds a year to Edward and Jane Phillips "and the longest liver of them." To this Edward Phillips, who was his servant, he bequeathed his wearing apparel, and he desired his body to be decently buried in St. Andrew's Church, Dublin. His "herbarium vivum" or "hortus siccus," a collection of botanical specimens which he had made at Padua, he had presented to Merton College in 1663, and it is still preserved in the Library there. The catalogue of his library and the diploma of his degree at Padua are preserved in the Library of Trinity College. The catalogue is a quarto volume, newly bound in calf. It contains the entries of 775 volumes, arranged alphabetically under the names of the authors; in addition, several entries have been obliterated, as if the books had been removed from the library. The latest dated book noticed was for 1690, but on the first four pages there are a number of entries of books which have been lent to various persons. Some of these entries are dated, the latest being April 29, 1692. There is not any mention in the catalogue of books either by King or by Molyneux.

XIV.

SILVA FOCLUTI.

By PROFESSOR EOIN MacNEILL, D.Litt.

[Read February 12. Published March 23, 1923.]

Dr. Newport White's edition of "Libri Sancti Patricii" (Proceedings of the Royal Irish Academy, vol. xxv, section C, Nos. 7 and 11—"The Paris MS. of St. Patrick's Latin Writings") suggests a solution of the many difficulties that have arisen around the placing of "Silva Focluti" in St. Patrick's account of the vision in which he seemed to hear voices calling him back to Ireland. The pertinent phrases of the narrative are these (p. 242, cp. p. 549):—

Et iterum in Britanniis eram cum parentibus meis . . . . Et ibi scilicet uidi in uisu noctis etc. . . . et . . . putabam . . . audire uocem ipsorum qui erant iuxta siluam Focluti quae est prope mare occidentale, et . . . exclamauerunt . . . Rogamus te, sancte puer, ut uenias et adhuc ambulas inter nos.

According to Dr. White's list of variants, the reading *Focluti* is not found in the MSS. cited by him under the reference letters B, C, F, F4, P, and R, so that apparently it is the reading of the Book of Armagh alone. The readings of the other MSS. are: *uirgulti* B, *uirgulti uolutique* C, the same with *uolutique* marked for deletion F4, *uirgultique* F, *uirgulti uelutique* P, *uirgulti ueluti* R.

These variants at once force us to recognize that St. Patrick could not have written *Focluti*. In Irish words beginning with F, F did not replace the older V until the beginning of the seventh century. *Focluti*, therefore, has been substituted in the Book of Armagh (A) for the word originally written by St. Patrick.

I take it that *-que*, which is absent in A, B, and R, is no more than a duplication of the following word *quae*, for which *que* would be a normal spelling in early Irish MSS. It is possible to regard *uirgulti*, absent from A, either as an incorporated gloss or emendation or as part of the original text. The fact that *uirgulti* stands without *uoluti* or *ueluti* in two MSS. and is represented in a third by *Focluti* alone gives ground for supposing that the original here had a single word, which a redactor proposed to replace or explain by the, to him, more intelligible *uirgulti*, and that *uirgulti*, interlined for this reason, afterwards passed into the text of a number of transcripts, in some as a substitute for the older reading, in others as an addition to it. It matters little, however, whether we suppose an older reading *iuxta siluam Uirgulti*, *Uoluti* or *iuxta Siluam Uoluti.* In one case the words *Uirgulti Uoluti*, in the other the words *Siluam Uoluti*, would represent St. Patrick's way of writing a particular place-name. I propose to reject *ueluti*, because *Focluti* could hardly have arisen from it, and might well have arisen from *uoluti* through an intermediary reading *uocluti*—the Irish change from initial U (V) to F must have been familiar to every scribe of the seventh and eighth centuries. Though *ueluti* is sufficiently inept in the context, its substitution for an unintelligible *uoluti* is much more likely than the converse process.

We shall then, I think, agree with the Armagh version in regarding *Siluam Uoluti* as the partly latinized name of a particular place. It was doubtless knowledge of St. Patrick's later association with "Fochloth," near Killala, where he founded the church of Domnach Mór (Book of Armagh, 10b, 14b), that caused this scribe or some authority followed by him to adopt the name *Focluti*, and thus to set others, down to our time, wondering and seeking to explain how the name of a place on the west coast of Ireland could have arisen to St. Patrick's mind at a time when, according to all that is known or told of him, he had never been within a hundred miles of that place. Professor Bury, holding that St. Patrick's narrative above quoted evidently implies that the place named therein and the place of the captivity were in one neighbourhood, has boldly—his own word is "frankly"—rejected the traditions of Sliabh Mis and transferred the captivity to a western forest, which would have joined in one local association Killala and Croaghpatrick.[1]

Dr. Newport White, in "St. Patrick, his Writings and Life," pp. 6-11, puts aside Bury's theory and proposes an alternative explanation, based on the view, which is certainly no longer tenable, that St. Patrick wrote *Focluti.*

All the MSS. agree in making the word or the two words following *siluam* end in *-ti.* My thesis is that the original reading was *siluam Uluti*, possibly but less probably *siluam Uirgulti Uluti*—for, if *Uluti* be accepted, the likelihood that *uirgulti* came in by way of attempted emendation is obviously increased. I take *siluam Uluti* to denote the district later known as *an Choill Ultach*, "Killultagh," meaning the woody district of the Ulaidh. This name was formerly given to a district of much wider extent than it now denotes, which lay on the eastern side of Lough Neagh, in the southern part of the county of Antrim.

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[1] "Life of St. Patrick": for the various points at which the argument recurs, see the index, s.v. *Fochlad.*

**Uluti* is in fact the early form of the name *Ulaidh*; we have the Old-Irish accusative plural *Ultu* < **Ŭlutūs*, and genitive plural *Uloth n-* < **Ŭluton*. But *Uluti* is nominative plural. We might expect St. Patrick to have written a genitive *Ulutorum*, or even *Ulutum*, parallel with the *uox Hiberionacum* of the same passage; but the fact that all the variants end in *-ti* seems fairly decisive evidence that the word originally written had the same ending. My view is that St. Patrick, in latinizing an Irish name, might well have used a nominative plural where a better latinist would have used a genitive plural. I mention, but do not accept, the possibility that he might have used *Uluti* as an adjective in concord with *uirgulti*. In the Latin inscriptions of western Britain, from Selkirkshire to Devonshire, there is abundant evidence that, in the period immediately following the Roman evacuation of Britain, in the fifth, sixth, and seventh centuries, the case-inflexions of Latin had quite broken down, and were no longer correctly used even by the more or less literate persons who devised the inscriptions. A collection of such inscriptions is found in the paper by the late Sir John Rhys in Y Cymmrodor, vol. xviii, where Rhys has bravely sought to explain, on various grounds, the frequent absence of concord.

It is quite possible that, besides the solecisms of idiom which remain, St. Patrick's writings abounded in errors of accidence, which later scribes and redactors would be certain to correct. All the MSS. seem to have left uncorrected an original *ambulas*, for the subjunctive *ambules*, in the passage quoted. At all events, the actual readings make *Uluti* more likely by far than *Ulutum* or *Ulutorum*, or an adjectival **Ulutacam*, which would represent the later *Ultach*.

The actual variants would then have arisen as follows:—The original *uluti*, mistaken for a Latin word and a puzzle to the scribes, became *uoluti*, the Latin word which most closely resembled it. When later on the editing and emendation of St. Patrick's Latin was undertaken, *uirgulti* and *ueluti* were independently substituted, as yielding a somewhat better sense. Collation led to *uirgulti uoluti* and *uirgulti ueluti*. We can see collation at work in the *uirgulti uolutique* and subsequent deletion of *uolutique* of F4. The scribe of the Book of Armagh, or rather some earlier scribe in his line of tradition, recognized that a place-name might be expected, and *uoluti* became *Uocluti*, then *Focluti*. Adamnan, a century earlier, writes both *Uirgnous* and *Fergnous*.

It is remarkable that two other instances of the change of **Uluti* to a form bearing the guise of a Latin word are on record. One of these is the well-known Οὐολούντιοι of Ptolemy. It is quite possible that Ptolemy recorded the name in the nearest equivalent Greek spelling Οὔλουτοι; more likely, perhaps, that he made it Οὐλούτιοι, for a plural nominative in -ī, in Celtic as in Latin, might leave a Greek writer in doubt as to whether the stem had *-io* or only *-o*. It can hardly be doubted that the further scribal development of the name into Οὐολούντιοι represents attraction towards the Latin *uoluntas, uoluntarius.*

The parallel of the second instance is much closer. In the Book of Ballymote, 196, are preserved some fragments of a tract in Latin on Irish genealogical lore. They contain (col. 2, l. 24) the phrase *in tempore Uolotorum*, meaning "in the time of the Ulaidh," i.e. in the time of the heroes or of the kingdom of Emain. Here clearly the unfamiliar archaic Irish *Uluti* has been changed by scribes into the familiar Latin *uoluti.*

To sum up the argument: St. Patrick could not have written *Focluti*; *Focluti* is a later redaction of the original word; among the extant variants, *Focluti* cannot have arisen from *uirgulti* or *ueluti*, but has obviously arisen from *uoluti*, probably through **uocluti*; as in the BB instance, *uoluti* is a Latin substitute for the Irish **uluti*; all the variants attest the ending *-ti*. In his use of the Irish name, St. Patrick, *more Brittanico*, like the Cymric language of all periods, dispensed with case-inflexion. *Silua Uluti* would represent such a name as **Caill Uloth* or **Fid Uloth* in seventh-century Irish. In the earliest Irish of the Ogham inscriptions, the genitive plural *Uloth* would appear as *Uluta*—cp. TRIA MAQA MAILAGNI = *trium filiorum M.* The modern name Coill Ultach cannot be traced to any great antiquity, but is probably older than De Courcy's occupation, which brought the rule and record of the Ulaidh to an end.

This explanation of *silva Focluti* gets rid of all the difficulties that have been found in explaining St. Patrick's dream with reference to a wood or forest separated almost by the breadth of Ireland from the only part of Ireland in which, before this dream, tradition knew him to have been. The saint, in his narrative, has the vision vividly before his mind; and when he speaks of the *mare occidentale*, he means, if I mistake not, the sea to the west of Britain, not the sea to the west of Ireland.

The name of his master and owner in his captivity, according to an unquestioned tradition, was Miliucc moccu Booin (later maccu Buain). This name signifies that Miliucc belonged to the sept known later as Dál Buain. The lands of this sept were situate immediately to the east of Lough Neagh. Sliabh Mis, "Slemish" (not "Slemmish" to rhyme with "blemish," but with the long ē), the traditional scene of the captivity, Dál Buain, and Killultagh, all come within a range of twenty miles; and the *adhuc* of the voices requires no strained explanation. When the Confessio adds, *Deo gratias, quia post* *annos plurimos praestitit illis Dominus secundum clamorem illorum,* it is quite likely that *illi* has reference to the people of that very district.

The lands of Dál Buain and Coill Ultach were partly co-extensive. Dál Buain, according to Hogan's Onomasticon, "included the parishes of Drumbeg, Drumbo, Hillsboro', Blaris, Lambeg, Derryaghy, Magheragall, Magheramesk, Aghalee, Aghagallon, Ballinderry, Glenavy," also Magh Comair = "Muckamore." This indicates an extent along the whole eastern side of Lough Neagh, and thence south-eastward across the Lagan river, comprising probably the greatest part of the baronies of Massareene, Upper and Lower, in County Antrim, and Upper Castlereagh, in County Down. Under Coill Ultach, Killultagh, Hogan has "County Antrim . . . *recte* in Co. Down; as in my 'Description of Ireland as it is in 1598,' p. 7:—Kilulto in County of Down, a very fast Countrie full of Wood and Boggs, bordereth on Lough Evaghe (L. Neagh) and Clanbrassell;[1] the Captaine thereof is Bryan McArt O'Neill." Hogan forgot that the county of Down, as it was described in 1598, included much of the southern part of the present county of Antrim. "Killultagh House," about half-way between Glenavy and Lisburn, is in the very middle of Dál Buain.

Muirchu's Life, based in part on the Confession, has *Fochloth* where A has *Focluti.* If we could be sure that Muirchu wrote *Fochloth,* we should have to infer either that *Focluti* or perhaps *Uocluti* was the reading in the MS. of the Confession which he used, or that he himself was the first to substitute *Focluti* and *Fochloth* for the word in the original. It is, however, quite possible that Muirchu did not write *Fochloth,* and that the same redactor who substituted *Focluti* in the Confession substituted *Fochloth* in Muirchu's Life. In this connexion, it is worth noting that *Fochloth,* a form by itself not easy to explain, is identical in its ending with the genitive plural *Uloth* of Muirchu's time. If *Fochloth* is a compound of the word which in Old Irish is *caill* "a wood," its genitive in Old Irish should be *Fochleth,* not *Fochloth.* There is near Killala a hamlet now called in Irish *Fōchoill.* In this name the long vowel of the first syllable may be due to conscious etymology, *fō* being what may be called the grandiloquent form of the preposition *fo,* and *faoi* (*fuī*) the ordinary colloquial form in present-day Connacht usage. In St. Patrick's time, however, this name, if it existed, should have been written **Uocallit-* or *Uocallet-,* or, after syncope, **Uochlit-* or *Uochlet-.* All the variants of the Confession have *u* in the penultimate syllable, *-uti, -ulti.*[2]

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[1] We should probably read "Lough Neaghe, Evaghe (= Uibh Eachach, "Iveagh"), and Clanbrassell."

[2] Regarding Muirchu, and what has been written about his father Cogitosus by Dr. Newport White and others, it may be well to point out that *moccu Machtheni* does not

The following examples of the confusion of case-inflexions in Latin inscriptions of western Britain and of the immediately post-Roman period, the fifth, sixth, and seventh centuries, are taken from the paper by Sir John Rhys forming vol. xviii of "Y Cymmrodor." Rhys endeavours to construe most of these instances as correct Latin in concord. His explanations vary; the phenomenon, however, is the same from Selkirkshire to Devonshire, and, in my opinion, admits only of one explanation, namely, that the loss of case-inflexions in the vernacular Celtic speech of Britain led to a corresponding failure to observe the case-inflexions of Latin, which continued to be the traditional language of culture in the same regions. So far as I have observed, no such confusion is found in the Latin of early Irish writings or inscriptions. The Celtic of Ireland, unlike that of Britain, preserved its system of case-inflexion.

P. 5. Hic memoriae et belli insignisimi principes Nudi Dumnogeni hic iacent in tumulo duo filii Liberalis. (*Recte* Nudus [et] Dumnogenus. Nudus, treated as an O-stem, properly has the stem Nudont.)

P. 12. Culidori iacit et Oruuite mulier secundi. (*R.* Culidorus, Oruuita, secunda.)

P. 15. Brohomagli iam ic iacit et uxor eius Caune. (*R.* probably Cauna.)

P. 18. Nonnita Erciliui Ricati tris fili Ercilinci.

P. 21. Barrivendi filius Vendubari hic iacit.

P. 34. Evali fili Denovi Cuniovende mater eius. (*R.* Cuniovenda.)

P. 41. Cantiori hic iacit Venedotis cive fuit consobrino Magli magistrati (five wrong inflexions).

P. 49. Catacus hic iacit filius Tegernacus. (*R.* Tegernaci. Rhys proposes to regard the word as an adjective.)

P. 50. Evolenggi fili Litogeni hic iacit.

P. 51. [Co]nbelini posuit hanc crucem.

P. 55. . . . nicci filius . . . ic iacit securi in hoc tumulo.

P. 59. Latini ic iacit filius Ma[qui Ia]ri.

P. 61. Andagelli iacit fili Caveti.

P. 61. Hic iacit Cantusus pater Paulinus.

P. 65. Drustagni ic iacit Cunomori filius.

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mean "son of Machthene" but member of a sept claiming Machthene for its eponymous ancestor. The name of this sept should have been Dál Machtheni or Corcu Machtheni, but it is not on record. If Cogitosus is based on Machthene, it is not the personal name of Muirchu's father, but rather a latinization of the surname. It may correspond to "(Ultan episcopus) Conchoburnensis" = Ultán moccu Conchobuir of the sept Conchobuirne or Dál Conchobuir. Muirchu (floruit 693-695) is the latest instance known to me of the use of the surname-formula in *moccu*, which seems to have become obsolete about his time.

P. 66. Talori Adventi Maquerigi filius.

P. 70. Advecti filius Guani hic iacit.
Quenatauci ic Dinui filius.
Rugniatio fili Vendoni.
Corbalengi iacit Ordous (= Ordouix).

P. 72. Vitaliani emereto.

P. 74. Dervaci filius Iusti ic iacit.

P. 76. Dobituci filius Evolengi.

P. 79. Boduoci hic iacit filius Catotigirni pronepus Eternali Vedomavi.

P. 82. Fili Cunalipi Cunaci ic iacit.

P. 84. Figulini fili Loculiti hic iacit.

P. 85. Tunccetace uxsor Daari hic iacit.

[As at pp. 12, 15, 34, the genitive in *-e* (= *-ae*) replaces the nominative in *a*.]

P. 88. Brocagni hic iacit Nadotti filius.
Iovenali fili Eterni hic iacit.
Meli medici fili Martini iacit.

P. 89. Cunogusi hic iacit. [Here again, as at p. 5, there is a change of declension. Cunogussus is of the U-declension.]

P. 90. Hic [in] tumulo iacit R . . . stece filia Paternini. [As at p. 85, R . . . stece is probably genitive.]

P. 92. Senacus pr(e) sb(yter) hic iacit cum multitudinem fratrum.

P. 95. Turpilli ic iacit puueri Triluni Dunocati.

P. 96. Carausius hic iacit in hoc congeries lapidum.

The prevalence of the genitive case-ending in the title-name may be ascribed to the influence of the Ogham inscriptions. Professor Macalister has found remains of Oghams accompanying a number of the Latin inscriptions of western Britain, in addition to a few previously recorded. The examples cited above show, however, that the peculiar misuse of case-endings is by no means confined to title-names, and is not to be explained as an imitation of the Ogham formulae. Even if *hic iacet* be taken for an extra-syntactical element and eliminated from the syntax, it is still evident that those who used Latin in almost all parts of western maritime Britain were no longer possessed of a sense of case-inflexion.

Additional Note.—As this paper goes to press, Mr. R. I. Best has drawn attention to a brief notice by the late Professor Kuno Meyer (Zur Keltischen Wortkunde, viii, p. 619, Kgl. Preuss. Akad. d. Wissensch. Sitzungsber. phil.-hist. kl. 1918) on the name Ulaid, with reference to Ptolemy's Οὐλούντιοι and to U(o)loti in Muirchu (Trip. 286, 12), and in the passage above cited from Book of Ballymote, 196*b* 23.

XV.

MANUSCRIPTS OF THE "MODUS TENENDI PARLIAMENTUM" IN THE LIBRARY OF TRINITY COLLEGE, DUBLIN.

By OLIVE ARMSTRONG.

[Read June 11. Published July 31, 1923.]

There are in the Library of Trinity College, Dublin, four manuscripts of the "Modus tenendi Parliamentum." Two of them, E. 4. 5 and E. 3. 18. f. 4, are the "Modus" for England, and two, E. 3. 18, f. 1 and f. 10, that for Ireland.

Of the former, E. 4. 5 is a transcript of the English "Modus" written on parchment at the end of the volume, which consists chiefly of *formulae brevium*, many of which belong to the reign of Edward III. The quaternions are in some places incomplete, but for the last seventy-two pages the work runs consecutively, and is possibly written by one hand. Miscellaneous material immediately preceding the "Modus" is dated 1343, but the character of the writing is probably that of the fifteenth century.[1] The "Modus" has the marks[2] noted by Duffus Hardy as belonging to the earliest known documents. From errors and omissions in the text[3] it is evident that it is a transcript, and from the text itself it would appear that the exemplar from which it was made was written between 1294 and 1327.[4]

It consists of twenty sections, without the customary headings. For the first thirteen of these it follows the arrangement of the MS. in the Bibliothèque Nationale, from which Hardy published his edition. Then follow the sections *De modo, De inchoatione, De praedicatione, De pronuntiatione, De loquela*, and *De absentia Regis*. It breaks off in this last section at the words

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[1] This is the opinion of the Librarian, Dr. Smyly.

[2] MS. T.C.D., E. 4. 5, p. 463, "electi" instead of the "clerici" of later MSS.; p. 464, "*pro* expens*is* du*orum* milit*um* . . . una*m* marca*m* *per* diem"; later MSS. add "now four shillings"; p. 467, "parliame*n*ti debent teneri in occulto loco." In later MSS. the evident error in "occulto" is corrected by the insertion of the missing words. (The correct phrase is found in one early MS—see "Eng. Hist. Rev.," vol. xxxiv, p. 209, *et seq.*); p. 468, the amerciament of a baron is omitted, etc. See Hardy, "Modus tenendi Parliamentum." Lond., 1846.

[3] E. 4. 5, p. 462, in the preamble "successorum" is omitted. In the summons and in the section concerning the clergy the bishops are left out. In that for the laity a whole line is left out, spoiling the sense. The section *De Casibus* is incomplete, breaking off in the middle of a sentence. There are many other inaccuracies in transcript.

[4] See Hardy, pp. viii and xvi.

duobus militibus comitatuum. The sections *De gradibus, De loco, De hostiario, De clamatore, De stationibus, De auxilio, De partitione,* and *De transcriptis* are absent. Generally speaking, the text follows the edition published by Hardy in 1846,[1] although there are many minor differences and omissions.

The second English "Modus," E. 3. 18, f. 4, is bound up with the two for Ireland as the first part of a miscellaneous volume. It is written on paper, and evidently someone called Lumley[2] had some connexion with it, for the name and the initials "L. S. L." appear. The hand in which it is written belongs to the late sixteenth or early seventeenth century.[3] It is not a transcript of E. 4. 5, but is evidently made from one of the later MSS. of the English "Modus." It is of small importance in comparison with the other English transcript, E. 4. 5.

The other two documents are transcripts of the "Modus" for Ireland. They are also written on paper in a late hand. The first of them, E. 3. 18, f. 1, agrees *litteratim* with the Irish "Modus," printed for the first time by Anthony Dopping, Bishop of Meath, in 1692.[4] It also breaks off at the same place as Dopping's edition with the words *cætera desunt in antiquo manuscripto è quô ista desumpsimus.* Now Dopping in the introduction to his "Modus" said that he printed it from a MS. in his possession which had been originally in the Treasury at Waterford,[5] and which he believed was "the very Original Record said by my Lord Cook to have been in the custody of Sir Christopher Preston in the 6th of Henry IV."[6] He thought that there were internal evidences,[7] as well as "the character, ink, and parchment," which proved it "to have been composed and transcribed in the reign of King Henry II." His son showed the MS. to Molyneux, who testified to its "venerable antient appearance."[8] This MS., which would be of the highest value, cannot now be found,[9] but it is evident that the transcript before us was made from it, and

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[1] Hardy, "Modus tenendi Parliamentum." The "Modus" was published from the same text by D'Achery, Spicilegium, p. 557 (see "Eng. Hist. Rev.," as above).

[2] MS. T.C.D., E. 3. 18, f 4, "Lumley," at the foot of the page, f. 9.v. "L.S.L."

[3] Monck-Mason, "MS. Catalogue of Manuscripts in Trinity College, Dublin," about the year 1600.

[4] Dopping "Pamphlets," No. 4.

[5] Harris's Ware, "Antiquities," p. 86. Sir R. Bolton (c. 1644) saw exemplification under Great Seal of Statutes not in the Rolls, which were in the Treasury of Waterford.

[6] *Recte* Hen. V.

[7] (1) *Conquestor Hibernie*, a title proper only to Henry II, (2) the mention of the four Irish Archbishops who had received their palls just before the invasion, (3) *procurator terre*, the style of the chief governor in the reign of Henry II, disused later, (4) the provision for choosing a justice in the absence of the king or procurator, exercised after Strongbow's death.

[8] Molyneux, "Case of Ireland," p. 36.

[9] Major Dopping-Hepenstall, the present representative of the family, has not got it.

that the *antiquo manuscripto* referred to was the document in the Treasury at Waterford, later owned by Dopping and seen by Molyneux. Dopping's contention that his MS. dated from the time of Henry II cannot be upheld, for both the edition he printed and the transcript before us contain the *praemunientes* clause, which is evidence that it is no earlier than 1294, and the payment of knights, which limits its modernity to 1327.[1] These may, of course, be interpolations, as it is evident that such were made from time to time; but in this, its earliest known form, the Irish "Modus" belongs to the late thirteenth or early fourteenth century. It is simply an abridged edition of that for England fitted to Ireland, with two clauses added, which do not appear in any other document. They are as follows:—

De Consiliis. Ac etiam Rex vult quod eadem forma in Consiliis p*er* summonic*io*nem facta*m* observetur, excepto quod p*ro* Rege et legibus in ipsis Consiliis erunt ordinaciones in parliamento vero statuta.

Constitutio Justic*iarium* in Hib*er*nia. Ac etia*m* Rex vult ut absenc*e* reg*e* a dict*a* terr*a* sine procuratore eiusd*em* terr*ae* quocunq*ue* alio nomine censeatur[2] (here the MS. breaks off, as above).

The second Irish "Modus," E. 3.18, f.10, also on paper, was written between the years 1597 and 1629.[3] It occurs in a transcript of an exemplification of documents found with Sir Christopher Preston by Sir John Talbot, Lieutenant of Henry V.[4] Its authority is vouched for in a note at the end: "This is a true copie of y^e exemplificacion under y^e greate Seale of Ireland remayning in y^e handes of S^r Ro: Cotton, Knight. Dan: Molyneux, Ulster Kinge of Armes." The first document in the exemplification is the "Modus" for Ireland. It closely follows the transcript examined above, but with this important difference, that whereas the last provision (that for providing a governor) is incomplete in the former, in this it is perfect. It is as follows:—

Et etia*m* Rex vult ut absente rege a d*icta* terra [sine][5] procurator[e] vel gubernator[e] ejusd*em* terr*ae* quo-

And also the King wills that, in the absence of the King from the said land without a procurator or governor of the

He suggested that it might have passed to another branch or have been sold in 1849 or 1851. Inquiries have been made, but no trace can be found. The MS. was not in the Record Office before it was destroyed, nor is it in the Library of Trinity College or that of the Royal Irish Academy.

[1] Hardy, "Modus," pp. viii and xvi.

[2] E. 3. 18, f. 3.

[3] Molyneux, under whom it was transcribed, was Ulster King of Arms from 1597 to 1629.

[4] See below, p. 263, note 7.

[5] The square brackets [ ] enclose the corrections of Molyneux, Ulster King of Arms. The word for which "sine" is substituted would appear to be "summ*us*."

cunque alio nomine senciatur p*er* ipsum Rege*m* constitutus[1] (sic) quod stat [im] . .[2] celeritate concilium*m* Regis ib*idem* mittat*ur*[3] pro Archiepis*copis* Epis*copis* Abba*tibus* priorib*us* comi*tibus* Baronibus et eorum paribus aliisq*ue* p*r*oceribu*s* et discretis viris ad nimis p*roximum* tr[i]um com*itatuum* p*r*ox [*imorum* ubi] festin*an*tius convenire possint[4] ad certum brevem diem et locu*m* cura*e*[5] ipsis essend*um* ad tractand*um* consulend*um* et consenciend*um* . . .[6] Justic*iario* Regis t*er*ra*e* Hib*er*ni*ae* qui vices Regis ut d*omin*us Hib*er*ni*ae* in no*min*e ipsius Regis in omnibus supplebit, super quo [statim][7] concilium Regis p*rae*dictu*m* sub magno sigillo Regis t*errae* praedict*ae* Justic*iarum* Hib*er*ni*ae* constituatur (sic) t*er*ram p*rae*dicta*m* in omnibus no*min*e Regis justificando.[8] Hanc formam Rex vult ut in t*er*ra sua Hiberni*ae* in omnibus . . . observetur.

said land by whatever other name he may be known, having been appointed by the King himself (that) straightway . . . . (with) haste the council of the King there shall be summoned for (i.e., to consist of) the Archbishops, Bishops, Priors, Earls, Barons, and others their peers and the nobles and discrete men to the very nearest of the three adjacent counties where the more quickly they can come, on a certain immediate day and at a place which they must decide upon, for deliberating, taking counsel, and agreeing (concerning) a Justiciar of the King for the land of Ireland, who shall supply in all things the offices of the King as Lord of Ireland, on which straightway the aforesaid council of the King under the Great Seal of the King for the aforesaid land may appoint him Justiciar of Ireland for governing the aforesaid land in all things in the name of the King. The King wills that in his land of Ireland this form may be observed in all things.

This was the customary procedure in a voidance. Dopping believed that it was exercised as early as Strongbow's death. However that may be, it is referred to in the Rolls of Parliament in the time of Richard II as a statute of Henry fitz Empress (Henry II).[9]

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[1] The correction to "constituto" may have been overlooked by Molyneux. His former corrections would, most naturally, require it.

[2] Since working on this MS. I have found that Hakewill made a transcript of the exemplification, which is published in Steele's "Tudor Proclamations." I have compared this and noted any variant readings. In this case he supplies "cum."

[3] Hakewill's transcript, as edited by Steele, p. cxci, "mittat."

[4] This Steele edits as "ad minus comitatus proximi, ut festinius convenire possint," which does not seem to yield sense.

[5] Steele, "coram."

[6] Steele, "cum." This would mean that they took counsel with the Justiciar, which would be impossible when they were meeting to appoint him.

[7] "Statim" originally appeared after "concilium."

[8] Steele, p. cxci, "justiciandum." In a foot-note he states that Hakewill's transcript reads "justificandum." This was the word in use in late Latin, and was not a mistake on Hakewill's part.

[9] Harris's Ware, "Antiquities," p. 79.

Immediately following the "Modus" is a provision for its custody:—

Et quod in custodia Archiep*iscop*i Casselen*sis* tanquam in medio t*err*ae hoc script*um* populo ejusde*m* te*rr*ae remaneat custodiendo.[1]

And that in the keeping of the Archbishop of Cashel since (it is) in the midst of the land, this writing for the people of the same land may remain for keeping.

Then follows the oath to be taken by the Custos:—

Constitutus a Rege custos suus t*err*ae Hibe*r*niae quocunq*ue* no*min*e scenciatur tactis sacrosantis evangeliis hoc sacrame*ntum* pr*a*estet coram Cancellario[2] consilio et . . . custodiet Deo et populo t*err*ae Hibe*r*ni*a*e leges lib*er*tates et custumas[3] rectas quas antiqui Reges Angli*a*e p*rae*decessores Regis nunc, et ip*s*e Rex, Deo et populo Angli*a*e et te*rr*ae Hibe*r*ni*a*e concesserunt. Et quod observet (sic) Deo et sanctae Eccl*es*i*a*e clero et populo pace*m* et concord*iam* in Deo integriter[4] secundum potestate*m* suam. Et quod f[ier*i*][5] . . . in omnibus judiciis [judicibus] suis *a*equa*m* et recta*m* justitia*m* cu*m* discretione miserecordia et veritate. Et quod tenebit et custodiet rectas leges et custumas quas populus t*err*ae elegerint[6] (sic) sibi [esse] tenendas et ipsas defendere et fortificare debet ad honore*m* Dei pro posse suo. Et memorandum quod hoc juramen*tum* . . . est a juramento Regis Angliae. Et accepto juramen*to* investitur . . .[7] Justiciarium potestate sibi concessa: [et non antea finitur].

He who is appointed by the King his custos of the land of Ireland, by whatever name he may be known, having touched holy books, shall take this oath before the Chancellor, Council and . . . he will keep for God and the people of the land of Ireland the laws, liberties, and right customs which ancient Kings of England, predecessors of the present King, and the King himself have granted for God and the people of England and of the land of Ireland. And that he will observe for God and holy church, for clergy and people, peace and concord wholly in God according to his power. And that he (will cause) to be done in all his suits equal and right justice with discretion, mercy, and truth. And that he will hold and guard right laws and customs which the people of the land shall have chosen to be kept by him, and that he ought to defend and stablish them to the honour of God, for his own power. And note that this oath is (taken) from the oath of the King of England. And having taken the oath, he is invested Justiciar with power granted to him, and not before is the ceremony finished.

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[1] Steele, p. cxci, "hoc scriptum populo ejusdem terre custodiendum."

[2] *Ibid.*, "cancellario" is omitted.

[3] This was written "custumias."

[4] Steele, "pacem in Deo integram."

[5] In the margin "fieri faciat."

[6] Steele, p. cxci, "elegerit." "Fœdera," ii, p. 36, "quas vulgus elegerit." Brady, in "Glossary," "have already chosen"; Prynne, "Sovereign Power of Parliament" shall choose (Stubbs, "Constitutional History," ii, p. 331, note 4).

[7] Illeg., Steele, "juratus."

This very oath is known to have been sworn by the custos in 1462.[1] As stated above, it is taken from the oath of the King of England. On examination we find that it was not the form sworn by Richard I, John, or Henry III,[2] and that, while it resembles the accredited oath of Edward I, it is almost identical with that sworn by Edward II in catechetical form.[3] This connexion with the reign of Edward II is strengthened by the fact that this very catechism appears next in the transcript. It closely resembles the catechism of the "Liber Regalis"[4] of the English Kings. Of this work there are two versions, one belonging to the time of Edward II and one to that of Richard II. The catechism here given is that of Edward II, as is shown by the short rubrics. It was written on a separate roll of papyrus and found at the same time with Christopher Preston by Sir John Talbot. It was evidently exemplified with the "Modus" as complementary to its latter part. The Custos was to be bound by all the undertakings of the King. The catechism is as follows:—

Metropolitanus electu*m* mediocriter distinctaq*ue* interroget voce,[5] si leges et consuetudines ab antiquis Regib*us* plebi Anglor*um*[6] concessas cu*m* sacramenti confirmac*io*ne eidem plebi concedere et serva (sic) voluerit, et p*rae*sertim leges et consuetudines et libertates a gloriosiss*imo* Rege et sancto Edward*o* clero populoq*ue* concessas. Si[7] autem omnibus hiis assentire se velle promiserit exponat ei Metropolitanus ita dicendo. Servabis eccl*esiae* Dei cleroque populo pacem ex integro et concordia*m* inde (in Deo?) secundu*m* vires tuas? respondebit, Servabo. Facias[8] fieri in omnib*us* judiciis tuis *a*equa*m* et recta*m* justiciam et discretionem in miserecordia et veritate secundum vires tuas? respondebit, facia*m*.

The Metropolitan shall ask him with moderation and in a distinct voice if he is willing to grant and guard for the same people the laws and customs granted to the people by ancient Kings of the English with the confirmation of an oath, and especially the laws and customs and liberties granted by the most glorious King and Saint, Edward, to clergy and people. Now if he shall have said that he is willing to agree to all these things the Metropolitan shall put the matter to him, speaking thus: Wilt thou preserve for the church of God, for clergy and people, peace and concord wholly (in God?) according to thy power? He shall reply, I will keep them. Wilt thou cause to be done in all thy suits equal and right

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[1] Rot. Pat. Hib., 1 Ed. IV, No. 62.

[2] Stubbs, "Constitutional History," vol. ii, pp. 18, note 1 and 331.

[3] "Fœdera," ii, p. 36.

[4] Wickham Legg, "English Coronation Records," p. 81.

[5] This is a shortened form of the rubric in Liber Regalis, temp. Ed. II (Legg, p. 87).

[6] Steele, "ab antiquo a regibus Anglorum"; Liber Regalis, "ab antiquis justis et deo devotis regibus plebi Anglorum."

[7] This is the rubric of Liber Regalis, temp. Ed. II.

[8] Steele, p. cxci, and Liber Regalis (Legg, p. 87), "Facies."

Concedis justas leges esse . . *per* te esse[1] *protegendas* et ad honore*m* Dei roborandas quas vulgus eligit[2] secundu*m* vires tuas? Respondebit, concedo et promitto.

justice and discretion in mercy and truth according to thy power? He shall reply, I will do so. Dost thou grant that the righteous laws which the people choose are to be (held) and by thee to be guarded and strengthened to the honour of God, according to thy power? He shall reply, I grant and promise.

Then follows the admonition of the bishops on behalf of the church. This does not appear in the "Liber Regalis" of Edward II, but is found in that of Richard II.[3]

Sequitur admonitio Ep*iscoporum* ad Regem et legatur ab uno Ep*iscopo* cora*m* omnib*us* clara voce sic dicendo. D*omi*ne Rex, a vobis pe*r*donari petimus ut unicuiq*ue* de vobis (*marg.*, nobis)[4] et eccl*esi*is vobis[5] . . . (*marg.*, com*mis*s*is*) privilegiu*m* ac debita*m* legem atque justitia*m*[6] concervetis (sic) et defens*i*o*n*em exhibeatis, sicut Rex in suo regno debet unicuiq*ue* suo Ep*iscop*o Abbat[ibus] (sic) et eccl*esi*is sibi com*missis*. Respondebit, animo libent*i* et devoto p*ro*mitto[7] vobis et perdonoq*ue* unicuiq*ue* de vobis et Eccl*esi*is vobis com*m*issis canonicu*m* privilegiu*m* et debita*m* lege*m* atq*ue* justic*iam* servabo et defensione*m* quantu*m* potero adjuvante Deo [D*omi*no] exhibeo (sic), sicut Rex in suo Regno unicuiq*ue* Ep*iscop*o Abbat*i* et eccl*esi*is sibi com*missis* *per* rectu*m* exhibere debet.

The admonition of the bishops to the King follows, and is read by one bishop in the presence of all in a clear voice, thus: Lord King, we ask it to be freely granted by you that for each one of (us) and for the churches (committed) to (us) . . . privilege and right law and justice you will keep and defend, as the King in his realm ought to do for each of his bishops and abbots and for the churches entrusted to him. He shall reply: With a mind willing and resolved, I promise you and grant it freely, and I will keep for each one of you and for the churches entrusted to you canonical privilege and right law and justice, and I will defend you, as much as in me lies, to the glory of God as the King in his realm ought rightly to do on behalf of each bishop, abbot, and the churches entrusted to him.

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[1] Steele, "Concedes justas leges per te esse," etc; Liber Regalis, "Concedis justas leges et consuetudines esse tenendas et promittis eas per te esse," etc.

[2] Steele, "elegit"; Liber Regalis, "elegerit."

[3] Wickham Legg, "English Coronation Records," p. 87.

[4] These emendations are in the hand of the scribe, not Molyneux.

[5] Liber Regalis, "nobis."

[6] Steele, p. cxci, "debitam legum justitiam."

[7] Steele, "promitto vobis perdonoque unicuique," etc; Liber Regalis, "promitto vobis et perdono quia unicuique," etc.

The King swears these things at the altar, and the ceremony concludes with the reciprocal oath of fealty.

Adjiciantur *prae*dictis interrogationib*us* quae infra[1] fuerunt[2] pronuntiatis omnibus supradictis dictus princeps conservet[3] (*marg.*, concedet forte) se omnia *prae*dicta observaturu*m* . . . .[4] altare cora*m* cunctis protinus pr*ae*stito. Rege itaque in solio suo taliter collocato pares regni . . . (*marg.*, Domin*um*)[5] Rege*m* undiq*ue* circumstantes manibus pala*m* extensis in signu*m* fidelitatis offerent se ad dicti [Regis et] dictae coronae sustentatione*m*.

There may be added to the aforesaid questions those things which were below. The aforesaid propositions (having been put) the said prince may grant that he will observe all the aforesaid, taking (the oath) forthwith (upon) the altar in the presence of all. Thus, the King having been in this manner established in his realm, the peers of the kingdom surrounding the King on all sides with their open hands extended in sign of their fealty shall proffer themselves for the sustenance of the said King and crown.

The transcript concludes:—

In cujus rei testimoniu*m* has l*itt*eras nostras fieri fecimus patentes. Teste *prae*fato locu*m* n*ost*rum[6] tenente apud Trym 12° die Januarii an*no* regni n*ost*ri 6.[7]

P*er* ips*um* locu*m* tene*nt*e*m* et co*n*siliu*m*.

Ex*plicatur* per Jo*hann*em . . . . (margin, passant)[8] et Will*ielmum* Sutton, cl*er*icos.

In testimony of which we have caused these our letters patent to be made. Witness our aforesaid Lieutenant at Trim on the twelfth day of January in the sixth year of our reign.

By the Lieutenant himself and the Council.

Set forth by John . . . . (Passant) and William Sutton, clerks.

To sum up, of the four MSS. of the "Modus" examined, two relate to England and two to Ireland. Of the former, E. 4. 5, is a parchment transcript, bound up with material of the fourteenth century, but probably written in the fifteenth. It is made from an exemplar which was written between 1294 and

[1] Liber Regalis, "justa"; Steele, "justa."

[2] Liber Regalis, (Edward II,) "fuerunt; (Richard II,) "fuerint." Steele, "fuerint."

[3] Liber Regalis, (Richard II,) "confirmet."

[4] *Ibid.*, "sacramento super altare."

[5] *Ibid.*, "dictum."

[6] Steele, "nostro."

[7] MS., T. C. D., E. 3. 20. Annals ascribed to Marlburgh. "1418. 26 die Junii *prae*hensi sunt apud Clane comes Kildarie et dominus Christoferus Preston et *dom*inus Joannes Bedlow et positi sunt in castro de Trim." The opening words of the MS. also prove that the reign was that of Henry V (1418), "Henricus Dei grat*ia* Rex Angl*iae* et Franc*iae*," etc.

[8] Steele, p. cxci, "Parsant." John Passavant was Clerk of the Hanaper, 1 Henry VI. William Sutton was Clerk of Common Pleas, 5 Henry IV; temporary Keeper of the Rolls, 9 Henry VI; Clerk of Hanaper, 13 Henry VI (Steele).

1327. The second, E. 3. 18, f. 4, is a paper transcript of the early seventeenth century, not made from E. 4. 5, but from some later document. Of the two MSS. of the Irish "Modus," E. 3. 18, f. 1, is a paper transcript of the sixteenth century, made from an old MS. owned in the late seventeenth century by Dopping, Bishop of Meath. This MS. cannot now be found. The second Irish "Modus" E. 3. 18, f. 10, also on paper, and written between 1597 and 1629, occurs in a transcript of the documents exemplified by Henry V at Trim. The "Modus" then exemplified would appear to be Dopping's MS. before it was mutilated. Thus from these two transcripts of the "old MS." certain conclusions can be drawn. It is the earliest document of the "Modus" for Ireland known to have been in existence. Although now lost, copies of it remain, among them these two transcripts in Trinity College. Dopping's contention that it belonged to the reign of Henry II cannot be supported. From an examination of these transcripts it is evident that the original is no earlier than documents of the English "Modus" already known, i.e. it lies between 1294 and 1327. This would place it possibly about the reign of Edward II.[1]

This presumption is strengthened by the fact that the oath of the king of England, which was exemplified with it in the reign of Henry V, follows the form of the oath of Edward II found in the "Liber Regalis" of that reign.

Although this early MS. cannot now be found, its migration through Ireland can be traced. It was first deposited at Cashel[2] in the custody of the Archbishop. Thence it passed to Clane,[3] in Co. Kildare, where it was found with Sir Christopher Preston and brought to Trim[4] to be exemplified in 1418. Then it seems to have been mutilated and, when in that condition, transcribed in the sixteenth century.[5] It is next heard of in the Treasury at Waterford[6] about 1670. Thence it came into Meath to Bishop Dopping's hands in 1692. Finally, the last record of it is its perusal by Molyneux at Dublin in 1698.[7] Since then it seems to have disappeared. Until it is found, these two transcripts in Trinity College must remain the earliest known MSS. of the "Modus" for Ireland.

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[1] Recent inquiry assigns the English Modus in its earliest known form to the reign of Edward II ("Eng. Hist. Rev.," vol. xxxiv, p. 209 *et seq.*) or to the constitutional crisis of 1386 (Round, "Commune of London," pp. 317-18).

[2] See above, p. 260.

[3] E. 3. 18, f. 11.

[4] MS., E. 3. 18, f. 10.

[5] *Ibid.*, f. 1.

[6] Dopping Pamphlets, No. 4.

[7] Molyneux, "Case of Ireland," p. 36.

XVI.

ANCIENT IRISH LAW.

THE LAW OF STATUS OR FRANCHISE.

By EOIN MacNEILL, D.Litt.

[Read April 9. Published December 17, 1923.]

The most distinctive feature of ancient Irish law is the law of status. To the minds of the Irish jurists this law was the most important part of their jurisprudence. The chief collection of the oldest written laws was the compilation called *Senchus Már*. It is cited by name in Cormac's Glossary, and the writing of the tracts comprised in it, if not their collection under a single title, can be dated in the seventh century. An introduction to the collection, written in Old Irish, has been preserved, and in this introduction there is a statement of the contents of *Senchus Már* (I, 40).[1] From this statement it will be seen that *Senchus Már*, when the introduction was written, began with a tract on the law of status. The rest of its contents are still found in the order stated in the introduction, but the tract on status no longer appears in the extant version, its place at the beginning of *Senchus Már* being now taken by the long and elaborate tract on *athgabál* (procedure by distraint), of which there is no mention in the old statement of contents, and which therefore did not probably form part of *Senchus Már* as originally compiled. There can be little doubt that the tract on status which formed the first section of *Senchus Már* was that which now bears the title of *Uraicecht Becc.*[2] The opening sections of this tract were obviously designed as a proem to a *corpus juris*, and the accompaniment of gloss and commentary shows that the tract, in the tradition of the law schools, possessed the authority of the oldest writings on Irish law. It will be seen that the law of status, as interpreted by the jurists, before the writing of this tract, at the time of writing, and afterwards, was

[1] Citation by the Roman numeral has reference to the published volumes of "Ancient Laws of Ireland." The translation given in these volumes will be cited as "the official translation."

[2] This, to be cited as UB, is the first tract in vol. v.

subject to great variation in detail. Between the statement of the grades of status in UB and the statements in later commentaries there is no practical correspondence. This, perhaps, may explain why the tract on status disappeared from the beginning of *Senchus Már.*

The distinctive attribute and the measure of free status was "honourprice," called *lóg enech*, rarely *enechlann*, in the oldest tracts, always *enechlann* in the later writings. Most of the provisions of the law are such, or are so dependent upon other provisions, that the element of honourprice entered into almost every operation of law. Only one way in which a person's honourprice could be determined was known to the jurists, namely, by assigning the person to a particular grade to which, in the doctrine of the law, a particular honourprice had already been assigned. Hence it is to be understood that, however artificial the classification in grades may appear, and whatever variations it may present in different documents, this classification was no mere matter of juristic theory, but was an actual and important factor in the everyday practical working of the laws.

One of the most obvious characteristics of ancient Irish law is that it is the law of a limited and privileged class. It is so in its form and operation and in the theory of the jurists, its accepted teachers and custodians. The writer of UB says that Irish jurisprudence is based upon the class called *nemeth*, and the various ancient tracts never weary of repeating that the doctrines and rules of law which they enunciate are derived from the usage of the Féni.

Nemeth is the Old-Irish form of the older Celtic adjective *nemetos*, meaning "holy" or "sacred." In the process of transcription, *nemeth* has taken the later form *nemed*. The dative plural *nemthib* and the derivatives *nemthius, nemthenchus, nemthigud*, preserve the older consonant, and the interesting collection of glosses on the word in O'Mulconry's Glossary, evidently collected in part from a version of UB or some closely similar law tract, shows that the glossators had the form *nemeth* before them. It will be seen from UB that the term *nemeth* comprises all persons of free status. The association of free status with "holiness" dates from heathen times. Indeed *nemeth* in the sense of "holy" rarely enters into the vocabulary of Irish Christian literature. We can hardly doubt that freemen were "holy" in the sense of being qualified to participate in public religious rites. Caesar tells how those who refused obedience to the judicial decisions of the Druids were excluded by them from the sacrifices, and how this exclusion involved the loss of *jus* and *honos*. So (V 174) the Irish jurists, who held their function in unbroken succession to the Druids, declare that "the noble who does not yield judgment or due to man is not entitled to judgment or due from man," and "is not entitled to honourprice."

As Meyer, in his introduction to "Fianaigecht" (Todd Lectures, ser. xvi), has shown, Féni was at one time a distinctive racial designation. So is Góidil in that section of Irish literature which discriminated between the traditional race-elements of the people of Ireland. The two names were understood to be synonymous:

Féni ó Fénius as berta   bríg cen dochtai
Góidil ó Goidiul Glass garta   Scuitt ó Scottai.

"Féni from Fénius they were named, without strain of meaning; Góidil from Góidel Glass they were called, Scots from Scotta." My view is that Góidil was a byname, which came into use at a relatively late time, and that it was probably adopted from Cymric as Scotti was adopted from Gallo-Latin; further, that both names originally designated the Irish raiders who infested the coasts of Britain and Gaul, Scotti meaning "raiders," and Góidil "wild men," from old Cymric *guid*, Welsh *gwydd*, the Irish equivalent being *féd*, *fíad*, < * *védos* "wild." Féni, like Góidil, denoted specifically the dominant Celtic race-element. For their doctrines and rules, the jurists claimed, not their own authority, but the authority of the Féni. Already in UB, the term *bélre Féne* "the speech of the Féni" denotes the archaic diction of Irish law, but in UB and throughout the later juristic writings, the Féni are no longer a race, they are a class, the class of landed freeholders. These are the typical and normal freemen who hold the franchise of Irish law. To their franchise are admitted, in virtue of calling, churchmen, men of secular learning, men of the arts and crafts that were recognized to be "liberal." The body of ancient law was called *Fénechus*, "the usage of the Féni."

There is evidence of an early legal classification of the Féni in three grades, *rí*, *aire febe*, *bóaire*—king, noble of worth, noble of kine. This classification is found in certain provisions of the law of fosterage, stated in the Commentary, II 146, 148–150, 192. At II 146, the grades are named *rí*, *aire*, *aithech*—king, noble, client. *Aithech*, connected with *ath-fen*, "repays," *aithe*, "repayment," is synonymous with *céle* in this word's special meaning of a freeman who enters into a contract with a noble to receive capital (*rath*) and render food-provision and services in return. Though a *bóaire* might remain uncontracted in this way, it is abundantly evident that the *céli* or *aithig* were all of the *bóaire* class, and that most of this class became *céli*. All the Féni who had sufficient property were of the class of *aire* or noble. In fact, the Féni were the nobility. At II 148–150, the same classification is given under the terms *rí*, *aire*, *grád Féne*—king, noble, grade of the Féni. At II 192, the "chattels of maintenance," given by a foster-father to a fosterson to secure maintenance in old age, are on a threefold scale: one rate for the son of a king; another for the son of a ruling noble, from *aire forgill* ("noble of superior testimony") down to *aire etir dá airig* ("noble between two nobles," i.e. between the grade of ruling noble and the grade of *bóaire*); the third for a son of a non-ruling noble, from *bóaire* to *fer midboth.* At V 286, the ancient text divides the nobles into two classes, *aire febe* and *bóaire,* and the gloss at V 290 defines *airig febe* by *na gráid flatha,* "the grades of rule" (or "of rulers"). At V 382 seqq., the ancient text has three grades, *rí, aire febe, bóaire* and *ócaire* together. At V 396, the ancient text has three grades: king and *aire forgill* together, every *aire* from *bóaire* to *aire forgill, bóaire* and *ócaire* together. The gloss, V 398, has *Airechaib febe .i. na graid flatha uile ; is aire feibe gach aire o boaire gu rig*—"nobles of worth, i.e. all the grades of rulers; every noble from *bóaire* to king is a noble of worth." At V 398–400, the ancient text has three grades: *rí, aire febe, ócaire* and *bóaire* together. At V 402, the ancient text has three grades: *aire forgill, aire febe* "from *aire etir da airig* to *ard-airig,*" *bóaire* and *ócaire* together. At V 412, the ancient text has: king, *aire febe* = "every noble from king to *aire etir da airig,*" *bóaire* and *ócaire* together. The same classification is repeated at V 414, 416 (twice), 418, each time in the ancient text. Certain discrepancies can be noted in it, such as the inclusion of *aire forgill* in one class with the king and elsewhere with the *aire febe.* These may be ascribed to variant attempts to adjust an earlier to a later classification.

With the establishment of Christianity, the men of native learning abandoned the designation of Druid, closely associated with heathen belief and practice, and became afterwards known as *filid.* In UB, the Druid, then probably a mere sorcerer, takes rank with craftsmen. The *filid* rank equal in status to the nobles. To this higher status, the clergy also were admitted. Crith Gablach[1] may well be historically correct in saying that the existence of seven orders in the clergy gave rise to a sevenfold classification of civil grades. In confirmation, we may note that the early law tracts have already adopted *grád* as a technical name for a grade of civil status. *Grád,* from Latin *gradus,* in ordinary usage, even to the present day, means "holy orders" or any grade of holy orders.

There is evidence that, in the first expansion of the civil grades from three to seven, the seven civil grades comprised all persons entitled to exercise franchise by voice in court or assembly. This is the classification which CG recognizes as existing in the tradition of the Féni—*a dligiud Fénechuis,* "by right of Féni-law." The seven grades were *fer midboth, bóaire, aire désso, aire ardd, aire túise, aire forgill,* and king. The bishop and the master *fili* (*ollom*

[1] This tract (vol. v) is cited *infra* as CG.

filed) are equal in grade to the king, and remain so in later developments of classification. The *fer midboth* was *macc beoathar*, "son of a living father," who had certain rights to franchise, but was not wholly *sui juris*. The terminology bears testimony to gradual development. *Aire désso* means "noble of a *déis*." *Déis*, according to CG, implies the whole authority of a ruling noble. In a more limited sense, it means his collective body of subject persons. This is probably the older meaning, exemplified in the names of certain population groups, *Dési Breg*, *Dési Muman*, *in Déis Becc*, *in Déis Túaiscirt*. *Déis*, *i.e.* *ferann*, "land," given in some glosses, shows the same transference of sense as is exemplified in *tuath*. The distinction between *bóaire* and *aire désso* or *aire febe* is this, that, while both were landowners, the status qualification of the *bóaire* consisted mainly in the possession of cattle, that of the *aire désso* or *aire febe* in the possession of authority over *céli* or *aithig*, contractual clients, who collectively formed his *déis*. *Aire désso* must have originated as a generic name for the whole class of ruling nobles. The names of the higher nobles were obviously adopted with a view to further differentiation, *aire ardd*, "high noble"; *aire túise*, "first noble"; *aire forgill*, "noble of superior testimony." We have actual evidence of the gradual establishment of a recent terminology. In UB, the *aire ardd* is of higher grade than the *aire túise*; in the other tracts, the positions are reversed.

By the time when the laws came to be written, about the middle of the seventh century, a further stage of classification had been reached. The ruling nobles were now divided into seven grades, exclusive of the *bóaire* class. This is the doctrine of UB, and it became the traditional doctrine of the law schools, for the glosses and commentaries use the terms *grád flatha*, "order of government," and *grád sechta*, "sevenfold order," applying both indifferently to the grades of ruling nobles collectively; to all others of free status they give the collective name *grád Féne*, "order of the Féni." In this terminology, the plural, *gráid*, *gráda*, *grádaib*, is sometimes used.[1]

To eke out the number seven, UB introduces a higher grade of king, *rí ruirech*, and, above *aire désso*, a grade of noble, *aire échta*, "noble of death-deeds." CG, though it recognizes three grades of king, does not admit them to the sevenfold classification. It makes up the seven grades by introducing, below the king, the *tánaise ríg*, "second to a king," "whom the *tuath* expects to succeed the king." CG also admits, to make up the number seven, the grade

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[1] See I 43 gloss—*grad flatha . . . grad Feine*; I 55 gloss—*graid flatha*; I 61 commentary—*na secht ngraidh flatha*; I 62 comm.—*do gráidaibh Feine . . . do gradhaibh flatha*; I 96, gloss—*uasalnemid .i. gradh seachta*; I 112 gloss—*nemthib .i. grad flatha*; I 112 comm.—*na graidh Feni . . . na graidh flatha*; I 116 comm.—*grad Feine . . . gradh flatha*; and so passim.

of *aire échta*, but where it treats of this noble afterwards in detail, it assigns him no distinctive honourprice, and says expressly that "his retinue and sick-maintenance are due as those of an *aire désso*." Generally in the early law tracts, there is no distinct grade of *aire échta* and only one legal grade of king. This is the doctrine of *Cáin Iarraith*, vol. ii; of *Cáin Aicillni*, vol. ii; of *Cáin Lánamna*, vol. ii; of *Corus Bésena*, vol. iii; of *Bretha im Fuillema Gell*, vol. v. On the other hand, instead of *aire échta*, but below *aire désso*, the text of the last-named tract has the grade of *aire etir dá airig*, apparently the equivalent of the *fer fothlai* of CG, a *bóaire* who has acquired clients, but not in sufficient number to give him the rank of *aire désso*, and who is thus "a noble between two nobles."

It is clear from these variations that, in the time of the ancient tracts, the classification of the ruling grades was in course of development and had not settled down into commonly accepted doctrine. The same is true of the non-ruling grades. UB makes out seven of these by including three grades of boys under age, a grade of *fer midboth* not wholly *sui juris*, a grade of *mruigfer* "landman," and two grades of *bóaire* or *ócaire*—terms which in this tract appear to be synonymous. The three grades of young boys, *inol*, *flescach*, *garid*, are found in no other early text. CG has eight grades of *bóaire*. In these, the *mruigfer*, inferior in UB, is superior to the *bóaire*. The *fer fothlai* and the *aire coisring* of CG are found in no other early text.

The glosses and commentaries show consistent evidence of a still later expansion and adjustment of grades. In them, we find distinction of three grades of *fer midboth*, three of *ócaire*, three of *bóaire*, one of *aire etir dá airig*, *aire désa*, *aire ardd*, *aire túise*, three grades of *aire forgill*, and four grades of king—the king of one *tuath*, the king of a great *tuath* (a group of *tuatha*), the king of a fifth or "province," and the king of Ireland. Such a multiplication of grades was perhaps a natural result of the exposition of the law in writing and its development by a class of jurists who were fond of meticulous distinctions.

Honourprice was the valuation of the freeman's status, not a valuation for life or for a year, but a valuation of the power and effect of his status at any given time. When a freeman entered into a contract of *aicillne* to a ruling noble, becoming his *dóerchéle*, or subject client, he received, in addition to an amount of capital (*rath*) which varied according to his grade, his honourprice in the form of *séoit turchluithi*, "recoverable chattels." In other words, he made a sale of his status to his lord (*flaith*), and transferred to him his franchise. The lord acquired the power of judgment (*ríar*) over him and acted on his behalf in court and assembly. The client could separate from the lord and recover his franchise upon terms prescribed by law. Wrong done to a freeman incurred payment of the whole or part of his honourprice, in addition to material restitution (*aithgin*). Any mulct in excess of equivalent restitution is called *díre*, "off-payment." The corresponding verb is *di-ren*, "pays off." Hence, in the tracts on status, *díre* is frequently used instead of *lóg enech* or *eneclann*. A man's honourprice was also the measure of the extent to which he could become surety, so that his liability as surety, in case of his default or inability to pay, should become chargeable on his legal kin. In litigation, the extent to which his oath or testimony was valid was in some way measured by his honourprice.

The principal early texts on the subject of status are *Uraicecht Becc* (V) and *Crith Gablach* (IV). The development of the subject in UB confirms the inference, drawn from the presence of gloss and commentary, that this text belongs to the series of the oldest written law tracts. These are characterized by an easily recognised style and manner of treatment which mark the transition from the mnemonic oral teaching of the older schools to the exposition of legal doctrine by jurists accustomed to the writing of prose. CG, on the other hand, shows a more developed prose style with long consecutive paragraphs which were not written to be memorized and are only slightly reminiscent of the mnemonic method of teaching. Meyer dates it in the eighth century. The genitive *aireg* (IV 320, 24), and its scribal disguise in *airig* (308, 26; 310, 4, 16), which later becomes *airech*, may indicate a date as early as the close of the seventh century—cp. Adamnan's *Fechureg*, which is represented in oghams by VECREC and VEQREQ.[1] No gloss or commentary accompanies CG.

I give in translation only tracts and detached articles which date from before the Norse invasions, omitting and using only for explanation the glosses and commentaries of later date, my aim being to exhibit the evidence of the early documents on the laws and institutions, the social and economic conditions, of a definite period. Many modern writers on the subject of ancient Irish law have failed to observe that the extant material covers about a millennium and contains abundant evidence of change, of growth and decay, in laws and institutions.

It is to be borne in mind that, while the same laws were held to be applicable over the whole of Ireland, each *tuath* ruled by a petty king constituted a separate jurisdiction. The civil rights which belonged to a citizen in his own *tuath* did not belong to him in any other. The freemen of

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[1] From stem *aireg* is formed *airegde*; it seems to represent *are-sag-*, corresponding to the verb *ar-saig*—III 10 *ar said aititiu*, read *ar-saig aititin*, "it amounts to acknowledgment"; infin. *airigid* used in the sense of "honorific portion" given to the principal guest at a feast. *Aire* would thus primarily mean one who pushes forward, a leader.

each *tuath* formed a distinct body politic. In the early law tracts *tuath* means this body politic, and the rendering "territory" of the official translation is misleading. From the "Book of Rights" it would appear that the number of petty kingdoms in its time, the tenth century, was about ninety.

The official translations bristle with errors. Many of these errors amount to serious misinterpretation, and not a few are still more grave, tending to conceal or pervert fundamental features of the laws. I have endeavoured by study and comparison to arrive at a just interpretation of the ancient terminology. By bringing together tracts and detached articles which are connected in subject, I have sought to present a clearer view of the laws and of the social, economic, and political conditions which they illustrate, often with remarkable fulness and minuteness.

Uraicecht Becc.[1]

V 2.—1. Wherein is the Jurisprudence of the Language of the Féni found? Answer: In proof and right and nature.

V 6.—2. Proof is founded on rules and maxims and true testimonies. Right is founded on verbal contracts and acknowledgment. [The law of] nature is founded on remission and joint arrangement.[2]

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[1] The title *Uraicecht Becc*, "Little Grammar," is not as old as the text, since it is not glossed. It is doubtless based on the passages of commentary (V 56–70) which deal with various grades of poets and the kinds of metrical composition held to be proper to them. This matter was, we may think, of more interest to the men of letters of a later age than the obsolete legal provisions of the text. It supplemented the similar matter found in the versions of *Auraiccecht na n'Eces*, "The Grammar of the Poets."

"Is found," *agar*, H *aragar*, gloss *airegar*, read *airecar*. "Jurisprudence," *brithemnus*. *Breth* means a judgment or judicial decision not only on a particular case but also on a general principle or provision of law. The plural *bretha* means "rules of law," as in the titles of various law tracts, *Bretha Nemed*, *Bretha Etged*, *Bechbretha*, etc. Hence *brithem*, "brehon," means rather a professional jurist than a judge. In the court (*airecht*) of the *tuath*, decisions were given by the voice of those, nobles, clergy, men of learning, master craftsmen, who had the right of speech—hence *gó airechta, gó thúaithe*, "a false decision by the *airecht*, by the *tuath*"; but the decision was usually proposed by the king, who presided, or by a *brithem* who acted as legal adviser to the court. "Proof": this is the technical meaning of *fír*—see text, V 468, 470. "Right": *dliged*, in the early usage means "a right," later "a law." "Nature," *aicned*: the Irish jurists seem to have derived from Roman jurisprudence, doubtless through the Church, the idea of a "law of nature," equated with "the law of nations" and with natural equity. From Biblical Latin they learned to equate *gentes* with the heathen nations, hence they say that the "law of nature," *recht aicnid*, obtained in Ireland before Christianity (III 30).

[2] "Testimonies," *testemnaib*: the gloss understands this term in its later meaning of "texts," which could not have been the meaning at a time when texts of Irish law were innovations. So the gloss explains that "proof," as regards jurisprudence (*breithemnus*, *brethemnacht*), is founded on principles of law and on texts, but that, as regards actual decisions (*re conairib fuigill*), the proof of the thing which he pleads is established by the man who comes to plead. Altogether, the explanation in the gloss amounts to the

V 8.—**3**. Proof and right together are founded on the *nemeth*.[1]

V 10.—**4**. Whatever decision is not founded on any of these is altogether void.

5. Whatever decision (or regulation) of the Church exists is founded on proof and right of Scripture. The decision of a *fili*, however, is founded on rules of law. The decision of a ruler, however, is founded on them all, on rules of law and maxims and testimonies.[2]

V 14.—**6**. There are two [kinds of] *nemeth* that exist on earth, the free *nemeth* (*sóernemeth*) and the subject *nemeth* (*dóernemeth*). The free *nemith* that are, are churchmen, rulers, *filid*, *Féni*; the subject *nemith*, however, the folk of every art or craft besides. The reason why the folk of every art or craft are [called] subject *nemith* is because they serve the free *nemith*; but everyone also is free who purchases his franchise by his art. Hence there is [a saying], "the free in the seat of the unfree and the unfree in the seat of the free." Everyone [may become] free by his wealth; everyone [may become] unfree by his lips.

V 20.—**7**. "The free in the seat of the unfree," the man who sells his land, or his authority, or his body in service. "The unfree in the seat of the free," the man who buys land or rights or franchise by his art or by his husbandry or by his talent that God gives him. Hence there is [a saying], "a man is better than his birth."[3]

V 22.—**8**. The seven grades of the Church: lector, usher, exorcist, subdeacon, deacon, priest, bishop.

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statement in the text—proof in a suit is based on the existing law and on evidence, evidence comprising not only the testimony of witnesses but the tests held to be furnished by various kinds of ordeal, by oath, duel, fire, etc. "Rules," *roscadaib*: the precise meaning of this term has not been defined. Since it is distinct from *fasaige*, "maxims," it may mean the ordinary rules of law in mnemonic form, verse or prose. *Aititiu*, "acknowledgment," on the part of persons having authority, gave validity to contracts made by those under their authority (III 10, etc.). "Joint arrangement," *cocorus*: "nature" here means equity.

[1] *Nemeth*, ordinarily meaning "sacred," is a generic term for every person having the franchise of the Féni.

[2] At the time of this text, *fili* was used in its wide sense of a man of Irish learning. The *filid* had all the functions of the earlier Druids except the care of religion. They were the custodians of law. "Prophecy had ruled in the law of nature, in the jurisprudence of the island of Ireland and in her *filid*" (III 30). "The rules of true nature which the Holy Ghost had spoken through the mouths of the jurists (*brithemon*) and the just *filid* of the men of Ireland" (I 16). *Roscadaib*, "rules of law": these, acc. to the commentary, were in *filidecht*, which is to be understood in its later sense of "poetry." Cenn Faelad (III 550) composed a work known as *Dúil Roscad*.

[3] The only class in the community which was excluded from obtaining franchise was that of *dóerfuidir* (V 520) consisting of persons who had forfeited their lives (V 360), but who had been ransomed and accepted as tenants under a lord. For others, if they had

V 24.—**9**. The seven grades of government (government in regard of subject clientship): *aire désso, aire échta, aire túise, aire ardd, aire forgill,* king, and overking.[1]

V 26.—**10**. The seven grades of *filid,* however: *fochluc, macc fuirmid, doss, cano, clí, ánruth, ollum.*

V 30, V 40, V 42.—**11**. Seven chattels of *díre* for an *aire désso,* and protection for three days, four men's food-provision for him, and four cakes to each man with their condiment and their seasoning. If it be true *caindenn,* sixteen flakes to each cake, or four stalks of true *caindenn* to each cake; or honey, or fish, or curds; or a salted joint with every twenty cakes. In like measure even up to king.[2]

V 42.—**12**. Ten chattels, now, for an *aire échta,* and protection for five days, and thirty cakes.

V 44.—**13**. Fifteen chattels for an *aire túise,* and protection for ten days, and forty cakes for him.

14. Twenty chattels for an *aire ardd,* and protection for fifteen days, and sixty cakes.

V 46.—**15**. Thirty chattels for an *aire forgill,* and a hundred laymen with him, and a month's protection for him, and eighty cakes.

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wealth enough to "buy franchise," free status was possible. In the term *dóernemeth, dóer* means "inferior" relatively, not "unfree" absolutely. In O'Mulconry's Glossary, much of the details s.v. *Nemed* seems to be derived from the glosses on this or some similar text: "Three superior *nemid* are enumerated here . . . the Church, *filid,* kings and rulers . . . Four other *nemid* are enumerated herein . . . whitesmiths and blacksmiths . . . wrights (*saoruib*) . . . musicians . . . cattle . . ."—the last because certain cattle, especially milch-cows, were privileged from distraint. A freeman became "unfree by his lips" when he contracted to become a *dóerchéle* under a lord, but this contract was revocable (II 312, seqq.). *Déis,* "authority," especially over clients, *céli.*

The text up to this point forms a brief introduction to Irish jurisprudence in general, passing by an easy transition, through the term *nemeth,* to an introduction to what the jurists deemed the most important and what was in fact the most characteristic part of Irish law, the law of status.

[1] "Overking": the text has *rí ruireach,* "king of overkings." We should expect *ruiri,* and the actual reading has probably arisen from some confusion of gloss with text.

[2] "Chattels," *séoit*: the standard *sét,* the chattel which is the normal unit of value in the laws, was a *samaisc,* a young cow before her first calf. This was reckoned at half the value of a milch-cow. In reckoning values of five chattels and upwards, every fifth chattel was of the value of a milch-cow. Seven chattels = three milch-cows. "Protection," *turthugud,* in C.G., *snádud*; a more general term is *foessom,* which also means adoption (of a child); the power to protect strangers is meant, any offence against the protected person becoming an offence against the protector. A better reading may be *turthuge,* cp. *tuige, imthuge, fortga.* "Four men" are this noble's lawful retinue on a visit of hospitality, and his lawful company on sick maintenance, i.e., when he is maintained at the expense of a person who has caused his wounding. *Caindenn,* a seasoning vegetable—garlic, onion, or leek. "Joint," *cammchnáim,* lit. "bent bone," perhaps a "ham."

V 50.—**16.** A king of one *tuath,* seven hundred laymen with him, half of seven *cumals* his *díre,* and a month's protection for him.

17. An overking, three kings with him, and protection for three fortnights, and a hundred and sixty cakes for him.

V 52.—**18.** In like measure for the grades of the church, as to food-provision and protection and *díre,* but penance is added for these along with *díre.*[1]

V 54.—**19.** [In like measure for heirs of a church as are the grades of the churches to which they belong, though they themselves be not in holy orders, if their means be otherwise good].[2]

V 56.—**20.** Seven grades of *filid*: an *ollum* is equal in *díre* to a king of one *tuath,* and has a month's protection, and three times eight men are his number.

V 58.—**21.** One minor chattel is the *díre* of a *fochluc,* one day his protection, and food-provision of two men for him.[3]

V 60.—**22.** Three chattels for a *macc fuirmid,* and food-provision of three men, and three days' protection.

V 62.—**23.** Five chattels for a *doss,* and food-provision [of five men ?] for him, and five days' protection.

V. 66.—**24.** Seven chattels for a *cano,* and food-provision of six men, and a week's protection.[4]

25. Ten chattels for a *clí,* and food-provision for eight men, and ten days' protection.

V 68.—**26.** Twenty chattels for an *ânruth,* and food-provision of twelve men, and fifteen days' protection.

V 70.—**27.** What is wanting from each man's means is wanting from his dignity. What is added to his good means is added to his good dignity.

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[1] "Penance," *pendait,* here denotes a mulct payable for offences against ecclesiastics.

[2] It is questionable if this article belongs to the original text. The early law tracts contain no other reference to laymen holding the office of "heir" (*comorbbe*) to the headship of a church or monastery. The meaning is that the "heir" is equal in status to the principal ecclesiastic in his church. "Means," *foluid*: a frequent term for the means, material or other, by which a person sustains his functions or liabilities.

[3] "Minor chattel," *sét gabla.* There appear to have been three grades of chattel, the lowest being *sét gabla,* the middle or average, *sét accobuir,* and the highest, *clithar sét. Fochluc*: the genitive in the text is *fochlacain,* which may be a scribal error for **fochlocon* —cp. *drissiuc,* gen. *driscon,* etc.

[4] Though the honourprice of the *cano* is the same as that of the *aire désso,* his food-provision and protection are on higher scales.

28. Half the dignity of each man to his wife, or to his dutiful son, or to his administrator, or to his prior.[1]

V. 76.—**29.** A hospitaller is equal in grade to a ruling noble if he have besides the double of each grade's amount of land and husbandry. It is by reason of the ruler's kindred and house-custom that he excels.[2]

V 76.—**30**. He is no hospitaller who is not hundredful. He repels no condition (of person). He refuses no company. He reckons against none howso often he may come. This is the hospitaller who is equal in *díre* to the king of a tuath.[3]

V 78.—**31**. The superior hospitaller, this man has double wealth, he has an ever-stocked cauldron, he has three roads.[4]

V 78.—**32**. The classes of worth, now: *inol* and *flescach* and *garid* and *fer midboth*—it is he whose foot and hand are not restrained—and *mruigfer* and second *bóaire* and first *ócaire*.[5]

V 80.—**33**. The *díre* of an *inol*, a fleece of wool, or a ball of yarn, or a hen without secret.[6]

V 84.—**34**. A lamb of (the value of) a sack (of corn) for a *flescach*, and a

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[1] *Cátu*, "dignity," is here said of a measure of free status. *Gormacc*, "dutiful son," a son who does his duty to his parents, especially the duty of maintenance, *gaire*, in their old age. *Rechtaire*, "administrator," acc. to the gloss, "of a king in the *tuath*." *Sechnabb*, "prior," lit. "second abbot."

[2] "Hospitaller," *briugu*. He provided open hospitality, it is not clear within what limits. To be equal in grade to a ruling noble, it was necessary that he should have twice the qualifying wealth of the noble's grade. A freeman of the non-ruling class, in order to rise to the grade of a ruling noble, unless his father and grandfather had been ruling nobles, was required to have besides twice the number of clients (*céli*) proper to the grade of ruling noble. The qualifications in regard to clients, land, and husbandry, only mentioned generally in the present text, are specified for each grade in the commentary and in C.G., but with differences. "House-custom," *bés* (*taige*), was the food-provision to which a ruling noble (*flaith*) was entitled from his clients. "That he excels": *forcraid .i. imarcraid*; the text probably contained the corresponding verb; the meaning may be "that he (the hospitaller) exceeds" the ruling noble in required qualifications.

[3] "Hundredful," *cétach*, acc. to the commentary means "having a hundred men after the manner of slaves"—note that they are not called slaves—"and a hundred of every (kind of) cattle."

[4] "Superior hospitaller," *briugu leittech*. *Leittech* is glossed by *togaidi*, "chosen, choice."

[5] "Classes of worth," *fodla febe*. These collectively are equivalent to the *grad Féne*, "order of the Féni," of the glosses and commentaries passim. The list is peculiar to this text, being doubtless a particular essay to produce a sevenfold classification of the non-ruling grades. "Are not restrained," *nád comathar*: he is responsible for his own "liability of foot and hand," *cin coisse ocus láime*.

[6] "A hen without secret," *cercc cen rún*: the commentary, guessing, says that this means either a hen that is not hatching, or a hen that is not laying.

sheep for a *garid*, a yearling heifer for a *fer midboth*, and three cakes his food-provision.[1]

V 86.—**35**. Three chattels for a second *bóaire*, and from one canonical hour to the other his protection, and five cakes with milk for him, or butter.[2]

V 88.—**36**. Five chattels for a first *bóaire*, and two days his protection, and eight cakes for him with their condiment, and salt for their seasoning.[3]

V 90.—**37**. Subject *nemith*, now, wrights and blacksmiths and brasiers and whitesmiths and physicians and jurists and druids and the folk of every art and craft besides . . . The franchise of jurists and wrights increases till it reaches food-provision for twelve men and fifteen chattels for *díre*.[4]

V 92.—**38**. If he be a jurist of the three rules—the rule of the Féni, and the rule of the *filid*, and the rule of the white speech of Beatus; if he be a chief master craftsman, he rises to twenty chattels for *díre*, and has a month's protection.[5]

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[1] *Flescach* is still in use (*fleasgach*), meaning a stripling. The commentary (V 86) recognizes three grades of *flescach*, their ages being (up to) eight, ten, and twelve years. The gloss (V 85) equates the *garid* with the middle grade of these. The commentary recognizes also three grades of *fer midboth*, with age-limits of 14, 20, and 30 years. For a fuller account of the *fer midboth*, see C.G., which does not recognize the higher grade from 20 to 30. The *fer midboth* was a youth or young man under his father's authority: "this person has not power of his own foot or hand, his father has the power of them" (gloss, V 80, 7). *Inol, flescach, garid*, are thus names for children under 12. Their honourprice is fictitious (see commentary, V 87), and their function in the text is to raise the number of non-ruling grades of freemen to seven. The text omits to state in order the honourprice, protection, and refections of the *mruigfer*—probably another token of tentative classification. In C.G. *mruigfer*, "landman," is the name of the highest class of non-ruling noble, next to the *fer fothlai*, who has clients but not in sufficient number to make him a *flaith*.

[2] "From one canonical hour to the other," *ón tráth co 'laill*, meaning to the corresponding hour on the following day. From this usage, *tráth* sometimes means a day's space, 24 hours, distinct from *laithe, láa*, which means either the time of daylight or a full day measured from nightfall to nightfall. The fact that *tráth* was used, instead of a Latin loanword, to designate the ecclesiastical divisions of the day, indicates that it signified some similar division in pre-Christian usage, probably a third of the day. For the use of symbols which appear to indicate a threefold division of the day in the Coligny Calendar, see the paper on that calendar by Rhys, Proceedings of the British Academy, vol. iv, p. 78.

[3] Here *bóaire* replaces *ócaire* of the list above, the terms ("noble of kine," "junior noble") being apparently synonymous for the writer of this text. In other texts, glosses, and commentaries, *ócaire* denotes a grade inferior to *bóaire*.

[4] *Súire*, "franchise, free status." The second clause seems to imply that a statement of the minimum measure of status for these classes preceded. We may observe that the text acknowledges the existence of druids, but the honours that formerly belonged to the druids have gone to the Churchmen and the *filid*.

[5] "The rule of the Féni," *breth Ḟéne = Fénechus*, traditional Irish law. *Breth filed*, "the rule of the *filid*," the doctrinal law of the schools. "The rule of the white speech of Beatus": Scriptural law and Canon law. "The white speech of Beatus" is Latin. In the Latin schools, learners began with the Psalms, and the first word of the first

V 94.—**39.** Blacksmiths and brasiers and whitesmiths and physicians, though it be a chief master of them, are entitled only to food-provision for four men, eight chattels are their *díre*, and three days' protection.

V 96.—**40.** What gives *díre* to a person? Answer: merit and integrity and purity.[1]

41. There are three divisions of (the measure of) a person's honour, *eneclann* and *enechruicce* and *enechgríss.*[2]

V 96.—**42.** The good arts are both free and subject, because they serve and are served. Their distraints are free and their judgments are free over their rightful customs and over their apprentices.[3]

V 98.—**43.** The jurist who is competent to give decision for the folk of arts and crafts in regard of justice, in the estimation and measurement of the work and the remuneration of every product, and who is competent to reconcile custom and award, has seven chattels for *díre*, and three days' protection and food-provision for four men.[4]

V 100.—**44.** The jurist of the language of the Féni and the lore of the *filid*, ten chattels are his *díre*, and five days' protection, and thirty cakes for him.[5]

Psalm is "Beatus." The first grade of pupil in a Latin school was *cóictach*, one who had learned the first 50 psalms (V 102, 18).

[1] By "merit" is to be understood the possession and worthy use of qualifying wealth, by "integrity" the potential and actual fulfilment of functions and duties, by "purity" being guiltless of misdeeds. See I 54 seqq.

[2] *Ainech*, *enech*, in the legal technical sense of "honour," is neuter plural, genitive *enech*, dative *inchaib*. The oldest form of the word found is in the ogham *Ineqaglasi* = *Enech-glais*. In the early law tracts *lóg enech* is much more frequent than *eneclann*, which replaces it in later writings. Acc. to the gloss, there were two divisions of *eneclann*, full honourprice and half honourprice; two of *enechruicce*, half honourprice and a seventh of honourprice; two of *enechgríss*, $\frac{1}{3}$ and $\frac{1}{21}$ of honourprice. The seventh part of honourprice is also called *airer*, II 204, III 538. These measures have reference to various degrees of injury.

[3] "Their distraints are free": acc. to the gloss this means that artists and craftsmen are exempt from distraint for a kinsman's liability. "Judgments," *riara*: "judgment," or the power of judgment over subject persons, is the usual meaning of *riar* in the early law tracts. The commentary here replaces *riar* by *breithemnus*, which in the text means "jurisprudence."

[4] This is a low grade of jurist, having less honourprice than that of the craftsmen for whom he adjudicated. "Product": read *haicde* for *hoic* of the text (*oigdi*, gloss), any article of skilled craftsmanship. *Fuigell*, a judicial decision, must have meant first a pledge to submit to adjudication, then submission to adjudication, lastly adjudication. *Fuighellestar Sen* r. *fo-gelset Sen*, I 78, 4, "they submitted the case to Sen." *Co fuigled Conchubur imbi*, I 250, "so they submit the case to C."

[5] "The language of the Féni," *bélre Féne*; we may judge from the presence of this phrase that already at the time of writing of this text the language of the laws was recognized to be archaic.

45. The jurist of the three languages is equal in *díre* to an *aire túise.*[1]

V 102.—**46.** The master of the Letter is equal in franchise to the king of one *tuath.* The second master of the Letter is equal in *díre* to an *aire ardd.* The junior master is equal in franchise to an *aire túise.* The man of a fourth of mastership is equal in franchise to an *aire désso.* All this comprises food-provision and protection and *díre.* Students of Latin from that down are entitled to smaller franchises, for there is no Latin learning without franchise.[2]

V 102, V 104.—**47.** The accurate wright of oaken houses is equal in franchise to an *aire désso.* The diligent wright of ships and barks and hide-covered boats and vessels, who is able to make all these, has the same amount of franchise. The millwright, the same amount. The master in yew-carving, the same amount. The franchise of an *aire désso* to each of them.[3]

V 104.—**48.** The man who practises together two or three [of the aforesaid crafts is entitled to an honourprice of the value of eight milch-cows, and to food-provision for eight men.][4]

V 104.—**49.** The man who practises together four (of the crafts aforesaid), fifteen chattels for his *díre,* and food-provision for twelve men, and ten days' protection for him.

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[1] "Three languages": acc. to the gloss these are *Fénechus*—the ancient laws, *filidecht*—the lore of the *filid,* and *légend*—Latin learning.

[2] "Master of the Letter," *súi littre,* equated in the gloss with *fer légind,* a later title ("man of Latin learning") for the headmaster of an ecclesiastical school. The "Letter" is the written law of Scripture. "Second master of the Letter," *tánaise suad littre,* equated in the gloss with *súi canóine,* "master of Canon law." "Junior master," *ócsúi,* equated in the gloss with *forcetlaid,* "teacher." "Man of a fourth of mastership," *fer cethramthan suithe,* equated in the gloss with the *staraige,* "historian," meaning probably the student who has learned the "historical" interpretation of Scripture. Below this, the gloss names, in the ascending scale, three grades of student, the *cóictach* (who had learned the first fifty psalms), the *foglaintid* ("learner"), and the *descipul* ("disciple"). For a different classification see C.G.

[3] "Of ships," *long,* acc. to the gloss, *na longa fada,* "naves longae," the Irish word being taken from the Latin. "Of barks," *báircc* (r. *bárcc*?), equated in the gloss with *na serrcinn,* "which are not rowed." "Hide-covered boats," *curach*: still used along the western seaboard, but covered with tarred canvas instead of hide. *Lestra,* "vessels": the gloss understands domestic vessels to be meant. It seems likely, however, that small boats are intended—cp. V 474, 8, *foimrim noe no lestair,* where the use of a *lestar* without the owner's leave incurs a penalty of five chattels, equated in the gloss with two milch-cows; cp. also the uses of the English word "vessel," and the modern Irish *soightheach.* "Millwright," *sóer muilend,* craftsman (i.e. builder) of mills. Ownership or part-ownership of a watermill was held to be part of the qualifications of every civil grade from *ócaire* upward: see C.G. and the commentary, V 88 seqq. For partnership in millraces, see *Coibnius Uisci,* IV 206 seqq. "Yew-carving," *ibróracht*: yew was the favourite wood for decorative woodwork.

[4] The lacuna in the text is supplied inferentially from the gloss.

V 106.—**50**. Chariot-wright and house-carpenter and cloth-figurer and relief-carver and shieldmaker, the franchise of a second *bóaire* for them. If he practise together two crafts of them, the franchise of a first *bóaire* for him.

51. Turners and fettermakers and leather-workers and [wool-] combers and fishermen, the franchise of a *fer midboth* for them.

52. The harp, that is the one craft of music that is entitled to franchise, so long as it accompanies nobility. The franchise of a first *bóaire* for him.[1]

V 108.—**53**. Every art, now, that we have said, that is entitled to franchise, the franchise that he has in the *tuath* does not fail for want of his art if he practise it elsewhere, be it in a *tuath* or in a church. Hence is (the saying), "the *nemith* do not diminish each other."[2]

54. Whose art is one, his *díre* is one. Whose art is many, his *díre* is many. It increases franchise.[3]

55. The folk of vocal and instrumental music besides, jockeys and charioteers and steersmen and followers in feast and retinue (?), and mummers and jugglers and buffoons and clowns and the lesser crafts besides, it is in regard of the honour of those who keep them that *díre* is paid for them. Otherwise they have no franchise apart.[4]

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[1] "So long as it accompanies nobility": the actual text has *cen imteid la hordain.* The gloss, followed in the official translation, paraphrases this by *gen gurab imaille re huasal*, "though it be not along with a noble." This would require, as a restoration of the scribally corrupt text, *ceni immthé(it) la hordain.* I read *céin immetheít*, and understand the sense to be that a harper had free status so long as he held official rank. See the description of a king's house, with the *airecht* in session, in C.G., where the harper occupies a place near the king at the table, while the other musicians are in a corner apart behind the king's seat along with jugglers, over against the forfeited hostages.

[2] The meaning is that to maintain the franchise acquired by reason of an art or craft, it is not necessary that the person so enfranchised should practise his art or craft in the *tuath* to which he belongs or for its immediate benefit. "If he practise it elsewhere," *dia congba*, lit. "if he practise jointly"—*com* having its full sense. "The *nemith*," etc.: for *ni mina digbat* of the printed text, read *ní 'mma dígbat*, the *imm* of the original being represented, as usual, by the *em* of the etymological gloss.

[3] The maxim quoted at the end of the preceding article seems to refer properly to this article. It was probably introduced first as a marginal or interlinear accretion, and so became misplaced.

[4] The rendering of some of the terms in this article is conjectural. The gloss distinguishes between *áes ciúil* and *áes airfitid*, calling the former *crónánaig*, "singers of crónán," the latter *fedánaig*, "players on a pipe or flute"; but *áes ciúil ocus airfitid* may be only a comprehensive phrase = musicians. "Besides" means other than the harper. *Comail ocus daime.* I read [*óes*] *comóil ocus dáime. Creccoire*: acc. to the gloss, they make a green *creccad* on the eyes—some sort of disguise. All who follow this list of occupations are without franchise, but when they are engaged in the service of a freeman, injury done to them incurs liability to him. The original text probably ended here. The articles that follow have the appearance of random accretions.

V 112.—**56**. A master over kings is the King of Munster. Twice seven *cumals* are his *díre*. Two beeves and two bacon hogs for the six score of his company, and two hundred cakes. A year's protection for him. A noble master bishop, the same amount; a master of the great canon (?), the same amount; such as Immliuch Ibair or Corcach Mór of Munster.[1]

57. Who is not of good means is not of good merit.

58. A master of *fili* and a master of wisdom and a master hospitaller, each of them is equal in franchise to the king of one *tuath*. They have thirty chattels (of honourprice) and a month's protection, and eighty cakes, for each of them.[2]

V 112.—**59**. A second master of the Letter and an *ánruth filed* and a chief master of handicraft, are equal in franchise to an *aire ardd*.

V 114.—**60**. A master of test, blacksmith, or whitesmith, or brasier, who is raised to franchise by the *tuath*, each of them is equal in franchise to an *aire désso*.[3]

Crith Gablach.

IV 298.—**61**. [Why is Crith Gablach so called? Answer—Because the man of a *tuath* (= the citizen) of his good means in the tuath purchases that he be reckoned in his proper grade in which he is in the *tuath*. Or because of the number of branches into which the grades of a *tuath* are subdivided.

Question—How many subdivisions of these? Seven.][4]

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[1] "A master of the great canon (?)": Atkinson's proposed emendation [*már-*] *chathrach* for *mor canach* fits in with the clause that follows. The translation then would be "master of (the school of) a great city (= episcopal see), such as," etc.

[2] "Master of wisdom," *ollam gáise*, acc. to the gloss, a master jurist.

[3] "Master of test," *ollam foccail*: gloss, *in ti foclaiter conid ollam*, "he who is tested so that he becomes a master." For *focul*, "test," see II 242, 244, *trifocuil .i. tri fromaid.* The etymological gloss *fo iacail*, II 242, points to *foccal*, with cc = k. This article shows that the franchise of a master craftsman was conferred on him by the *tuath*. The commentary, pp. 112, 114, speaks of the appointment, *uirdned*, of the "second master of the Letter," and of the *ánruth*, or *fili* of the second degree, the person who appoints being the king of a *tuath*, the king of a *mórthuath*, the king of a Fifth, or the king of Ireland. It is clear, however, that appointment by the king of one *tuath* was of no special effect, giving no increase in status (see 114, 14 and 16, 10); which implies that appointment by a king took special effect only when the king was overking of a number of *tuatha*. There were seven persons or places in a *tuath* to which notices of a find of lost property were given (III 273): king, monastic chief (*airchinnech*), hospitaller, (the king's) *brithem*, the chief smith (*prímgoba*), the mill of the *tuath*, the people of the homestead and village where the find was made. It is therefore to be inferred that in each *tuath* there was a chief of each craft who was appointed by the *tuath*, i.e. by public election, and who thus acquired status on a level with the lowest grade of ruling noble.

[4] It seems unlikely, though not impossible, that the author of this tract began by inventing a title for it and offering alternative explanations for it, and therefore these

62. Whence come the divisions of orders of a *tuath*? From a comparison with the orders of the Church, for every order that is in the Church, it is just that its like should be in the *tuath*, for the sake of declaration or denial on oath, or of evidence, or of judgment, from each to the other.[1]

63. Question: What are the orders of the *tuath*? *Fer midboth, bóaire, aire désa, aire ardd, aire túise, aire forgill,* and king—if it be by the right of Féni law; and if it be not that, the following seven orders are distinguished: *Aire désa, aire échta, aire ardd, aire túise, aire forgill, tánaise ríg*, and king.[2]

64. What are the subdivisions of *bóairig*? Two (grades of) *fer midboth*, and *ócaire*, and vassal who precedes vassals in husbandry, and *bóaire* of excellence, and *mruigfer*, and *fer fothlai*, and *aire coisring*.

65. What is the [measure of the] oath in litigation, and the bond, and the guarantee, and the evidence, and the honourprice, and the food-provision, and the sick-maintenance, and the protection, and the client-price, and the house-custom of each of them? Answer: As the Féni-law declares in verse:

> That thou mayest know the orders of the Féni,
> by estimate of [their rights in] court they are reckoned.[3]

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opening phrases are here printed in brackets. They may have been added in the time of the oldest glosses on law tracts, probably towards the end of the ninth century. *Gablach* means "branching," but *crith* can hardly be connected with *cren-*, "purchase," unless it was parallel in usage with *creicc*, the noun found as infinitive of *cren-*. The antiquity of *creicc* is attested by the compounds *fochraicc, taurchreicc,* found in the early texts. Meyer (*Contribb.*) says that this word *crith* is infinitive of *crenim*, but has no instance of it in that sense except the title of this tract and O'Davoren's gloss, "*.i. íc*," "that is, payment," which is probably based on the explanation in the tract. On the strength of this evidence, Meyer gives the meanings "contract, payment"; but a title meaning "branching contract" or "branching payment" seems wholly inappropriate here. A more suitable sense would be found if we could connect *crith* with the root *kri* and explain it to mean "a sorting, a classification." The second explanation in the text above, if it does not ignore *crith*, which is hardly possible, explains it either through *fodlaiter*, "are subdivided," or through *lín*, "number."

[1] What was of established custom appeared to be of necessity. In the Irish custom, as between the oath or evidence or judgment of two persons, that of the person of higher status prevailed.

[2] The writer ascribes the first classification to the tradition of the Féni. The second, which he adopts below, is a variation of the classification of ruling nobles in *Uraicecht Bec*, placing the boaire grades in a distinct lower class. An interpolation, which seems to refer to the next article, prefixes to the second list the question: "What if it be not the *bóaire* with his eight subdivisions?"

[3] *Immthoch*, "oath in litigation." The prefix *imm-* denotes that two parties are in question. *Naidm*, "bond": a person, called *macc nascaire*, was pledged as surety. *Ráith*, "guarantee": the guarantee of a third party when a secured contract, *cundrath*, was made. *Fiadnaise*, "evidence": in some way, not fully explained, a man's evidence was valid to the extent of his honourprice. *Biathad*, "food-provision," for a certain

IV 300.—**66.** Two (grades of) *midboth* men. (The first is) the *fer midboth* who makes declaratory oath in litigation involving fines. He makes oath (in case of fines) from a needle to a heifer in its first age. That is his honour-price for his defamation, for violation of his precinct, for his expulsion, for dishonouring him. That is the amount to which his bond and his guarantee and his evidence and his hostage extend. His food-provision is for himself alone, milk and curds or corn. He is not entitled to butter. He protects his equal in grade over his own *tuath*, and (the protégé) is fed by him till he goes over the border.

67. Why is this man called a *fer midboth?* Because they come out of boyhood (?) by right of fosterage, and he does not reach (the ownership of) a *fertach* (of land).[1]

68. Is a particular age determined for the *fer midboth* who swears to fines? The age of fourteen years is determined. The reason why he does not maintain statement or evidence is because he is only capable of evidence on every trivial matter before (the age of) seventeen years, (and) that he has not taken a possession (of the land of his kin) or an inheritance before that, unless a man of the Féni be joint husbandman with him. This is the person who swears to the fines of farm law.[2]

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number of retinue in guesting. *Othrus*, "sick-maintenance," for himself and one or more to attend him during his cure of wounds. The man who wounded him was liable. *Snádud*, "protection," the right of protecting strangers in the tuath; called *turthugud* in *Uraicecht Bec*. *Taurchreicc*, "client-price": when a freeman contracted to become a *dóerchéle*, or client without franchise under a lord, the lord paid him his honourprice, besides supplying him with stock. *Bés taige*, "house-custom": the food-tribute rendered by a client to his lord.

[1] *Both*, a booth, a cabin, a house of low degree. *Fer midboth* seems to mean "a between-house man," "a man of mid-cottages." From what follows, it is evident that the person so named was a minor, and from the foregoing, that he was under fosterage. Perhaps he was "between dwellings" in the sense of belonging both to his father's and to his foster-father's house. His right to a voice in legal matters may have arisen from a custom of showing special favour to foster-children.

[2] Proof by oath and proof by evidence were distinct processes. A man was not necessarily a witness of the facts about which he made oath. He declared his belief in a certain statement, and his declaration carried weight in proportion to his status. A person of superior status had (*for-toing*, "he overswears," *fortach*, "superior oath") the power of setting aside by his oath the oath of an inferior in status. This did not imply a right to swear falsely. On the contrary, "the lord who swears what he does not sustain" loses his rights over his clients (V 358, 7); and it may be inferred that no greater impunity belonged to persons of lower grade. Proof by oath may be regarded as a form of ordeal. It is mentioned (V 468, 470) along with three forms of ordeal which Saint Patrick is said to have confirmed. Proof by oath or ordeal is called *fír* (ib.).

Apparently the text implies that a minor between the ages of fourteen and seventeen could hold land in some kind of partnership, and exercise in some small degree the distinctive powers of franchise.

Mruigrecht, "farm-law," seems to be a name for the laws governing the relations of small agricultural communities which grew out of joint families. To this branch of law

69. The second *fer midboth*, who preserves statement, he is of better thrift. His statement is collected for him in three words till the third day. He preserves it without increase or diminution. He makes oath after some other man who takes precedence of him in swearing, and he swears (to the extent of) a heifer in the third stage or its value. This is his honourprice for his defamation, for violation of his precinct, for his expulsion, for dishonouring him. To this his bond, his guarantee, his evidence, his hostage, extend. Food-provision for himself alone, milk and curds or corn. He is not entitled to butter. He protects a man of his own grade over his *tuath*, having then a right to double food-provision.[1]

70. Sick-maintenance does not exist to-day, in this time, but only the payment of his worthy means to everyone according to his dignity, including physician's hire and linen and food-provision and the price of the disfigurement, injury, or defect; but there is a common due for every order of the orders of the *tuath* in the law of sick-maintenance.[2]

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belongs *Bretha Comaithchesa* (IV 68), the law of bee-keeping (IV 162), the law of partnership in watercourses (IV 206), and a very old, though unglossed, tract on common pasturage which has been printed as commentary (IV 100). "The fines of farm-law" were payable by one member to another of such communities in respect of trespasses, neglects, etc.

[1] *Innsce*, statement, has reference to a statement made in court, probably on oath. The statement of a youth was tested, apparently, by being reduced to some sort of formulation "in three words" or sentences. Three days later, he was required to repeat it. If he could do so "without increase or diminution," he was classed as a *fer midboth* who preserves statement.

The stages or grades of value in cattle begin with the *dartaid*, a weaned heifer calf, valued at two screpalls of silver or three sacks of corn. The *dairt*, or yearling heifer, valued at three screpalls. The *colpthach*, a two-year-old heifer, valued at eight screpalls. The *samaisc*, or young cow that has not yet calved (*sam-sesc*, "dry in the summer," the normal season of calving being the spring, so that the *samaisc* yielded no milk in its third summer), valued at twelve screpalls. The milch-cow was held to be double the value of the *samaisc*. The *sét*, or "chattel," when the word is used as a measure of value, denotes the value of a *samaisc*. This was the normal unit, and the *dairt* was the usual fraction in reckoning.

"Defamation," *áir*: the word can hardly be limited to its later sense of a literary satire. *Díguin*, "violation of precinct," literally means absence of slaying or of wounding. Each landed householder had a "precinct" of land about his house, called his *maigen*. It varied in extent according to his status. A late tract on the subject (IV 226) appears to be a somewhat tentative essay based on older statements. Slaying, wounding, or quarrelling on the *maigen* was an offence against the owner's status. This ground is more fully named *maigen dígona*, and hence briefly *díguin*. Further, *díguin* came to imply "special immunity from trespass": *fér dígona* = grass preserved for hay or winter pasture. *Essáin*, "expulsion," probably from a guesthouse or place of common resort. *Sárugud*, "dishonouring," lit. "overpowering," chiefly with regard to the right to protect strangers, etc.

[2] This is one of the many passages that indicate changes in the law known to early writers. We are to infer that, in an earlier time, the person who inflicted a wound on his fellow-citizen was himself obliged by law to make direct provision for the care and cure

IV 302.—**71.** An oath is sworn by body and soul, and a hostage is given (lit. goes) on behalf of the man who sheds the blood, for fulfilment of the law (lit. in the law) of sick-maintenance to the value of (lit. in) a cow. (The wounder) conveys (the wounded man) over gory sod into a high sanctuary with protection that protects against sudden wave of throng. He gives additional pledge afterwards against a bed that a physician forbids, (and) to provide a physician until final cure, in fore-health, in after-health. It is fulfilment (of the due) of the carriers (lit. number) of the bed, to protect them as far as the station of the *tuath*.[1]

72. What are the proper provisions due from everyone for which a hostage is given to obey the physician's decision? Full attendance secured upon guarantors, unless one obtain his care from the offender—and by force it is exacted. It is along with full *díre* and honourprice that the claim is sued, even though suit be made through a tongueless person. (The wounded man) goes and his mother with him upon support. He is entitled to cream in place of new milk on the third, fifth, ninth, and tenth days, (and) on Sunday.[2]

73. Is a special age determined for the *fer midboth* who preserves statement? Yes, from fourteen years to twenty, to the fringe of beard. Even though he were to attain the condition of *bóaire* before he is beard-encircled, his oath only pays as the oath of a *fer midboth.* Even though he be without

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of the patient, but that, at the time of writing, instead of direct provision, payment of the expenses was required. For "sick-maintenance," instead of *othrus* (lit. "sickness" or "wounded condition") as above, the older term seems to have been *foloch*, with verb *fo-loing*. See Heptad 60, V 313, where the commentary says that the wounder may choose either to bring the wounded man and his attendants to his own house or to pay for their support, etc.

[1] This paragraph seems to embody the mnemonic provisions of oral law. The assailant puts himself on the safe side of the law by immediately swearing to provide for the cure of the wounded, giving a hostage as security for initial expenses, and escorting the wounded to a special place of safety with sufficient guard to prevent a further attack by a crowd of his own party. The high sanctuary (*ardnemed*) and the station of the *tuath* (*forus tuaithe*) point to a public infirmary. Final cure (*dérosc*) implies a legal period, varying according to the nature of the wound. This period included the time of recovery (*arsláine*, "fore-health"), and the time of full convalescence (*iarsláine*, "after-health"). If anything went wrong with the wound in the meantime, the pledge must be fulfilled. Upon this, see also III, 535.

[2] This differs from the commentary above mentioned, in indicating that the choice between payment and direct support belongs to the wounded person. "By force" (*ar écin*) does not mean by physical force, but is the contrary of *ar áis*, "by consent"—it means that direct support can be exacted by process of law against the will of the offender. If the latter refuses consent at first, the claim comprises honourprice and *díre*, i.e. *corpdíre*, "bodyprice," as well as maintenance (*othrus, foloch*). A very old poem, with glosses, on these three payments, is found at III. "A tongueless person" (*étnged* means a person without franchise, and so normally incapable of suing. The time is divided into periods of ten days, probably an old Celtic division, the third part of a month.

taking an inheritance (of land), too, until old age, his oath still does not go beyond a *fer midboth.* His purchase as client is five chattels. A wether with its accompaniment is his house-custom. That is the custom of a single-kin a man who cultivates neither possession nor land for himself. The accompaniment of the wether: twelve cakes, butter, *nem beóil,* a bunch of leeks with heads, a drinking-vessel of milk three palms (high), cream and new milk and *draumce,* or buttermilk.

74. No one is entitled to invite to his house as long as he is a minor, until he is capable of husbandry apart and of taking property; a *fer midboth* (is not so entitled) as long as he is single-kin, unless he be bound to it by (his) lord, so as he sustain no custom beyond a wether with its accompaniment.

V 304.—75. If the means of his house increase so that he is of the means of a *bóaire,* or something higher, the ordering of his client-purchase increases for him accordingly. He likewise increases his render until his house-custom therein is according to his dignity, unless some other lord make a further contract with him. A half-share in a cornfield (is due) from him on the third day after notice. (He owes) to (his) lord a third of his *donn* and of his inebriety and of his sloth and of his payment.[1]

76. *'Ocaire,* his position as *aire* is higher. Why is he called *ócaire,* "young noble"? For the juniority of his noble grade. [Nay, but because he is younger (than *airig* in general) when he begins husbandry].

77. What is his property? He has sevenwise means: seven cows with their bull; seven pigs with a brood sow; seven sheep; a horse both for working and for riding. He has land of thrice seven cumals. That is a "cow's land" in the tradition of the Féni, it sustains seven cows for a year; that is (when it is let for grazing), seven cows are put into it, (and the grazier) leaves one of the seven cows at the year's end for the rent of the land.[2]

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[1] To the rule that a minor could not entertain guests, there is the exception that he could entertain his lord, having bound himself thereto, provided that he is subject to no more than his proper house-custom. If he makes a contract of clientship with a second lord, he must give notice to his first lord and forfeit the produce of a piece of cornland. He owes his (first?) lord certain reliefs, when the lord incurs certain liabilities. *'Eraicc,* "payment," probably refers to liability for homicide or violence. *Lesca,* "sloth," may have reference to remissness in suit of court, hostings, etc. *Donn* appears to mean theft or similar wrong committed by one guest against another and involving the host in liability.

[2] This is one of the rare statements that help towards an understanding of the ancient Irish notion and manner of valuing land. According to this passage, 21 *cumals* of land had an annual letting value of one cow. This must be ordinary pasture land, not mountain grazing. The *cumal* of land measured six *forrachs* in breadth and twelve *forrachs* in length (V 276, y z). The *forrach* was twelve times the *fertach* of 12 feet: 144 feet. This gives an area of about 34⅓ English acres for the *tír cumaile* or *cumal* of land. It is, however, wholly incredible that twenty-one times this area, or about

78. He has a fourth (share of) a plough; an ox, a plough-share, a goad, a halter; so that he is competent to be a partner; a share in a kiln, in a mill, in a barn; a cooking pot.[1]

79. The size of his house: it is larger than a house of rentcharge. For the size of the latter is seventeen feet. It is of wickerwork to the lintel. From this to the roof-tree, a *dit* between every two weavings (?). Two doorways in it. A door for one of them, a hurdle for the other, and this (the hurdle)

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721 acres, supported only about seven cows, a cow to 100 acres. When the writer says, "That is a cow's land," supporting seven cows and rented annually for one cow, he must mean a single *cumal*. The *cumal* as a measure of value was equal to three cows.

According to the text *Fodla Tíre* (properly *Di Thír Chumaile* IV 278 z), the purchase value of a *cumal* of the best arable land was 24 milch-cows, of medium arable land 20 milch-cows, of inferior arable land 16 milch-cows. Of grazing land, the purchase value, according to quality, is given at twelve or eight dry cows. This does not comprise woodland or mountain land (IV 278, 8, 9). These are basic values, augmented, as the text says, by the proximity of woodland, a silver-mine, a mill-site, a byroad, a main road, the sea, a stream, mountain grazing, river fishing, a cattle-pond, a road for cattle; each of these conveniences made an addition, varying from a heifer to a *cumal*, to the capital value.

The low value attached to land, in comparison with cattle, confirms the evidence of *Bretha Comaithchesa*, *Coibnius Uisci*, etc., that the seventh and eighth centuries were a time of very great agricultural development, when much of the fertile land began to be partitioned among holders and fenced off for the first time. Except men of learning, arts, or crafts, every freeman in C.G., including the higher nobility, from the rank of *fer midboth* upward, is owner or part-owner of a plough and a water-mill. There was plenty of good land awaiting division and enclosure. The values quoted above refer only to enclosed land. The definite measures of length and breadth, everywhere in evidence, point to systematic laying out and fencing. The method was of ancient Celtic tradition. The land was enclosed in rectangular strips, the length being twice the breadth. The long side of the area is called *taeb*, "side," the short side is called *airchenn*, "fore-end." From the Celtic original of this term, **areqennos*, was derived the Gaulish *arepennis*, and thence the French *arpent*. According to Columella, *arepennis* was the name given by the Gauls to a *semijugerum* of 150 feet (in length and breadth). A later writer (see Holder, Altcelt. Sprachschatz, s.v.) says that the *arepennis* measured CXX by CX[X] feet, and that two *arepennes* made a (Roman) *jugerum* (240 × 120 feet). The name itself, however, is a sufficient indication that the *arepennis*, like the *jugerum*, was based on a rectangular plan, in which the side was twice the length of the "fore-end." The Irish *forrach* of 144 feet corresponds closely to the lateral 150 feet of the *arepennis*, which may have been made to conform later or locally to the Roman *jugerum*. According to another writer (Holder, s.v.) the *arepennis* contained 12 *perticae*. The Irish longitudinal *forrach* contained 12 *fertaig*. *Fertach* is thus a loan word from the Latin *pertica* (> English *perch*). The first *fer midboth* in C.G. "does not reach [i.e. own as much as] a *fertach*."

[1] The *ócaire* had thus only one-fourth of the extent of tilled land that one plough normally ploughed in the season. To each plough there were four oxen, but these were probably yoked two at a time. Already in the Bronze Age the Ligurians ploughed with two oxen (Déchelette, Manuel II, fig. 1). Small landholders tilled, ground their grain, and stored it, in partnership. *Commus*, genitive *coimmse*, in the text, must mean "partnership." It is the noun corresponding to the verb *con-midiur* in the sense of "to equal."

without (projecting) wattles, without protuberances (?). A bare fence of boards around it. An oaken plank between every two beds.[1]

IV 306.—**80**. An *ócaire's* house is larger. Its size is nineteen feet. Its outhouse is thirteen feet, so that his house-custom may be divided (?) in two. Eight cows are his loan-capital. That is ten chattels. It is the double of the loan-capital of the previous grade; for it is from land that these (?) grades do vassal-service; of land, too, the value of his ten chattels (is given) to this man to retain him as vassal. That land, too, is as means for him against it (i.e. against the service due from him).[2]

81. A *dartaid* of Shrovetide with its complement is his house-custom. A pig's belly (i.e. a belly of bacon) therewith is the bacon that he pays with the cow, or a bacon of one inch, fairly cut, and three sacks of malt and a half-sack of wheat. For as double of the loan-capital of the lower grades is the loan-capital of the higher grade, double of the render, too, is his house-custom.[3]

82. He protects his equal in grade, for no grade protects one of higher grade. He is entitled to food-provision for two persons, of milk and curds or corn. He is not entitled to butter. A noggin of twelve inches of *draumce* instead of new milk for each of the two, and a full-sized cake, or two cakes of woman's baking. He is two (i.e. another accompanies him) on sick-maintenance. Butter, in this case, on the third, fifth, ninth, and tenth day, and on Sunday.[4]

83. Three chattels are his honourprice, but they are chattels of kine. He is entitled to the *díre* of a hostage.

Wherefore are these chattels paid him? Answer—For his defamation, for his expulsion, for violation of his precinct, for his dishonouring, for the burning

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[1] *Cís* in the early usage of the Laws denotes a charge for a particular purpose imposed on land, etc. *Inchís* probably meant an "introduced charge," i.e. a charge in support of some external object. A foot-note, IV 305, says that a *teg inchis* was a house for an aged man who gave up his land in return for maintenance. The size of a house is usually indicated as above by a single dimension, so that the house was either square or circular in plan. If *cleithe* meant roof-tree or ridge-pole, the house was square. *Dit itir cach diiti* is translated (IV 305) "A dripping-board between every two weavings," which seems conjectural.

[2] The writer indicates that this is an exceptional case, in which land is given, instead of cattle, as the loan-capital by which vassal-service is purchased. *Taurchreicc* means both the purchasing of vassal-service (*aicillne*) and the capital given for that purpose. The verb is **to-aurchren*, said of the lord, "he purchases (a *dóerchéle*) by a loan of capital."

[3] A *dartaid* at Shrovetide would probably be a heifer about nine months old. "With the cow" must mean with this animal. *Bés taige*, "house-custom," is the annual food-payment made to the lord as a return on his capital. *Somáin*, "profit," is also used to denote the return on capital.

[4] *Draumce*, dative sing. *draumcu*, is translated "*draumche*-milk," IV 303, and "sour milk," IV 307; *ar lemlacht* is translated "upon new milk," but the change of *for*, "upon," to *ar* is much later than this text, and "sour milk upon new milk" is most unlikely.

of his house, for robbing it, for (taking) theft out of it, for (taking) theft into it, for forcing his wife, his daughter. But it is a rule of law in the tradition of the Féni, half of the *díre* (i.e. of the honourprice) of every grade of the *tuath* for his wife and his son and his daughter, unless it be a *dormuine* or a son who is a defaulter from his filial duty—for these a fourth. His honourprice is (the measure of value to which) he makes oath and which goes upon his bond and his guarantee and his hostage and his evidence. And the two chattels that are wanting for him, it is because the establishment of his house is not complete, and that he cannot become guarantee for them like every *bóaire*, owing to the smallness of his means.[1]

IV 308.—**84.** A "vassal excelling vassals in husbandry": his cattle are in sums of ten: that is, he has ten cows, ten pigs, ten sheep; a fourth part in a plough, to wit, an ox and a ploughshare and a goad and a halter. He has a house of twenty feet, with an outhouse of fourteen feet. Four chattels are his *díre* for his defamation, for his expulsion, for violation of his precinct, for violation of his honour. He makes oath to that extent. He is bond, surety, hostage, suitor, witness to that extent. Ten cows are his capital from a lord. The choice of his yearling stock and a bacon of two fingers, fairly cut, and four sacks of malt, and a . . . measure of salt, is the custom of his house. Proper furniture, both irons and vessels.[2]

85. This is the "baptismal vassal," if he be in his innocence, free from theft, from plunder, from slaying a man except on a day of battle, or someone who sues him for his head; being in rightful wedlock and faultless on fast days and Sundays and in Lents.[3]

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[1] The last clause indicates that five chattels was held to be the normal minimum of honourprice for a freeman. Five chattels was the ordinary *díre* for offences against property, and a person who could not give security to that extent was below the normal free status. The *ócaire* was a sort of freeman cadet. What is said above of his son and daughter shows that the term *ócaire* (lit. "young noble") is not indicative of youth. *Dormuine* was the name of one of several kinds of concubine.

[2] "A vassal excelling," etc. The text here has *aithech ar a threba*; *a deich deichde*, etc. *Deichde* belongs to the following clause. Read *aithech ara-threba aithechaib. Aithech* means primarily a person from whom *aithe*, repayment, is due. The repayment in question is the return on capital advanced by a lord, and *aithech* means a person bound to make such repayment. *Ar.treba*, lit. "fore-cultivates." Cp. *ar.bí*, "excels."

"The choice of his yearling stock," lit. "the choice of a generation." As the classification is between that of the *ócaire*, who pays "a Shrovetide heifer" in house-custom, and the *bóaire febsa*, who pays a two-year-old steer, the "generation" must mean the calves born in the year before payment.

[3] "Baptismal vassal," *aithech baitside*. The name, in the form *aithech baitse*, appears again in *Miadlechta*, IV 352, to denote one of the low grades without franchise and unfit for military service. Taking the two passages together, we may infer that the term was one of current usage rather than a legal technicality, and the notion was of a man who had "preserved his baptismal innocence," which to one writer meant that he was a good peaceful agriculturist, to the other that he was not good in any other sense.

86. What deprives this man of the status of *bóaire*? It is that perhaps four or five men may be in joint heirship to a *bóaire,* so that each of them cannot easily be a *bóaire.*

He is entitled to the food-provision for two men of milk and curds or corn, butter on Sundays, a *serccol* of condiment with this, *duilesc,* onions, salt. He is entitled to have two persons on sick-maintenance, (and) to butter on alternate days.[1]

87. A "*bóaire* of excellence," why is he so called? Because his nobility and his honourprice are derived from kine. He has twice seven cumals of land; a house of twenty-seven feet, with an outhouse of fifteen feet; a share in a mill, so that he grinds for his family and his companies of guests; a kiln, a barn, a sheep-fold, a calf-fold, a pigsty. These are the seven roof-trees in respect of which every *bóaire* is paid *díre.* He has twelve cows, a half-share in a plough, a horse for working and a steed for riding. Twelve cows are his capital from a lord. A steer with its accompaniment is his house-custom as summer-provision and winter-provision. Five chattels for his *díre* as regards whatever is an offence to him for his honourprice.[2]

IV 310.—**88.** What makes five chattels the honourprice of the *bóaire*? Answer: His functions: a chattel for his bond, a chattel for his guarantee, a chattel for his evidence, a chattel for his hostage, a chattel for his composing (disputes) and for his judgment in farm-law. He makes oath (up to) five chattels, they (five chattels) go upon his bond and his guarantee and his hostage and his evidence. His food-provision is for three persons. He is entitled to have three persons on sick-maintenance; to butter on the second, third, fifth, ninth, and tenth day, (and) on Sunday. Fresh or salted onions for condiment. What is wanting to the qualifications of the *bóaire* is wanting to his *díre.*[3]

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[1] "A *serccol* of condiment." The official translation of *serccol tarsain* is "salted venison." A vessel or measure named *ol* is of frequent mention. *Sercc-* may represent *sergg,* "shrunken." *Duilesc* is still the name of a seaweed which is dried and eaten as a kind of condiment.

[2] "A horse for working and a steed for riding"—*cappall fognoma ocus ech immrimme*: the meaning may be "a saddle-horse for ordinary use and a racehorse for racing," since it is doubtful whether horses were generally used for work. *Díre* in the second passage means honourprice. In the first, it probably means *trebdíre,* special amends due for injury done to a house.

[3] The statement that the *bóaire's* five chattels of honourprice are based on his five legal functions, when compared with the other grades, is seen to be merely mnemonic.

"Salted onions," *cainnenn saillte. Cainnenn,* rendered sometimes by "onions," sometimes by "leeks," means some vegetable preserved by salting (cf. § 11 n). *Fír-* as in the modern *fíoruisge,* "fresh water."

Mruigrecht, "farm-law." See § 68 n.

89. A "landman" (*mruigfer*), why is he so called? From the number of his lands. Land of three times seven cumals he has. He is the *bóaire* of adjudication, the *bóaire* of *genus*, with all the apparatus of his house in their proper places: a cauldron with its spits and supports; a vat in which a boiling [of ale] may be stirred(?); a cauldron for ordinary use [and its] utensils, including irons and trays and mugs, with its . . .; a washing-trough and a bath, tubs, candlesticks, knives for cutting rushes, ropes, an adze, an auger, a saw, a pair of shears, a trestle (?), an axe; the tools for use in every season, every implement thereof unborrowed; a grindstone, mallets, a billhook, a hatchet, spears for killing cattle; a fire always alive, a candle on the candlestick without fail; full ownership of a plough with all its outfit.[1]

90. The following are the functions of the *bóaire* of adjudication [aforesaid]: There be two casks in his house always, a cask of milk and a cask of ale. A man of three snouts (he is): the snout of a rooting hog that smooths the wrinkles of the face in every season; the snout of a bacon pig on a hook; the snout of a plough that pierces (? the ground); so that he may be ready to receive king or bishop or doctor or judge from the road, and for the visits of every company; a man of three sacks (that he has) always in his house for each quarter of the year: a sack of malt, a sack of sea-ash against the cutting up of joints of his cattle, a sack of charcoal for irons. Seven houses he has, a kiln, a barn, a mill—his share therein so that he grinds in it for others, a dwelling of twenty-seven feet, an outhouse of seventeen feet, a pigsty, a calf-fold, a sheep-fold. Twenty cows, two bulls, six oxen, twenty pigs, twenty sheep, four hundred hogs, two brood sows, a saddle-horse, an enamelled bridle. Sixteen sacks (of seed) in the ground. He has a bronze cauldron in which a hog fits. He owns a park in which there are always sheep without (need to) change ground.

IV 312.—He and his wife have (each) four costumes. His wife is daughter of his equal in grade in lawful matrimony. He is good in oath, in bond, in guarantee, in evidence, in hostage, in loan, in loan at interest, free from theft, from plunder, from homicide. Two *cumals* are his capital from a lord. A cow with its accompaniment is his house-custom, both winter-food and summer-food. Three persons are his company in the *tuath*. He is entitled to butter with condiment always. He protects his equal in grade. He is entitled to salted meat on the third, fifth, ninth, and tenth days, and on Sunday. He makes oath in litigation (up to) six chattels, he is bond, surety,

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[1] *Genus* may possibly mean "comfort" or "good cheer." The details in this instance indicate that the writer has in view a typical prosperous husbandman. *Fidchrann*, rendered "trestle" above, probably means a strong wooden frame to hold large timber for sawing, etc.

witness, hostage, and suitor to that amount. This is his full honourprice, but there are five chattels for going over his enclosure without leave. There is no penalty for opening it from without. Five chattels for opening his house without leave, a cow for gazing into it, a *dairt* for (taking) a handful (of thatch) from it, a *dartaid* for two, a *colpthach* for an armful, a *samaisc* for a half-truss, a cow for a truss, and restitution of the thatch. Five chattels for passing through his house or through his fold, for breaking his door; a *dartaid* for (removing) a rod below, a *dairt* for a rod above, a *samaisc* for a wattle below, a *colpthach* for a wattle above, a *dairt* for a front doorpost of the house, a *dartaid* for a rear doorpost of the house. Half honourprice of each grade of a *tuath* for stealing what is not his out of his garth, a seventh for stealing (bringing stolen property) into it. A short cast (of a spear) on each side is the lawful measure of his garth. Half the *díre* of a steading for trespass (therein). Penalty is and is not incurred towards him for breakage on the floor of the house: no penalty for each precious thing, penalty for each thing that is not precious; no penalty for gold and silver and bronze, penalty for every trough and all furniture that is proper on the floor; a *dairt* for a rear post of the couch, a *dartaid* for [a front] post of the couch . . . of fir (?) and oak; with restitution of each of them, both precious and not precious; a *dairt* for every piece of woodwork as far as the wall.[1]

IV 314.—To break a couch is exempt and not exempt from penalty. What is lower in order is exempt, what is higher in order is not exempt. The *forán* (?) of his kitchen has the same measure (of penalties) as the parts of the couch that are subject to *díre.* There is new straw (?) for the strewing of it.[2] What is subject to *díre* in regard of a bed: If it be a wisp (taken) from a pillow, its *díre* is a good cushion. If it be a wisp from any part below this, its *díre* is a good skin rug. If it be a wisp from the feet, its *díre* is paid in good shoes. If it be a wisp from the wall, new rushes for the

[1] "Penalty . . . for breakage." Breakage in the house, incurring penalties, must be by outsiders. If these were not present by the owner's leave, their acts would have a different complexion. The writer, then, has guests in view—a festive party, in effect, and damage resulting from indeliberate acts. This explains why liability is incurred for breaking things that are in their proper place on the floor, and not for breaking valuables which ought not to be on the floor, the responsibility in the latter case resting on the owner.

"Of fir and oak." There must be a lacuna preceding the corresponding passage in the text.

[2] *Airide* may mean something like an alcove. The lower parts, being ordinarily in the way of breakage, are exempt; the upper parts, being less in the way, would not be broken except by needless and excessive violence, and their breakage thus incurred liability. *Díre* = penalty above restitution. We may conjecture that the *forán* of the kitchen was a resting-place for the menials of the guesting party. To supply fresh litter is part of the penalty for the damage.

strewing of it. If it be throwing upside down, a chattel therefor, and restitution.[1] (There is) exempt and unexempt in the case of a bed. It is exempt to sit and lie down in it, and even if breakage be done it—in this case, up to a height level with the head; whatever is higher than the head is not exempt. The *díre* of the two posts is one chattel. If it be in the winter quarter, a half is added.[2]

91. Grinding without leave in the mill of a "landman," five chattels and forfeiture of the meal that is ground without permission, and honourprice if his guests have to fast. If there be damage, honourprice of each man whose property it is, and restitution with (forfeiture of) the forepledge of grinding.[3] If it be a kiln that is damaged, (in using it) without leave, a cow with a *dairt* is the *díre* for it, and restitution. Injury to anything in it is exempt, except corn that is threshed on the floor and its own sets of implements.[4]

92. The *díre* of his barn, five chattels, and restitution (of damage done to the building) with whatever is damaged in it. The *díre* of his pigsty, five chattels in swine, and restitution. The *díre* of his hatchet, a *colpthach*; half thereof for his billhook, before the time of fencing; in that time it is a *colpthach*.

IV 316.—**93.** *Fer fothlai,* "a man of withdrawal," why is he so called? This man takes precedence of (the other) *bóairig*, because he withdraws somewhat from the position of *bóaire* in order to lend capital to clients. The surplus of his cattle, of his cows, his swine, his sheep, that his own land cannot bear and that he cannot sell for land, that he himself does not need, he gives in capital to acquire clients. What are the returns from this man's chattels? Returns of seed from them: the value of each cow's manure in seed of corn for food; for a vassal is not entitled to malt till he be a lord.[5]

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[1] "The feet" may mean what is called in English the foot of the bed. "The wall" may mean the upstanding portion forming a back to the bed; it was probably padded with rushes after the manner of thatching.

[2] Here again, it is taken as a matter of course that the guests, having feasted, may damage anything that rightly comes in their way. If they go out of their way to damage things which are in a reasonably safe position, liability is incurred. The bed, having only two posts, must have been attached at one side to the wall. In winter, the damage caused greater discomfort and was harder to make good.

[3] *Tairgell* or *tairgillne*, "forepledge" (see *Bretha Comaithchesa*). When husbandry was carried on by neighbours in common, even to the extent of having fences between two holdings, they gave this kind of pledges to each other in advance as security against damage which one might suffer from the act or neglect of the other.

[4] The principle of proper place again operates here. Except its own implements and the corn, other articles are out of place in the kiln.

[5] This grade is between the vassal (*aithech*) and the lord (*flaith*) of Irish law. He has begun to acquire clients by lending his surplus capital, he himself remaining client to another.

94. Question—When does a vassal become a lord from the grade of *bóaire?* . . . . . When he has double (of the qualifications) of an *aire désso*, then he is the *aire désso* who is called a "*bóaire* excelling *bóairig*"—he acquires distinction over them if he obtains by advancing capital the [number of] clients of any *aire désso*, differing from him, however, (in having) double of (the qualifications of) an *aire désso*. Eight chattels is the price of his honour.[1]

. . . . . When, then, he doubles the wealth of a *bóaire*, then he is an *aire désso*; for, though he increase honourprice to that extent, it does not change the name of (his) grade for him. He makes oath (up to) eight chattels, he is bond, surety, hostage, suitor, and witness, to that extent. Four *cumals* are his capital from a lord. A cow with its accompaniment is his house-custom every second year, a two-year-old steer in the alternate year. Twenty-seven feet is his house, seventeen his outhouse. Four is the number of his guest-company. Butter with condiment for him always. He is entitled to four persons on sick-maintenance, lighting for four, salt meat on the third, fifth, ninth, and tenth days, and on Sunday. It is of this grade that the law of the Féni proclaims: "True lords are entitled to excess over the obedience that they reckon. A lord who is not valid obtains half the equivalent of the wealth that he amasses. Unless ten chattels give him status, five chattels sue covenants till there be perfect fulness of equivalents, for a half perishes from inevitable default (?)."[2]

95. *Aire coisring*, "a noble of constraint," why is he so called? Because he constrains *tuath* and king and synod on behalf of his kindred, to whom he does not owe fulfilment over simple contracts, but they accept him for chief and he makes speech for them. This is the "noble of a kin." He gives a pledge for his kin to king and synod and craftsmen, to compel them to obedience.[3]

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[1] Immediately following the question is the phrase, *Indul is frith faithce*, for which O'Curry's translation is, "Upon going into a true green," explained in a foot-note as referring to a precinct of four fields surrounding the house, but the words do not bear this rendering, and, as they stand, are to me unintelligible. The scribe may have substituted for some phrase obscure to him the known phrase *frith faithche*, meaning "lost property found on private land" (see V. 320, 328).

[2] The clause omitted, *Ni ar mrugfer riam*, is translated by O'Curry, "It is not among 'brughaidh'-men he is counted"—an untenable rendering. The text appears defective. "Lighting for four," *fursunduth cethrair*; there is no corresponding provision for the other grades. O'Curry's rendering is, "Food for four is required." The quotation, one of many not found in any published ancient tract, is not clear in meaning to me.

[3] I do not pretend to understand the technical force of the foregoing passage, beyond that the noble in question is the legal head and spokesman of a joint family. The "constraint" which is the basis of his designation is probably that which is expressed in the last sentence.

96. What is the amount of the pledge he gives? A pledge (to the value of) five chattels of whatever he has, of silver or bronze or yew.[1]

IV 318.—**97.** What is the fulfilment of his pledge? A cow for every night that (the pledge) is outstanding (?) on behalf of those on whose behalf it is given, up to the tenth night, is the (*fuillem*) price of engagement of the pledge, and (there is) in addition the compensation (for loss) of its function, and his honourprice according to his dignity, if it be his proper pledge that he has given; and if he give excess of pledge, his honourprice and his pledge sound with its price of engagement are to be repaid in like manner.[2]

98. Question—When is his pledge forfeited? At the end of a month. What is its fulfilment accordingly? A cow for every night that it is outstanding and that it has been neglected (i.e. that the condition for which it is security has been left unfulfilled) on behalf of a person who has neither given a pledge (on his own behalf) nor submitted to adjudication in its regard, as we have said. Five chattels, then, up to the tenth night, three times, in that case—this is the fulfilment of his pledge. This, then, is the engagement-price of his chattels, if he give them in a protecting cover.[3]

99. Nine chattels are his honourprice; he is bond, surety, witness, suitor, hostage to that extent. Five *cumals* are his capital from a lord. A cow with its accompaniment and a two-year-old steer with its garnishings in winter, along with summer-food, is the custom of his house. A house of thirty feet with an outhouse of nineteen feet. Five persons are his guest-company. He is entitled to butter, a *serccol* of condiment, salt meat on the third, fifth, ninth, and tenth day, and on Sunday.

100. The honourprice of every grade of these is complete, unless their means fail, that is, provided they fall not in the seven respects in which the honour of everyone falls. What are these? Answer—His defamation, to bring an accusation against him without (giving) a pledge for his honour, false witness, (to give) a false character, evasion of bond, default of suretyship, to forfeit his hostage in a matter for which the hostage has been given, defilement of his honour.

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[1] See "*Bretha im Fuillema Gell.*" In this form of security, a person incurring some liability was secured by getting someone of higher rank to deposit a pledge on his behalf. The pledge was usually an article of special value. Besides recovering the pledge, the debtor had to make a payment called *fuillem* for the benefit of it. If the pledge became forfeit by default, heavy liability was incurred.

[2] "*Bretha im Fuillema Gell*" states the kinds of pledge proper to be given by persons of various grades of status.

[3] "Five chattels" = the value of three cows. In the next sentence, "chattels" is to be taken in the ordinary sense, with reference to the articles, of whatever kind or value, that are given in pledge.

Slán, "fulfilment," here seems to mean the total liability incurred by the debtor or defendant towards the person who gives a pledge on his behalf.

V 320.—**101**. Question—What washes away from one's honour these seven things? Answer—Any filth that stains a person's honour, there be three that wash it away, soap and water and towel. This, first, is the soap, confession of the misdeed before men and promise not to return thereto again. The water, next, payment for whatever perishes through his misdeeds. The towel, penance for the misdeed, by the judgment of books.

102. These are the classes of *bóairig*. Each grade that is nobler precedes another.

103. After this begin the grades of lords. The basis of rule, that is, rule from (lordship of) a *déis* to a king.

104. How many are the subdivisions of these? Seven. What are they? *Aire désso, aire échta, aire ardd, aire túise, aire forgill,* second to king, and king.

What gives them status? Their *déis,* their rights, each of them, both small and great.

105. Question—What is the *déis* of a lord? The good right of protecting arts. There are four kinds of *déis* for lords: the ancient protection of the *tuath* is his function in the *tuath*, including the function of commander or second commander, whichever function of them it be; his clients of vassalage, his free clients, his old retainers; the punishment of every defective vassalage; the retention of cottiership and *fuidir*-ship that he brings on his land, for wealth is greater than worthies. If there be service from them to lords until the ninth nine (year), they are cottiers or *fuidirs*. They are old retainers thereafter.[1]

106. The *aire désso,* why is he so called? Because it is in regard of his *déis* that his *díre* (honourprice) is paid. Not so the *bóaire,* it is for his cattle that *díre* is paid to him.[2]

IV 322.—**107**. What is the property of an *aire désso*? He has ten clients, five clients of vassalage and five free clients. His five clients of vassalage, he is entitled to a definite food-provision from each of them. A cow with its accompaniment, and a two-year-old steer, and three yearling heifers, every winter, as well as his summer-food, he is entitled to from his five clients of

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[1] *Déis* here means the rule of a lord in the widest sense. Usually it means the body of persons subject to his rule. It is not easy to make out what particular four kinds of *déis* are intended. They are probably (1) military authority in the *tuath*, (2) *dóerchéli*, here called *céli giallnai*, "clients of vassalage," (3) *sóerchéli*, "free clients," (4) unfree tenants, including *senchlethi*, "old retainers," who were bound to the land, and *bothaig*, "cottiers," and *fuidre*, who were not so bound. After three generations of service, however, or eighty-one years, the *bothach* and the *fuidir* became *senchlethi*.

[2] In other words, the status of an *aire désso* or any noble of higher grade is based on the number of his clients; the status of a *bóaire* or any noble of lower grade is based on his wealth in kine.

vassalage. Ten married couples are his due (the company that he may lawfully bring with him) on visitation (of his clients) from New Year's Day to Shrovetide; he being son of a noble and grandson of a noble, and having his house in proper state, as to furniture and entertainment and rectitude. A house of twenty-seven feet, with a proper outhouse. Eight beds with their furnishing in it, drinking vessels, cauldrons, with the full supply of a noble's house of work-vessels, including a vat. He protects the rights of his clients in regard of liabilities, justice, statute-law, and treaty-law. (He has) a bed for his foster-son, his foster-brother, for man, for wife, for son, for daughter. He is well grounded in the law of the family and of the *tuath* and of lordship and of the church and of government and of treaties.[1]

Six *cumals* are his capital from a lord.[2] Two cows with their accompaniment are his house-custom in winter, with his summer-food (besides). A suitable saddle-horse with a silver bridle. He has four horses with green bridles and a precious brooch of an ounce. A lawful wife, his equal in birth, suitable to him, with equal outfit. Ten chattels are his honourprice. He makes oath, is bond, surety, hostage, suitor, witness, to that amount. Seven persons are his retinue in the *tuath*. He is entitled to butter always, with salted condiment. This is the *muclcithe* lord. He is entitled to six persons on sick-maintenance. Protection for six persons. He is entitled to butter and salt meat on the second, third, fifth, ninth, and tenth day, and on Sunday.

108. What gives ten chattels as the *díre* (= honourprice) of this man? Five chattels in regard of his own house in the first place, and five in regard of the five houses that are in vassalage to him, provided that he do not waste or diminish his nobility in regard of its means, small and great, lest he be cast out of his rule.

IV 324.—**109.** The *aire échta*, why is he so called? Because he is a leader of five who is left to do feats of arms in [a neighbouring territory under] treaty-law for the space of a month, to avenge an offence against the honour of the *tuath*, one of whose men has been lately slain. If they do not (avenge this) within a month, they come upon treaty-law, so that their beds do not follow him from without. If they kill men within treaty-law, the same five, the *aire échta* must pay on their behalf, provided that land or bronze of a

[1] This is a most important passage, showing that when it was written, though expert knowledge of the law belonged to the jurists, the ordinary knowledge and practice of it belonged also to freemen. It also states the main divisions of the law.

[2] From this it appears that a lord who had clients could himself be client to a superior lord. His "retinue in the *tuath*" is probably the number of persons who accompanied him to the assembly, as distinguished from his company when he visited his clients.

cauldron be not paid for it, but vessels to the value of a cow. He brings them out then to be . . . . . . till the expiration of treaty-law, (taking them) on the number of his protection and (that) of his friends. His retinue and his sick-maintenance are due as (those) of an *aire désso*.[1]

110. The *aire ardd*, "high noble," why is he so called? Because he is higher than the *aire désso*, and it is he who precedes him. He has twenty clients, ten clients of vassalage and ten free clients. His ten clients of vassalage, two cows with their accompaniment he is entitled to from them, and three two-year-old steers, and five yearling heifers, every winter, with their summer-food. He represents (?) his clients in contract and treaty-law. Each grade that is lower than he, they (can) be in clientship to him. Fifteen chattels are his honourprice; he makes oath, is bond, surety, hostage, suitor, and witness to that amount.

111. What gives fifteen chattels of honourprice for this man? Five chattels for him first, for the wealth of his own house; one chattel for each house from which he is entitled to a definite food-provision. Seven persons are his retinue in his *tuath*, five men in private. Protection of seven. He is entitled to salt meat and butter on the second, third, fifth [ninth and] tenth day, and on Sunday. Seven *cumals* are his capital from a lord. Three cows with their accompaniment are his house-custom. Twenty married couples are his proper company on visitation from New Year's Day till Shrovetide.

IV 326.—**112.** The *aire túise*, "leading noble," why is he so called? Because he is leader of his kindred and precedes an *aire ardd*. He has twenty-seven clients, fifteen clients of vassalage and twelve free clients. His clients of vassalage, he is entitled to four cows with their accompaniment from them, and five two-year-old steers, and six yearlings, every winter, with their summer food. Eight *cumals* are his capital from a king. Four cows with their accompaniment are his house-custom. Eight persons are his retinue in the *túath*, six in private. He is entitled to butter with condiment at all times. Eight persons on sick-maintenance, protection over eight. He is entitled to butter with condiment (during sick-maintenance), and ale or milk as his substitute for sick-maintenance on the second, third, fifth [ninth], and tenth day, and on Sunday.[2]

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[1] It is evident that the person above described differs from an *aire désso* only in function, not in status. No distinctive qualifications for status are ascribed to him. Apparently he was a sort of sheriff entrusted with the duty of punishing homicide committed on a member of his *tuath* by a person or persons in a neighbouring *tuath* under treaty-law (*cairdde*), but the exact nature of his operations is not easily understood, notwithstanding the simple diction in which they are stated.

[2] It may be observed that the number of animals in the return for capital in this case, as in the case of the *aire désso* and *aire ardd*, is the same as the number of vassal clients, though the animals are of different ages and values. If an *aire túise* becomes a vassal

Twenty chattels are his honourprice; he makes oath, is bond, surety, hostage, suitor, and witness to that extent. He is able to pay, if he be sued, without surety or borrowing. He has thirty married couples on visitation from New Year's day to Shrovetide, for the number on visitation is according to the number of (those who pay) food-tribute.[1]

Twenty-nine feet (is the measurement of) his house, nineteen his out-house. Eight beds in his house, with their full furnishing for the house of an *aire túise*, including six couches (*brothracha*), these having their proper furnishing, both cushions and rugs. Proper sets of furniture in the house, woodwork (?) of every size, and irons for every use and bronze vessels, including a cauldron which holds a beef and a bacon hog. He has clients for his company, holding free capital from a king.

Twelve horse-bridles, one of gold, the others of silver. He has not to beg (?) for pet animals, deer-hound, fighting-men, lap-dogs for his wife. He has the implements for every work, with a plough and its full lawful equipment. Two work-horses on the road. A wife in the legitimate right of marriage, his equal in kindred. So that he is full help in the *tuath* for pleadings (?), affirmations, pledge, and hostage in treaty-law across the border on behalf of his kindred and in the house of (his) lord (the king). He sustains right by warrant of his father and his grandfather. He can levy his full claim by his (own) power. He makes oath over a grade that is lower than he, and their affirmations support him (? are subordinate to him).[2]

IV 328.—**113.** The *aire forgill*, "noble of superior affirmation," why is he so called? Because it is he who makes affirmation above the grades that we have stated, on any occasion in which they happen to be opposed in statement, for his worth is nobler than the others. This man has forty clients, twenty clients of vassalage, and twenty free clients. His twenty of vassalage, he is entitled from them to five cows with their accompaniment, and six two-year-old steers and nine yearlings every winter, with their summer-food. Fifteen chattels are his honourprice; he makes oath, is

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client, his lord must be a king. Here is additional proof that the intermediate grade of *aire forgill* is of later origin than the grade of *aire túise*.

[1] There are two married couples as against each vassal client. So too, in the case of the *aire ardd* and the *aire désso*. Apparently these nobles were entitled to quarter themselves between New Year's Day and Lent on their vassal clients, and to exercise the same privilege for a definite number of their friends.

[2] This last sentence is probably an early gloss on the next following words, *aire forgill*. *Fosernnat a nóillig*: *nóillig*, "oaths," is nominative plural, and an infixed pronoun, 3rd sing. masc., is concealed in *fo-*. The noun corresponding to *fosernnat* is *fossair*, a thing *substratum*; it is the term for (1) the furniture of a house, 320 z, and (2) the minor provision that accompanied a steer, etc., in food-render (*Cáin Aicillni*, passim).

bond, surety, hostage, suitor, and witness to that extent. He pays them without security or borrowing, if one sues. Nine *cumals* are his capital from a great lord. Five cows with their accompaniment are his house-custom. Nine persons are his retinue in his *tuath*, seven in private. Butter with condiment, and salt meat, and ale or milk are his substitute for sick-maintenance on the second, third, fifth, ninth and tenth day, and on Sunday. Thirty feet (is the measure of) his house, twenty feet his outhouse. The furniture of his house, his great cattle, his horse-bridles, his apparatus (of husbandry) for every season, his wife's degree (are all) in propriety of right.

114. The "second of a king," why is he so called? Because the whole *tuath* looks forward to him for the kingship without dispute. He has five retainers (*senchlethe*) over and above (the number of clients proper to) an *aire forgill*. Ten persons are his retinue in the *tuath*, eight in private, ten on sick-maintenance, with the same right (of food-provision, relatively, as the aforementioned grades); with amplitude of great cattle, with full number of horses, with apparatus for every season, with a worthy wife. Ten *cumals* are his capital from a lord, six cows his house-custom. Thirty chattels are his honourprice; he makes oath, is bond, surety, hostage, suitor, witness to that extent. He pays them (i.e. is able to pay to that extent) without security or borrowing, if one sue.[1]

IV 330.—**115.** The king, *rí*, why is he so called? Because he exerts (*riges*) the power of correction over the members of his *tuath*. Question—How many classes of kings are there? Three classes. What are they? A king of peaks, a king of troops, a king of the stock of every head.

116. A king of peaks, first, why is he so called? This is a king of a *tuath*, who has the seven grades of the Féni with their subclasses in clientship, for these are the peaks of rule that we have stated. Seven *cumals* are his honourprice, a *cumal* for every chief grade that is under his power. He makes oath, is bond, surety, hostage, suitor, witness to that extent. He pays this (amount) without security, without borrowing, if one sue. Twelve men are his retinue in the *tuath*, nine in private. Ten persons on sick-maintenance, upon his due provision of food. Twelve *cumals* are his capital from a lord, six cows his house-custom.

IV 330.—**117.** A king of troops, why is he so called? Because he is a vice-king of two troops or of three troops. Seven hundred in each troop. This is the king of three *tuatha* or of four *tuatha*. Eight *cumals* are his

[1] The want of definite statement as to qualifications in wealth, etc., may be due to this grade not being of tradition. It is found in no other list of grades.

honourprice, for he takes a number of hostages, two or three or four, as (the the tradition of the Féni) says in verse:

> The king of the mead-round, of drinking, of governance,
> Whom drinking confoundeth not in his law,
> Is entitled to a *cumal* over seven
> For the *díre* of his function.

Twenty-four men are his retinue in his *tuath*, twelve men in private. Fifteen *cumals* are his capital from a lord, eight cows his house-custom. A king of troops has no sick-maintenance. Eight *cumals* take the place of his sick-maintenance. Eight *cumals* are his honourprice; he makes oath, is bond, surety, hostage, suitor, witness, to that extent. He pays this amount without security or borrowing, if one sue.[1]

118. A king of the stock of every head, now, why is he so called? Because it is under the power of his correction that every head is whom its lord does not constrain; for every head that is stronger takes precedence of that which is less strong. This is the king of overkings. There are twice seven *cumals* in his honourprice, because kings and *tuatha* are under his power and correction. He makes oath (up to) twice seven *cumals*; he is bond, surety, hostage, suitor, witness to that extent. Thirty are his retinue in his *tuath*, seven hundred elsewhere for correction among others. A king of overkings, a king-poet, and a hospitaller are without sick-maintenance among the grades of a *tuath*.

Half the sick-maintenance of (a man of) each grade is due to his lawful son, to his wife . . . for what is a fourth in regard of every unlawful person is a half in regard of every lawful person. A woman-guard, her sick-maintenance (is measured) by the honour (i.e. grade) of son or husband. Administrators, envoys, are maintained at half the sick-maintenance of their lords. They act so that by the goodness of their action they are maintained according to the provision made for them by their lord.[2]

IV 332.—Every craft that makes manufactured articles of ruler or church is maintained on half-maintenance according to the dignity of each one whose manufactured articles he makes. The maintenance of each grade in the church is according to the corresponding grade in the *tuath*. Every mother along with her son on sick-maintenance, if she be alive.[3]

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[1] *Aurri*, "vice-king," either because he leads the troops of his subject kings on their behalf or on behalf of a superior king. In later usage, *urri(gh)*, "urriagh" of Anglo-Irish, means a sub-king.

[2] The last clause seems to mean that the right of these persons to maintenance is based not on their own wealth or rank, but on the function they discharge as deputies for their lord and on the provision which he makes for them.

[3] The digression, in which the statement of the rights of a particular grade to sick-maintenance leads to a more general statement on the subject of sick-maintenance, is of a kind typical in the early law-tracts. Like the form of question and answer in which this tract is cast, such digressions are reminiscent of the school.

119. Question—Which is higher in dignity, king or *tuath*? The king is higher. What dignifies him (above the *tuath*)? Because it is the *tuath* that raises the king to honour, not the king that raises the *tuath*.

What are the sustaining means of a king toward the *tuath* that raises him to honour? Making oath on their behalf to (another) king at the bounds of the border; he makes denial on oath for (lit. from) them; he makes superior oath over them (to the extent of) seven *cumals*; he goes into joint adjudication, into joint evidence, with (another) king on behalf of his *tuath*. It is their right that he be a faithful judge to them. It is their right (that he give) pledge on their behalf. It is their right (that he give) sick-maintenance as he is maintained. It is their right that he do not pledge them to hold an assembly (in which) he does not assemble the whole tuath but only the co-nobles.[1]

120. There are three requisitions that are proper for a king (to levy) on his *tuatha*, an assembly, and a convention for enforcing authority, and a hosting to the border. The joint holding (?) of an assembly, however, belongs to the *tuath*. What a king pledges for an assembly is his (to decide), provided that the pledge he gives be a proper one.[2]

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[1] "Sustaining means," *foluid*: this word, a plural masculine, signifies the means, assets, functions, etc., by which a person discharges his duties or liabilities.

This is an interesting passage, in which the king appears less as ruler than as agent of the *tuath*. The king is higher than the *tuath*, but only because he is raised by the *tuath* above themselves. He transacts their legal business with other *tuatha*, for each *tuath* formed a separate and complete jurisdiction. The kings thus provided the nexus by which these distinct states were bound into a single nation and by which the national law, common in theory, was made common in fact. The king's function as judge is said to be a service to the *tuath* to which they are entitled from him. The last sentence is rendered by O'Curry: "They are entitled that he does not pledge them for a fair, that he assemble not the whole territory, but the neighbours (or co-occupants)." The *tuath*, however, means the body of freemen under a king. *Comaithe* is taken by O'Curry to be a miswriting of *comaithig*, and this word, which means "co-vassals," that is, clients who practised agriculture to some extent in common, came afterwards to mean "neighbours," from which it has also developed the sense "strangers," and hence an adjectival form, which may be written *cofuioch* and *cuihach*, "wild," etc. But O'Curry's rendering would require *tuinmella* not *tuinmell*, "assembles." I do not understand what is meant by "pledging an assembly on the *tuath*," unless it be that the king is not to give a pledge to cause his *tuath* to attend an assembly outside of their own territory. I take the *commaithe*, "co-nobles," to mean the *soerchéli* of the kings, called in the annals his *socii*. These were as a rule the principal nobles of the *tuath*, who by law were obliged to become free clients to the king if he so required. They were thus bound to attend his court, and no doubt to accompany him when he attended an external assembly. I understand the text to mean that the other freemen of the *tuath* were not so bound.

[2] The second and third of the foregoing sentences appear to have reference to a joint assembly of several *tuatha*. Such an assembly would be convened by a superior king. To ensure attendance, the superior king would begin by requiring a pledge, something specially precious, from each of the subordinate kings.

121. Question—How many things is it proper for a king to bind by pledge on his *tuatha*? Three. What are they? Pledge for hostings, pledge for government, pledge for treaty, for all these are benefits to a *tuath*.

122. Question—How many hostings are proper for a king to bind by pledge on his *tuatha*? Three. What are they? A hosting within the border inwardly to keep guard on (or against) an (external) hosting across it; a hosting to the bounds of the border to watch over proof and right, that he may have battle or treaty; a hosting over the border against a *tuath* that evades him.[1]

IV 334.—**123.** There are, then, four kinds of government to which a king binds his *tuatha* by pledge. What are they? The government of the common Irish law (*Féneчhais*) in the first place. It is the *tuatha* that adopt it, it is the king who compacts it. The three other kinds of government, it is the king who enforces them: government after their defeat in battle, that he may unite his *tuatha* thereafter so that they may not destroy each other; and government after a pestilence; and a king's government [over other kings], such as the government of the king of Cashel in Munster. For there are three governments [of a king] to which it is proper for a king to bind his *tuatha* by pledge: government for the expulsion of a stranger-kindred [i.e. against the Saxons], and government for the raising of produce (?), and a law of religion that kindles, such as the Law of Adamnán.[2]

124. These are the sustaining means of a true ruler over his *tuatha*, and he cannot violate them by falsity or violence or overmight. Let him be sound, distinguishing [fairly], and upright, between weak and strong.

125. There are also three other things that they require of a king: let him be a man of all sides, full of right; let him be a man inquiring after knowledge; let him be steady and patient.

126. There are four stoopings (?) that give the *díre* (i.e. honourprice) of a vassal to a king. What are they? His stoopings over the three hafts of a vassal, the haft of a mallet, the haft of an axe, the haft of a spade, for while he is upon them, he is a vassal; his stooping (to be) alone, for it is not proper for a king to go alone. That is the day when a woman by herself can prevail in oath fathering her son on a king, the day when there is none to attest for him but (himself) alone.

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[1] "Evades him," i.e. refuses to come to terms with the king about a claim or matter in dispute.

[2] Government belonged to the king specially, when the people were disorganized by defeat or pestilence, and in the case of a superior king over subordinate kings. "A stranger-kindred," *echtarchenél*. I think usurping intruders on the kingship are intended, but if the gloss "against Saxons" is ancient, it is a reminiscence of the invasion by the Angles in 685.

127. There is a month when a king does not go accompanied but by three (lit. does not go but four). What are the four? King and judge and two in servitorship. What month does he go in this wise? The month of sowing.

128. To be wounded in the back, too, in fleeing from combat gives him a vassal's *díre*, unless it be that he has gone through them (his enemies) [and so receives a wound in the back], for it is in such a case that *díre* for a king's back is paid as for his front.

129. There is, too, a weekly order in the duty of a king, to wit: Sunday for drinking ale, for he is no rightful ruler who does not provide ale for every Sunday; Monday for judgment, for the adjustment of *tuatha*; Tuesday for playing chess; Wednesday for watching deer-hounds at the chase; Thursday for the society of his wife; Friday for horseracing; Saturday for judging cases.[1]

IV 336.—**130.** There are three fastings which do not aggrieve (?) a king: (first), if a king be at a cauldron that has leaked; fasting when there has been default (in providing) a joint of his supply (?), but so that evil men are not sent to slay him; fasting when there has been refusal (of hospitality), for (in that case) he is entitled to more than (he loses by) the offence, since he is entitled to his honourprice.

131. Question—Who is proper and right to make a king's food? A man of action of three captures. What are these? A man who makes a capture in single combat by piercing the (other) man through his shield; a man who takes a man alive, capturing him in combat; a man who kills a stag with one stroke, finishing him; a man who takes a prisoner without aid (?); a man who captures a champion in front of an army so that he falls from one thrust.[2]

132. There are, too, three exactions for which they do not sue a king: exaction from an (external) *tuath* that avoids him when he invades it: exaction when there is an external king with him in his own *tuath*, if he reach not his man; exaction of dry cattle in waste land that have come in over the border. He makes restitution to everyone to whom the cattle belong in the two last exactions, but he does not make restitution in the first, unless it be an unrightful invasion.[3]

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[1] Apparently the king on Monday sits as judge in matters of state, on Saturday in ordinary litigation. Where the plural, *tuatha*, appears, the writer has a superior king in view. The programme is, no doubt, artificial, and serves to set forth a statement of a king's ordinary occupations—hospitality, presiding in his court, outdoor sports, and domestic life.

[2] Possibly an original three has been expanded to five by a later writer.

[3] Here, as in many other passages, invasion of a neighbouring territory is regarded as a lawful form of levying a claim. In the first instance, the claim being evaded, the

133. What is the due of a king who is always in residence at the head of his *tuath*? Seven score feet of perfect feet are the measure of his stockade on every side. Seven feet are the thickness of its earthwork, and twelve feet its depth. It is then that he is a king, when ramparts of vassalage surround him. What is the rampart of vassalage? Twelve feet are the breadth of its opening and its depth and its measure towards the stockade. Thirty feet are its measure outwardly.[1]

There are clergy for making the prayers of his house. A waggon of charcoal, a waggon of rushes, for every man if he have recited (the said prayers).

The ruler of a staff is not entitled to have his stockade made, but only his house. His house (measures) thirty-seven feet. There are seventeen beds in a royal house.[2]

IV 338.—**134.** How is a king's house arranged?

The king's guards on the south. Question—What guards are proper for a king to have? A man whom he has freed from the dungeon, from the gallows, from captivity, a man whom he has freed from service, from servile cottiership, from servile tenancy. He does not keep a man whom he has saved from single combat, lest he betray him, lest he slay him, in malice or for favour.

135. What number of guards is proper for a king to have? Four, namely, a frontman and a henchman and two sidesmen, these are their names. It is these that are proper to be in the south side of a king's house, to accompany him from house into field, from field into house.

A man of pledge for vassals next to these inward. What is this man's dignity? A man who has land of seven *cumals*, who presides over his (the

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whole *tuath* is held liable. The second instance is somewhat similar: the claim is made by an external king and supported by the king of the *tuath*; if the defendant cannot be reached, the levy is made on the *tuath* at large, since the due cannot rightly be withheld; but the local king (whether he can make the defendant pay or not) is bound to repay what he exacts from others. In the third instance, milch-cattle are excluded, because their milk repays the trespass; and the case is confined to waste land, because the law has distinct provisions for trespass on good land.

[1] The "rampart of vassalage," *drécht giallnai*, seems to denote an outer earthwork of which the external slope measures 30 feet, the internal 12 feet, the flat top 12 feet, diametrically, the width of the opening between its top and that of the inner earthwork or stockade being also 12 feet.

[2] The "ruler of a staff," *flaith bachail*, means a king who has abdicated and gone on pilgrimage, carrying afterwards a pilgrim's staff as the emblem of his turning to a religious life. Since he ceased to be a man of war, his house is unfortified. Ritchie (IV cc–ccvii), in the course of a laboured discourse intended to discredit the way of life of "a Celtic prince of the period," says that the measurement given above for the house of a pilgrim ex-king applies to "the house of the head king." The text gives no measurements for the house of a reigning king of any grade.

What follows is a description of a king's house when his court is sitting in it.

king's) chattels, including (those of) lord and base man and of the law of the Féni.[1]

Next to him inward, envoys. Next to these, guest-companies. Poets next to these, harpers next. Flute-players, horn-players, jugglers, in the south-east.

On the other side, in the north, a man at arms, a man of action, to guard the door, each of them having his spear in front of him always against confusion of the banquet-house [by attack from without]. Next to these inward, the free clients of the lord (i.e. of the king). These are the folk who are company to a king. Hostages next to these. The judge (the king's assessor) next to these. His (the king's) wife next to him. The king next. Forfeited hostages in fetters in the north-east.[2]

136. The king of a *tuath* (has a retinue) of twelve men (when he goes to the court of a superior king) to (protect) the interests of the *tuath*; whom the *tuath* itself sustains as regards their expenses (?). Twelve men, too, are the retinue of a bishop for the interests of church and *tuath* in which he himself goes (on visitation). For a *tuath* cannot bear the retinues of king and bishop if they be always battening on it. The retinue of a master also is twelve men.[3]

137. Which is higher in dignity, a king or a bishop? A bishop is higher, since a king rises to salute him because of religion. A bishop, too, raises his knee to salute a king.[4]

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[1] The meaning of the last phrase is not clear. *Andóin*, "a lowly person," is rendered "*andoin*-church" by O'Curry, who confuses the word with *andóit*. For *córus Féne*, "law of the Féni," we should perhaps read *córus fine*, "law of the joint family."

[2] The entrance is in the western end. The company is ranged in two rows face to face on the southern and northern sides. The king sits in the eastern end, no doubt facing the door. His wife sits on his right. Next to her, his judge. The unforfeited hostages have a place of honour on the king's right. The other occupants of the right or north side are the king's free clients, who are the nobles of the *tuath* and the principal members of the *airecht* or court. On the opposite side are harpers, poets, guests, and envoys. The inward corner on the king's right is occupied by forfeited hostages who are fettered; the corner on his left by musicians and jugglers. Near the entrance are the king's bodyguard on the left, the guards of his house on the right.

[3] The "master" (*súi*) is the head of a Latin school. His later title is *fer légind.*

[4] The gesture of "raising the knee" is perhaps what is called genuflexion, the knee being raised not absolutely but relatively as regards the body.

The meeting of a king's *airecht* in his house had a twofold character, social as well as judicial. It is likely that the court, after the manner described already, sat on two sides of a long table, and that business was followed by festivity. The poem quoted below represents the king presiding over the ale-feast, but goes on immediately to describe the kind of adjudication expected of him. The business of the court was mainly concerned with matters of land-law, such as are treated of in *Bretha Comaithchesa* (IV) and in *Din Techtugud* (IV). The translation is uncertain in some places.

[At the end of *Crith Gablach* there is added, apparently as an afterthought, a poem which is probably somewhat earlier in date than the prose, since it is quoted from *Fénechus,* i.e. from the law as it was held to have come down in ancient tradition. The poem is introduced by the words *Dligthir brithem la ríg rodbo brithem cadesin, amal arincan Fénechus.* "A (professional) judge should be with a king (in court), even though he himself be a judge, as Fénechus teaches"—meaning, not that a king might be a judge, for the judicial office belonged to every king, but that a king, even if he were himself an expert jurist, ought to have a professional assessor in his court. The poem is in archaic metre, without rhyme or exact measure of syllables, in short verses, each of which, as a rule, contains two fully stressed words, the last stressed word of each verse making alliteration with the first stressed word of the following verse. The type is found in lines 6-9: *mess tíre* | *tomus forrag* | *forberta díre* | *díthle mesraid.* From this type, however, there are numerous departures. O'Curry's transcript, from which the text in IV is printed, ended with verse 30. The remaining seventy-three verses are taken here from the copy printed by Meyer in "Zeitschrift für Celtische Philologie," XII, 365. This copy would have escaped my notice had not R. I. Best reminded me of it. The abrupt ending may indicate that even here the poem is incomplete.

The date of composition is earlier than *Crith Gablach,* and cannot be placed later than towards the end of the seventh century. As my references show, the poem is in the main a kind of metrical list of the contents of *Bretha Comaithchesa,* of which in several places (ll. 28–30, 75, 85–87, 91–95) it reproduces the actual wording. It adds, however, a number of titles, as we may regard them, of a kindred kind not referable to the extant text of BC, but possibly related to another version of that text, since some of them (e.g. ll. 70–74) are in close verbal relation to passages of Old Irish now embodied in the Commentary to BC. The orthography exhibits the mixture of earlier, later, and spurious spellings usually found in late transcripts of pieces of very early Irish. A few of the oldest spellings have been allowed to remain. In l. 7, *forrag,* read **forreg*; cp. *aireg,* in the text of CG, IV, 320, l. 24; already in Adamnán is found *Ficchrech* beside the earlier *Fechureg.* In l. 71 *ān, tān,* infinitives of *ag-, to-ag-*; Pedersen, Vergl. Gram., §§ 634, 652, has only *áin, táin*; Meyer, Contribb., only *áin,* but fragments cited in the commentary aforesaid, IV, 98 and 146, confirm *ān.*[1] In l. 99, *fogeltath.*

[1] Cp. IV 156 x: *Ata annad aclaidh dligeas cach comaithcach dia raile,* "there is one stay which every co-tenant is entitled to from the other": read *Attáu án nád acclaid,* etc., "there is a driving which is not (subject to) suit, to which each joint husbandman is entitled from the other." The right discussed is to drive cattle across a neighbour's land.

I have not essayed the difficult task of restoring the oldest spellings throughout, but have left unchanged some forms that are found in late Old Irish, e.g. *comaithig*, *fiachaib*, *airech.* Where a restored spelling seemed to require justification, I have given the MS. reading in a foot-note. Corrections of minor significance will be recognized from comparison with Meyer's text.

The general sense of the poem is that a king, in his judicial capacity, ought to be familiar with the details of the law of joint husbandry (*comaithchius*). The old name for the body of law on this subject is *mrugrecht* (lines 10, 88) — see IV, 124, where the scope of this body of law is described.*

The poem confirms my view that the law-tracts with accompaniment of gloss and commentary received in the law schools as "canonical," so to speak, may be ascribed to the seventh century.]

IV 340.—**138.**

má be rí rofesser	If thou be a king, know
recht flatho fo thōith	the rule of prince towards people.
iar míud mescbaid	According to dignity, he will make merry
a slóg sabaid	their throng of magnates
cuirmmthige cuirmmescai	with the intoxication of a festive house.
mess tíre	(Know) appraisement of land,
tomus forrag	measurement of *forrachs*,
forberta díri	increments of *díre*,
díthle mesraid	wastings of forest-fruit,
mórmúin mrugrechta	the great wealth of farm-law,
mrogad coicrīch	marking of common bounds,
cor cuálne	planting of stakes,
córus rinde	regulation of points,
rann etir comorbbe	sharing among joint heirs,
comaithig do garmmaimm	naming joint husbandmen,
Gaill chomlaind	Gauls of combat,
caithigti istoda	defenders of treasure (?),
anagraitto rīg	when they sue from (?) a king
rāith commairge	surety of protection.

[1] *Mad bé ríg* MS. [2] *flatha fothoth* MS. [3] *mbiad* MS. The usual expressio n in the Law for "according to status or dignity" is *fo miad*, I 40, 13, etc. The meaning is that, at the king's feast, the guests were seated according to precedence, as described at the conclusion of *Crith Gablach*, where the house in which the *airecht* sat is also called *cuirmmtheg.* [4] I take *sabaid* (*sabaide?*) to be an adj. formed from *sab.* [5] *cuirmmtigi cuir mesca* MS. [6] This is the subject of the tract *Fodla Tíre*, IV 276. For measurement by *forrachs* see ib. y, z, and III 335. [11-12] = IV 30. [13] = IV 112. [14-15] = IV 68. [17] *caithigti*, nom. pl. of **cathigthith?* *istoda* r. *autsado?* [18] R. *a n-aggrat ó ríg?*

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* For *ar nach ara*, "that he may not plough it," read there *ar nach áir* (< *ad-reg-*), "that he may not trespass on it by *árach* (tethering cattle)"; and for *ar nach aitreaba*, "that he may not inhabit it," read *ar nach attraba*, "that he may not trespass on it by *attrab* (housing cattle)." The list of trespasses indicated is *orgun mrogo*, "destruction of boundary"; *béimm fedo*, "cutting of wood"; *aurbe*, "breaching of fences"; *árach*, *attrab*, *caithche aile*, "damage (to cattle) by (dangerous) stakes"; *tarsce*, *ruriuth.* See poem, ll. 27, 31, 72, 81, 83.

[A] chórus co fesser	[Its] regulation that thou mayest know,
sétaib selb[aib]	with chattels, with lands,
slán cech comaithchius	every community of husbandry is secure
curthar gellaib	that is settled with pledges
gelltar smachtaib	that are pledged for fines
míach molauga	of sacks, greater, less,
lóg díri	the payment of *díre* ;
díre n-aurboi	the *díre* of breaching (fences),
ó dartaid co dairt	from *dartaid* to *dairt*,
dochumm colpdaige	as far as to a *colpthach*,
co cóic séotu cingit	up to five chattels they mount.
Cia annsom fidbéimme	Which is hardest (among cases) of wood-cutting
fiachib báeth	in liabilities of the unwise?
mrugid caille	The farmer of the forest,
coll eidnech	the ivy-clad hazel;
esnill bes díthérnam	a risk that shall be hard to escape,
díre fidnemith náir	the *díre* of the noble sacred grove;
ní bíe fidnemeth	the sacred grove shall not have
fíachaib secht n-airech	the dues of the seven nobles,
ar it téora búi	for it is three cows
ina bunbéimmimm bís	that are (allowed) for its stem-cutting.
bíit alaili	There are others
secht sétaib lossa	of seven chattels, herbs.
laumur ar dochonnaib	There is conceded (?) for unfree persons
dílse caille	the irrecoverable things of the forest,
cairi fulocht benair	a cauldron's cooking that is cut,
bos chnao fuisce	the handful of nuts carried away
frisna laim hi saith suí	

[23] = IV 78. The particular kind of pledge referred to is named *tairgillne, tairgille*, with a corresponding verb *to-airgella*, IV 128, 9. The technical names of varieties of *gell*, "pledge," are usually formed with *-gillne, -gille*, instead of *gell*, e.g. *lángillne, lethgillne, ingillne, coingillne*. *Tairgillne* was the kind of pledge given in advance by one joint husbandman (*comaithech*) to another as security against prospective damage by trespass of cattle, etc. [25] For *molauga* read *mau laugu*. The fines stated at IV 78 are of three sacks, one sack and half a sack (of corn). [27–30] = IV 152, *aurbe . . . dartaid . . . dairt . . . cóic séoit*. The successive stages, supplying measures of value in the Laws, of the growth of a cow are *lóeg* (1 to 6 months ?), *dartaid* (6 to 12 months ?), *dairt* (12 to 18 months ?), *colpthach* (18 to 24 months ?), *samaisc* (bearing the first calf), *bó* (after calving). The *sét* or standard "chattel" of the Laws was the *samaisc*. "Five chattels" equal in value three milch-cows. [22] *comaithces* MS. The prefixing of *com-* causes a secondary syncope in this word < *aithechus* (Meyer, Contribb.) < aithech < aithe < * *ate-vion*. Cp. *aithechaib, aithechde*. So acc. pl. *comaithchiu*. [34] What follows on the subject of trees is in relation to IV 146 seqq. [35] *esnill*, later *eslinn*, < *ess* and *indell*, I 242, 8, *a heslinn co innill*, "from an insecure place to a place of security." Cp. *comindell tuaithe*, II 12, a description of the proper place of custody (*forus*) for chattels seized in *athgabál*—glossed: "That it be not the border, i.e. that it be *indell* within the *tuath*, the middle of the *tuath*, that there be not thieves or purchasers." [36] *fidneimid* MS. [36] The *díre* for cutting the stem of any one of the "seven nobles," oak, hazel, etc., was one cow, IV 146. The sacred grove was an exception, V 474. [40] *ara teora bú ina bun béim bís* MS. [43] *dochundaib* MS., meaning persons not *sui juris*. I am not sure what to make of *laumur*, but propose to read *laumair*, lit. "it is dared." [45–46] Among the things that can be freely appropriated are *fulacht cecha caille* and *cnuas cech fedo*, V 482. *Fuisce* < *fo-scuich-* (*foscugud*, by analogy with *cumscugud*, etc.). Perhaps we should read *fuiscthe*. *Tairsce* < *to-air-scuich-*.

slán emde	
díthgus díthlai	
díre ndaro	The *díre* of the oak,
díre a gabal már	the *díre* of its great boughs,
mess ocus béobethu	fruit and living life,
a bunbéimm béimm bairr	its stem-cutting, cutting of top,
in óinchumba chulinn	the one hewing of the holly,
colluth cuill	destruction of the hazel,
combach n-ablae	smashing of the apple-tree ;
annsom de n-ardnemith	most difficult of the cases of *díre*
díríb secht n-airech	of the seven nobles of the high sacred grove
asabbi bo	for which a cow is (due),
bunbeimm bithe	the stem-cutting of the birch,
baegul fernna	the danger of the alder,
fube sailech	the assailing of the willow,
sluind airriu aithgin	declare for them restitution ;
anóg sciath	to incomplete restitution (?) the hawthorn
sceo draigen dringit	and the blackthorn rise,
co fedo forbull	with the . . . of the wood
forbul ratho	. . . of fern,
ráithiud áine	bogmyrtle, furze (?), rushes,
acht a ndílse do flaithib	but they become the property of lords.
fothla tothla	*Fothla, tothla,*
án tán aircsiu	driving in, driving out, looking on,
árach attrab	tying, housing,
follscud foilliuchta	burning, leaving tracks,
íadad aurlimm	closing, overleaping,
én cercc corr	Hawk, hen, heron,
ma bet pettai	if they be pets,
oiss eisrechta	tame fawns,
[caithche] con caithche bech	damage of hounds, damage of bees,
biit i trenaib tíre	they are in thirds of land
to n-accmoing tairgillne	to which anticipatory pledge applies.
taurrána tairsce	Drivings across (?), trespassing,
taulberna tar róut	front-breaching across a road,
ruriuth tar ilselba	rushing over many holdings,
samail tráchta	likewise strands.

[51] *gabail* MS. [52] *béobethu,* "living life," meaning sustenance for animals, IV 88 z. [53] *a bun beín beín mbarr* MS. See IV 148, 23, etc. [54] *in aencumma culinn* MS. Read perhaps *inann cumbe culinn,* "alike is the hewing of holly." [56] *n-abla* MS. [57] A poetical inversion for *annsom de díríb secht n-airech n-ardnemith.* [59] Read *assa mbí bó.* See V 146. [60] *bunbéimne* MS. [61] *boegal* MS. [62] *fuba* MS [65] *draigin dringid* MS. [65] Read *rait aitend?* See V 148, 1. [70-74] The list of "man-trespasses" at IV 98, 17 and IV 146, 16 has *aradh* : *araig* (read *árag*), *aitrebadh* : *aitreb* (r. *attrab*), *follscudh* : *follscuth, fothla, tothla, an, airgsiu* : *aircsiu.* IV 156, *Cuic seoit a n-ain ocus a tain. Fothla* and *tothla* are exemplified at IV 106 and V 466, 6. *'Arach, árag* (< *ad-reg-*) means tying one's cattle on a neighbour's land; *attrab,* housing them there—these were aggravated trespasses. *Foilliuchta* may mean making tracks or paths (*fo slicht*) through fenced land. *Iadad* is likely to mean shutting cattle in on a neighbour's land into which they have trespassed. *Aurlimm* = *airlimm,* IV index. [75-77] See IV 114, 10, regarding the trespasses of all these pets : *én* = *senén. Mad beth* MS. [78] = IV 120, 122. [79] = IV 114, 116, 1. [80] *tairgille* MS. See note to line 23. [81] *taurrán na* MS (< *tar-aur-án?*) For *tairsce* see IV index. [82] = IV 136, 19. [83-84] = IV 138, 2.

tomus airchinn	Measurement of the fore-end
cethrib[41] forrgib	in four *forrachs*
co n-aurchur flescaich	and a stripling's cast.
forcsiu mruigrechta	Overlooking in farm-law,
mrogad cocrích	marking of common bounds,
tarsce tigradus	last responsibility for trespasses,
smachta iar cintaib	fines after offences [husbandmen.
cóicthi cóir chomathech	on the fifth day in the right of joint
cid ag conranna fri ét	What calf shares equally with the herd?
cid airlimm óenoircc	what overleaping by one pigling
conranna fri trét	shares equally with the drove?
cis tána dichiallatar	what drivings are done privily
tonásegar tigrathus	for which last responsibility is not sued?
cis taurrána foichlide	what are the deliberate drivings across
forsná sói fogeltath	on which cost of grazing does not return?
cis formenn écndaircc	what are the ridings (?) in absence
doslíat dílsi	that incur expropriation?
cis ndíthle di threbaib	what are the takings from dwellings
ná tuillet díre.	that do not incur *díre*?

85–87 = *aircinne, cethrai, flescaith,* MS. IV 138: *Caide a n-airchenn? Teora forrge ocus aurchor flescaig* (sic. leg.). Acc. to *Fodla Tíre,* IV 276 yz, there were six *forrachs* in the "fore-end" (*airchenn*) of a *tír cumaile* and twelve *forrachs* in its length. 88 I take *forcsiu* to be like in meaning to *aircsiu.* Cp. V 464: *Fer tailci a chethra i n-athbóthar a chéli nó ar-da-aicci ann* (sic. leg.), where, for *ar do aice,* "who looks on at them (in the act of trespass)," Atkinson has "where there is tillage near." *Aicill araicci Temuir,* "A. which overlooks T.," is the often mistranslated first line of a poem by Cinaed Ua hArtacáin. 90 See Heptads, V 136, 137. *Tigrathus, tigradus* <*tig-, tiug-,* and *ráith,* seems to mean the liability which falls on the last person who had charge of animals, etc., which afterwards committed damage or suffered damage. 91–92 = *Smachta . . . cóicthi iar fogail,* IV 86 z; *smacht dia cóicthe iar fogail,* IV 94, 7. 93 = *ag conranna cinaid fri hed,* IV 108, 13. 94 = *orcc conranda cindta fri tret,* IV 108, 8. 98 *foichlichi* MS. See IV 156, 17. 99 *fogeltad,* cost of feeding cattle, etc., in custody. See IV 104 y, etc. 100 There is nothing in the *Comaithches* tract that appears to correspond to the last two questions. At V 486 there is a list of indoor effects that could be taken or used "without suit or payment" (*cen acre cen éraicc,* 490, 17). *Formenn,* nom. pl. of *forimm,* here perhaps an equivalent of *foimmrimm,* which means "using" or "working" an animal, boat, etc.—V 474, 8; 476, 7. *'Ecndairce,* adverbially, "in the owner's absence," seems practically equivalent to *díchmarc,* V 474, = *cen athcomarc,* "without leave," ib. gloss; *foimrim noe . . . no leasdair .i. cen athcomarc,* V 476, 4.

[Miadlechta].

At IV 344 begins a tract for which the editors have supplied the title, "Sequel to *Crith Gablach.*" It is, however, quite independent of Crith Gablach in all respects, and its original title was probably *Miadlechta* (*miad* + *slechta*), found in lines 1 and 7 of the printed text and meaning "classes of dignity." It may be of the eighth century. Instead of the serious technical treatment of *Crith Gablach,* it uses a rather rhetorical and fanciful style, with numerous quotations from poetry. In its classification of grades it differs from all the other published tracts.

It deals only with the free grades, omitting the unfree agricultural tenants, *fuidir, bothach,* and *senchlethe,* also the slave, *mug,* and the slave woman, *cumal.*

It divides the free population into four orders: civil, Latin-learned, Irish-learned, and ecclesiastical.

The civil order contains ten ruling grades: three of king, four of *aire*, three of gentlemen. The honourprice of all these is reckoned in *cumals*. Then follow seven grades corresponding roughly to the *bóaire* order of other tracts, whose honourprice is reckoned in kine. Then nine grades of men without property, who have no honourprice. Then seven grades of wisdom (*ecna*), i.e. of Latin learning. Then seven grades of *filid*, men of Irish learning. Lastly, there are the grades of churchmen, not enumerated, probably because a knowledge of them was taken for granted.

We need hardly doubt that, in the original form of this tract, the classification was in groups of seven grades throughout. The list of ten ruling grades has at its end three grades, *idna*, *ansruth*, and *dae*, which are not found in other texts. The list of nine grades that have no honourprice has at its end two grades, the robber and the beggar, which are not likely to have had legal rank as freemen. Of interpolation of the original we have some proof. The text begins by stating that there are twenty-six grades of freemen, but this number is made out by including the grade of *aire forgaill*, not found in the text except as a synonym, probably here also interpolated, for *aire ardd*.

The three grades of king are: *triath*, "sovereign," explained in verse to mean the king of Ireland; *rí ríg*, "king of kings," to whom seven kings are subordinate; and *rí tuaithe*, "king of a tuath."

Of the king of the second grade, it is said that he is entitled to a *cumal* from each subordinate king who fails to attend his house of ale-feasting or his (regular) assembly (*oenach*) or his (occasional) convention (*dáil*).

The grades of ruling nobles are *aire ardd*, *aire tuise*, *aire désa*, *aire fine*, *idna*, *ansruth*, *dae*. The absence of *aire forgaill* and *aire échta* may be noted.

The seven grades whose honourprice was payable in kine are: *ógflaithem*, *lethflaithem*, *flaithem*, *bóaire*, *tánaise bóaire*, *uaitne*, *seirthid*. *Flaithem* may be explained to mean "lordlike" (< *vlati-samos*); *óg-* means "perfect," *leth*, "half." The three grades of *flaithem*, instead of landed vassels such as are under a *flaith*, have tenants bound to the land, in number respectively three, two, and one. The likeness to lords is therefore very slight. The *seirthid* or "henchman" is a landless freeman who becomes a soldier or a guard.

The description of the unpropertied grades does not much increase our knowledge of the social structure. There is nothing in it to show that these are really grades differing from each other in status, and we may rather understand the list to state nine ways in which a freeborn man may become bereft of franchise: by selling his property, by having no property but cattle which he puts to graze on the land of others, by being deranged in mind, etc.

Of some importance is the list of rights and privileges that are characteristic of freemen: retinue, right to food-provision, right against expulsion or exclusion (from places to which freemen resort in common), to compensation for wounding, for violation of precinct, for violence done to a guest, right to protect strangers, to give security in various ways, to give evidence, to make declaration upon oath. But these potential rights did not become actual, unless the freeman had property qualifications. "There are seven things by which a man is measured: physique, kindred, land, husbandry, profession, wealth, integrity."

The statement of the seven grades of Latin learning is obviously artificial, since one of the grades has the poetical title of *sruth di aill*, "a stream from a cliff." The names of all the grades are purely Irish words, showing that, at the time of the tract, the boundary between Latin and Irish learning had been effaced. The first grade is *rosui*, "great doctor," also called *sui littre*, "doctor of the Letter," i.e. of Scripture. To this grade, too, is given the title of *ollam*, borrowed from the terminology of Irish learning. He is a master of "the four divisions of knowledge," which are not named. The second grade is *ánruth*, a title borrowed also from the native learning. The *ánruth* is skilled not only in Latin learning, *légend*, but in Irish poetry and Irish synchronic history, this last indeed a product of the Latin schools. The third grade is *sui*, "doctor." He teaches only one of the four divisions of learning, and a quotation from Cenn Faelad seems to indicate that the fourth division, in addition to the three which the *ánruth* professes, was the "Canon," i.e. the Canon Law? or Scripture. The fourth grade is, "the stream from a cliff." The description of this grade is very poetical, but indicates a tutor who assists the backward pupils. The fifth grade is *fursaintid*, "illuminator," analogous perhaps to the demonstrator of science of our time. The sixth grade is *freisneidid*, "interrogator." The seventh is *felmac*, a pupil who has learned to read the Psalms in Latin.

The seven grades of Irish learning are the same as in other lists, except that the highest grade is called *éces* instead of *ollam*. The title *ollam*, however, is found later in the text applied to this grade. Beneath the seven professional grades is that of *bard*, who "has no law of learning but his own invention."

The tract ends with a rambling discourse about the honourprice of bishops, priests, and laymen who retire into religious life. As it seems to be a literary rather than a juristic composition, I do not give a rendering.

MAIGNE.

The tract headed Maighne, "Precincts" (IV 226) is a somewhat late compilation on the subject of the right of protection. It embodies many quotations from older writings. It derives its present title from the fact that it begins with an account of the *maigen* or private precinct allowed by law to certain classes of privileged persons. These are the various grades of nobles from *bóaire* up to the king of Ireland, of ecclesiastical persons from the "exile of God" up to "the heir of Patrick," and of *filid.* Any person who happened to be within the precinct came under the owner's protection, and violence done to such a person was accounted a wrong against the owner, for which the owner could take legal remedy. The precinct of a *bóaire* was symbolically fixed at a circle around his house, the radius of which circle was the cast of his spear. The radius was doubled for the next higher grade, and so on for each grade in succession, so that the precinct of the king of (a number of) *tuatha* had a radius of sixty-four spear-casts. But this area could not extend beyond the owner's private land (*faithche*).

Protection in this sense is called *comairce* and *dítiu* in the tract. The older terms are *turthuge* (U.B.) and *snádud* (C.G.).

Certain regulations are stated :

A person under protection could not take others under his own protection.

"There is no protection without offer of law." If a suit lay against the protected person, and he refused to answer it, he could not be lawfully protected against the lawful proceedings of the plaintiff.

A multitude could not come under protection. The maximum number is stated at twenty-seven persons.

When a person whose life was forfeit came under the protection of a church, he could save his life by payment. If, however, he did not "offer law," the church incurred a liability for protecting him or for allowing him to escape. But, according to another doctrine, churches and ruling nobles could give protection "without asking questions," whereas the Féni grades had not this right.

A tutor who accepted a fee was under liability for offences committed by the pupil. It is to be understood that the pupil is resident under the authority of the tutor.

Subjoined here are two "heptads," one stating exceptions to the right of protection (*snádud, dítiu*), the other dealing with the right to "sick-maintenance" (*folach, folach n-othrusa*, often simply *othrus*).

V 290.—There are seven resistances in the usage of the Féni, the rights of which are most difficult to shield—there is no right for lord or for church or for nobles of worth, nor for defence of sanctuary (?), to protect them: protection against a standing surety ; protection of a son who flees his father ; protection against a daughter who flees her mother ; protection of a slave who flees his lord ; protection of a church-tenant who flees his church ; protection of a man who flees his government of God or man ; protection of a woman who flees her rule of matrimony—that which God has joined in the beginning, let not man put asunder.

V 312.—There are seven cases of support that are most hardly supported in a *tuath* ; support of a king ; support of a hospitaller ; support of a smith ; support of a wright ; support of a wise man ; support of an embroideress—for some one is necessary to perform the function of each of them in his absence, and that the earning of each of them may not fail in his house.[1]

Díre.

I 54.—There are four magnates of a *tuath* who degrade themselves into petty folk : a king who gives false judgment, a bishop who stumbles, a *fili* who fails in his duty, an incompetent noble. Who fulfil not their duties, to them no *díre* is due.[2]

V 168.—There are seven mansions in the usage of the Féni that are not entitled to *díre* or honourprice : the mansion from which every plight is refused ; the mansion of the man who eats theft and plunder ; the mansion of the man who betrays honour ; the mansion of the man who bears defamation that defames him ; the man's mansion out of which son expels father ; the mansion in which kin-murder is done ; the mansion that remains empty—it is in this case (that the maxim applies) "the *díre* of every empty to a *nemed*," but that "the *díre* of every empty" may not exceed one chattel and (i.e. besides) restitution of that which has been damaged in it.[3]

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[1] Only six cases are stated. The seventh may have been the *ollam* or chief man of lore in the *tuath*. *Folach*, "support," is understood in the commentary to mean sick-maintenance. The notion apparently is that the person so supported was to be treated away from home. The treatment was at the expense of the person held to be the agent of the harm suffered, and the commentary says that in these cases this person could choose whether the treatment should be in a place provided by him or in the sufferer's home. In the latter alternative, the measurement of expense would be "most difficult."

[2] *Fili diupartach*, "a *fili* who fails in his duty," i.e. who, in something that he is bound to do, causes *diupart*, privation of due, to another person. *Aire essindraic*, an incompetent noble": *indraic* appears to convey the idea of material and moral integrity, competence in all respects for fulfilment of duties and functions. The last clause is wrongly punctuated and wrongly translated in the official edition. The glossator, no doubt rightly, interprets *díre* in the particular sense of "honourprice," *eneclann*.

[3] "Mansion": "fort" does not give the meaning of *dún*, a circular earthwork surmounted by a stockade, surrounding the residence of king or noble. Such earthworks are still extant in great numbers. "Defamation that defames him": for *air no*

V 172.—There are seven kings in the usage of the Féni who are not entitled to *díre* or honourprice: the king who refuses every plight, not having his lawful (full) company of guests, for it is not refusal by anyone, if he have his lawful company, even though he refuse; the king who eats theft and pillage; the king who betrays honour; the king who bears defamation that defames him; the king (against whom) battle is won; the king whom a hound attacks as he goes alone without his lawful servitors; the king who does kin-murder.[1]

V 174.—There are seven nobles in the usage of the Féni who are not entitled to *díre* or honourprice: the noble who refuses every plight; the noble who eats theft and pillage; the noble who betrays honour; the noble who bears defamation that defames him; the noble who vows his perpetual pilgrim-staff, who speedily turns again to his will; the noble who protects an evader of government so that it becomes evasion behind his back; the noble who does not yield judgment or due to man—such a one is not entitled to judgment or due from man.

V 176.—There are seven women in the usage of the Féni who are not entitled to *díre* or honourprice: the woman who steals; the woman who reviles (*lit.* carves) every plight; the woman who betrays without recantation, whose kin jointly pays for her false tale; the harlot of a thicket; the woman who slays; the woman who refuses every plight. These are the women who are not entitled to honourprice.

V 368[2].—There are seven (cases) in which his honourprice falls from everyone: defamation in accusing him without paying him (for it); false testimony by him against anyone; giving a false character; neglect of bond; going beyond a hostage; evading his surety; betraying his honour.

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aire I read *áir nod n-aire.* The last clause, following "the mansion that remains empty," is not glossed and is probably not part of the original text, though its diction is of the same period. The text, if I mistake not, has in view the case of a residence permanently abandoned—this is the sense of *bís.* The maxim has rather in view the case of a residence temporarily unoccupied, in which trespass and damage incur restitution and a small amount of *díre*, not the full *díre* of an occupied residence.

[1] "Who betrays honour," i.e. who fails to protect anyone who has lawful recourse to his protection.

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