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TRANSACTIONS

AND

PROCEEDINGS

OF THE

Royal Society of Victoria.

VOL. XVII.

Edited under the Authority of the Council of the Society.

ISSUED 10th MAY, 1881.

THE AUTHORS OF THE SEVERAL PAPERS ARE SOLELY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN.

MELBOURNE:
MASON, FIRTH & M'CUTCHEON, PRINTERS,
FLINDERS LANE WEST.

AGENTS TO THE SOCIETY.
WILLIAMS & NORGATE, 14 HENRIETTA STREET, COVENT GARDEN, LONDON:
To whom all communications for transmission to the Royal Society of Victoria
from all parts of Europe should be sent.

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Royal Society of Victoria.

1880.

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Royal Society of Victoria.

ANNIVERSARY ADDRESS

OF

The President,

MR. R. L. J. ELLERY, F.R.S., F.R.A.S., Government Astronomer.

(Delivered to the Members of the Royal Society of Victoria, at their Annual Conversazione, held August 23rd, 1880.)

GENTLEMEN OF THE ROYAL SOCIETY,

When we last met at a similar gathering to the present, I told you that the council was taking steps to carry out certain alterations within this building, with the view of affording more room, as well as of otherwise improving this part of the house. These alterations, as you may now see, have been completed, and we have, besides this well-proportioned lecture-room, a large additional room beneath, which adds very considerably and conveniently to the house accommodation. Moreover, the rooms generally have been renovated, and above all the exterior of the building, which has for so long a time presented a somewhat shabby and dilapidated appearance, has been thoroughly repaired, and finished with stucco in a plain and substantial style. I am glad to tell you that although this undertaking has trenched heavily on our exchequer, and will hypothecate a part of our next year's income, it will not leave us in any serious debt.

The Society entered on its twenty-third season in March last, and it gives me pleasure to inform you that it is progressing steadily, and getting gradually stronger from year to year, not only in numbers, but in the acquisition of new and energetic working members, who have taken up investigation and research in some of the various by-ways of knowledge which fall within its scope. Our ordinary meetings have, on the whole, been better attended during the last year than heretofore, and there has been no lack of new and interesting matter to occupy attention and excite discussion on each occasion. Our printed transactions, now so promptly placed in the hands of our members, give the best evidence of the Society's vitality. Some of the sections for which our rules provide have been formed, and have held their meeting regularly each month; Section A, which embraces mathematics, astronomy, physical geography, and engineering, has, I think, been the busiest one. Another section, combining the subjects classified in our rules under sections, B, C, and D—viz., chemistry, mineralogy, natural history, geology, and microscopy—has also been formed, and commenced its meetings some few months ago.

The new rule enabling the Society to admit associates at a smaller subscription than members, and to which I referred in my last address, has continued to work very satisfactorily, and we have now no less than twenty-five who have entered the Society under this rule. We continue to increase our friendly relations with kindred societies abroad, by interchange of transactions and publications and in other ways; and, of course, our valuable and, as far as Australia is concerned, somewhat unique library grows in proportion. In October last the council made a change with regard to the paid assistants of the Society. The hallkeeper was relieved of all clerical work, and the services of an assistant-secretary and librarian were obtained, and the result so far is that the house and grounds are kept in much better order, and the library and clerical duties are more methodically and satisfactorily performed than under the former arrangements. I think I have now referred to all the principal facts in connection with the past year's domestic history of the Society, and I propose now to crave your patience for a few minutes while, in accordance with my usual custom on these occasions, I briefly review the year's work of our national art and science institutions.

While our Observatory, over which I have the honour to preside, has been fully occupied with its usual continuous work, but few matters of more than ordinary interest have occurred to claim its special attention since my last address. The comet of February broke the monotony of the routine work, but the hazy horizon so prevalent during the evenings of that month completely hindered satisfactory observation in the early part of its apparition, when it set soon after the sun; and afterwards, when measurements could be made, it increased its distance from us so rapidly that only a very incomplete series of measures could be secured. As there is rather more interest than usual attaching to this comet, I shall refer to it again presently.

In anticipation of the next Transit of Venus in 1882, the Astronomer Royal, Sir George Airy, has brought prominently under the notice of the scientific world in the old country the great desirability of determining telegraphically the longitude of Melbourne, or some one of the Australian cities connected with it by telegraph. I am now in communication with the president of the Royal Society in London on the subject. I am also in correspondence with the hydrographic office at Washington on the same matter, for the Americans propose to connect Japan, China, and probably Australia, with America by a chain of telegraphic determinations of longitude. It is, therefore, quite probable that before very long the longitude of our Observatory from Greenwhich will be determined by the most accurate method we know of—namely, by the interchange of telegraphic signals. Arrangement are now in progress for a systematic discussion of disturbances of terrestrial magnetism as recorded by the few self-registering magnetographs at work in different parts of the world, and our Observatory, which possesses one of these special instruments, has been requested to co-operate by furnishing fac-similes of the photographic curves obtained during disturbed periods. This is a very important step in the right direction, for a considerable amount of investigation is carried on at national observatories, which has a general as well as a local value, and the correlation of the results by some competent central committee is the only practical way by which to arrive at a solution of the great cosmical problems to which the investigations themselves pertain. Terrestrial magnetism has its local significance, but the broad question of the laws by which it is governed is one that can only be adequately dealt with by some such method as that now proposed. The great telescope continues to work well, and although a great deal of time is taken up by visitors, the systematic revision of the southern nebulæ is going on steadily and satisfactorily.

Baron von Müeller, our fellow-member, who so ably represents our national botanical department, has assiduously continued his researches amongst the flora of Australia, and although I regret to say that he has been unable, through lack of means, to extend his investigations into many of the collateral branches of the science, he is mindful of the importance in a young country like ours of a practical as well as of a purely scientific outcome of his work, and while he is steadily working towards a complete flora of the great Australian continent, investigations concerning new and useful vegetable products, and the selection of plants for industrial culture and naturalisation, have been by no means overlooked. Taking the statistics furnished by the Government botanist, there are, up to the present time, already recorded as pertaining to the flora of Australia about 7000 dicotyledonous, 1600 monocotyledonous, and 1900 acotyledonous species; and these, especially the latter, will doubtless be largely augmented by considerable additions to the lichens, mosses, and fungi, as exploration advances and new districts are open to the botanical examination. In such a list Baron von Müeller has still before him an immense amount of research in tracing out the geographical and geological distribution, and other important facts connected with the botany of our southern continent. Most valuable and important additions to the botanical collection have recently been made by Mr. Alexander Forrest's expedition to Port Darwin, which has opened up a hitherto botanically unknown region, a portion of which, however, was partially examined by our Government botanist in 1851 and 1856. The baron informs me that he has the second part of the school *Flora of Australia* nearly ready for publication. His work on select plants for industrial culture and naturalisation has appeared this year in an enlarged edition for the use of India, and published with the concurrence of the Victorian Government, at the cost of the central Government. He is making good progress with the *Atlas of the Eucalypti,* to which I referred in my last year's address. Already six parts, containing 60 species, elucidated by 66 quarto plates, have passed through the press.

To students in botanical science, and lovers of plants and flowers, our Botanical Gardens cannot fail to be an attractive resort, and the energetic curator, Mr. Guilfoyle, loses no opportunity, while giving full scope to his skill in landscape gardening, and so making the gardens a favourite pleasure-ground for the people, to supply to a great extent the more scientific requirements of such a place by the grouping together in beds and clumps allied families of plants, and by utilising the low and shaded parts for ferns and other classes requiring warmth and shade, so that they can be studied here almost as well as in their native *habitats.* The National Museum of Natural History in the University grounds, under the directorship of Professor M'Coy, continues to increase its collections, and during the past year the additions have been made principally in the mollusca, insecta, and radiated animals. The register now records 44,600 specimens completely classed and labelled in the case. The space is overcrowded, and there can be little doubt that if the other contemplated half of the building were erected it would soon be filled by relieving the present space and addition of new specimens. This institution keeps up its interest among the public, for during the past year there have been nearly 97,000 visitors.

The schools of technology, practical chemistry, engineering, &c., as also those of the fine arts in connection with the Public Library and Museum, continue doing good work, and fulfilling important functions in the community. In the art school there are 50 pupils in painting and 161 in drawing. In the technological school there are 28 pupils in technology and 18 in engineering. The museum catalogue has now increased to the number of nearly 30,000 specimens.

Since our last annual gathering two new scientific societies have come into existence in Melbourne—the Victorian branch of the British Medical Association and the Field Naturalists' Club. The first of these is a graft on an Australian stock of the great parent society in England, which now numbers among its wide-spread ramifications over 9000 members. The second is a young society formed on the lines of the old and well-known English one of the same name. Already it is making good progress, and as its objects are so closely allied to those of this society, we shall all wish it every success. The Microscopical Society is gradually progressing, and has added to the ordinary operations of such a body a system of classes for instruction in microscopical practice and research, which, supervised by that veteran and never-tiring microscopist, the president of the society, Dr. Ralph, cannot fail to do a great amount of good, not only in training students in this branch of science to the proper mode of working, but also in showing how extremely useful in trade, manufacture, agriculture, and numerous other directions is a little practical expertness with this great optical aid. The Medical Society has also been increasing in strength; its meetings have been more than fully occupied with valuable contributions on numerous points of medical and surgical science, and its Transactions, under the name of the *Australian Medical Journal,* now holds an important place in medical literature. The Pharmaceutical Society, also, I am glad to say, is prosperous and progressing. The Pharmacy Act, which has been secured by, and is in a great measure administered under, the auspices of the society, is one of considerable importance to the public, inasmuch as it provides for the proper education and training of all who engage in the dispensing or sale of medicines or drugs, and so removes the danger that so often results from ignorance or the lack of proper training, which is as essential in practical pharmacy as it is in medicine.

Passing now beyond our own limited sphere, and making a hasty survey along the ever-extending boundaries of physical and chemical science, our attention is arrested by some interesting examples which fairly illustrate the direction of modern thought and research in these branches of knowledge. The physicist, armed with the prism, the photographic camera, and other optical aids, and made strong with knowledge of the laws of matter and properties of light, electricity, and heat, obtained in the observatory and laboratory, now grapples with questions which but a few years ago would have been esteemed beyond human reach; and he is able to apply his scale and balance to heavenly bodies, millions of miles away, with a certainty of result scarcely inferior to that with which he investigates matter in his immediate vicinity. As an illustration, I may cite the suggestion by Professor Wiedemann, at a recent meeting of the Royal Astronomical Society, of a method for determining the pressures existing on the sun's surface. His proposed method is based upon the relations and behaviour of light with regard to the molecular motion of the gas from which such light may emanate, or through which it may pass; and he points out that, comparing any homogeneous light from a heavenly body which can be obtained by help of the prism, with the now well-known phenomena of interference bands, the knowledge of the relations referred to leads us to a means of deducing the pressures prevailing at the points from which this homogeneous light emanates. A knowledge of the pressure of the solar atmosphere is of the highest importance for the elucidation of many great astronomical questions, and especially in such a one as was lately presented to us by the wonderfully close approach of the February comet to the sun's surface, that body having probably grazed or passed through the outer envelopes of the solar atmosphere; and if we may except Mr. Proctor's speculation as to what might have been the result of such an occurrence, this question becomes one of very grave moment to us dwellers on earth. When this comet was first seen here, it had just passed it critical point, and it is fortunate we knew nothing of its close approach to the sun until it was sailing away into space again, as far as we could see, unharmed; otherwise, being properly prepared by a little sensational writing, with what a lively interest should we have awaited the perihelion passage, pregnant with such possible catastrophe. At the apparition of this comet in 1843 it approached within 96,000 miles of the sun's surface, and in February last its perihelion distance was probably somewhat less. When next it returns, as expected, in 1917 there may some of us be left to experience the result of its closer approach or perhaps its absorption into the sun.

It is not many years ago since nervous people were made very uncomfortable by graphic descriptions of the effects of a collision between a comet and the earth, but since it has become known that such catastrophes have occurred, with no more result, perhaps, than a beautiful shower of shooting stars or a peculiar foggy state of the atmosphere, the cataclysm of a collision between a comet and the sun is now made the "bogie," and depicted in verbal rouge and ochre. Some of the very painters of such catastrophes, if I am not mistaken, once accounted in part for the maintenance of solar heat from age to age by the falling in of comets upon the sun; yet after all the comets that have disappeared within the fires of the solar furnace, the great one of 1843, according to these alarmists, is *par excellence* the one reserved for mischief.

The researches of Pictet and those of M. Cailletet, on the liquefaction and solidification of the more stubborn gaseous elements, and the results obtained by these physicists, have done much to stimulate inquiry and thought in this department; thus Ramsay's researches have shown that gases under pressure have a direct solvent action on solids, and that the bodies they dissolve when returning once more to the solid condition do so by assuming the crystalline form. The remarkable outcome of these investigations is the artificial production of the diamond, the nature of which is vouched for by the very high authority of Professor Maskelyne, and although we are not yet fully informed of the details of the physics and chemistry of the method, there appears to be reason to hope that the hitherto mysterious secret of the formation of the diamond in nature is on the eve of solution, however remote the commercial manufacture of the gem may yet remain. It may be worth while to add that the artificial manufacture of the diamond of moderate size, even in a crude form, quite unfit for the purposes of jewellery, could it be economically accomplished, would bring about enormous changes in the mechanical arts, for the artificial diamond would at once take a front position as the material of turning tools and drills, and generally as a grinding and polishing agent.

New chemical elements are no longer sought out in the dark by painful, tedious, and often perplexing analytical research. Spectroscopic analysis greatly facilitates inquiries of this nature; and at the present time new elements, like new asteroids, are periodically turning up. But in addition to the facilities thus afforded by the methods of spectrum analysis, theoretical views—those of Mendelejeff especially, on the periodic law of the elements—arrange the known elements in a methodical series, show where a hiatus occurs, and predict, with considerable accuracy, the chemical and physical properties of the yet-to-be-discovered elementary substances. Gallium comes to fill one of these gaps, realising the expectations of its family likeness to the bodies nearest to it as well as individual characteristics of its own. In the discovery of gallium we are helped to further knowledge concerning the physical states of matter. This metal has so low a melting-point that it may be questioned whether it is a fluid or a solid at ordinary temperatures. When in the solid state, it will become fluid if warmed in the palm of the hand; and when thus fused it may again become solid as it is cooled, or may retain the liquid state for days, hours, or even weeks. This peculiarity regarded *per se* might appear anomalous. Faraday, however, many years ago, noticed some droplets of sulphur sublimed into the neck of a flask, which remained in the fluid state long after cooling, but which at once solidified and became opaque if touched by a hard substance. Similarly fluid gallium may be reduced to the solid state by simply touching it with a particle of solid gallium. As affording an illustration of the manner in which the several departments of physico-chemical research assist and illuminate one another, Dr. Van Rümsdijk in his investigation concerning the phenomenon of "flashing" in the gold bullion assay, has traced the absence of this change (for it does not invariably happen) to the presence of small quantities of the metal iridium in the gold assayed, the iridium being infusible and insoluble in the gold-silver alloy at the temperature at which the assay is drawn from the fire. When no solid particles of iridium are present the gold-silver alloy sinks below its melting-point, while still retaining the fluid state. This condition is called "superfusion;" and when at last the cooling alloy changes its state it does so suddenly with evolution of heat of fluidity, and with a sudden glowing up of remarkable brightness (the flashing). But the presence of a few points or particles of solid iridium prevents superfusion, for the gold in contact with the iridium cannot retain its fluid state below its melting-point; each particle of the iridium forms a nucleus from which the fluid metal gradually solidifies and crystalises, with gradual and not sudden evolution of heat. Thus from different sources we gain a new insight into the conditions affecting a change of state.

A noteworthy instance of the practical application of physiological and chemical science is presented by Fleuss's method of diving. Under ordinary circumstances a diver is supplied with a copious flow of air, forced by pumps through a flexible tube into his helmet, but Mr. Fleuss dives without air-pump or tube, and simply with a signal-line. The method is this—First, he provides a store of oxygen gas, compressed and stored in a special part of the helmet, which is double-cased. This can be admitted to the interior at will for breathing. Next, he arranges that all air once breathed shall be deprived of its poisonous carbonic acid, and then be again returned to the helmet for respiration. In this manner breathed and purified air can be breathed again and again until the natural supply of oxygen becomes partially exhausted, producing effects which Mr. Fleuss instantly recognises, when he at once lets a small supply of the compressed oxygen into his helmet to revivify the spent air. For this purpose there is on the outside of the helmet a tap which can be readily and instantaneously turned on and off by the hand. The removal of the carbonic acid gas from the expired air is effected by causing it to pass through a tube containing a cellular mass of caustic alkali sufficient to decarbonise the breath for four hours.

The progress of invention in the practical application of the known laws of electricity continues to attract great attention, and every new adaptation appears to render the scope for the utilisation of this force more and more wide. In my last address I referred discouragingly to the too sanguine expectation that electricity would soon supersede gas for illumination, and although I have no reason yet to alter opinions then expressed, there can be little doubt that scientific reasoning and experiment have indicated methods of overcoming many of the difficulties which were at that time besetting the efforts of electricians and inventors, and the prospects of the ultimate success of the electric light for many purposes have become proportionably encouraging. Great improvements, chiefly in the lamps and the methods of supplying them with electricity, have been made, and, although the promised new order of things which was to arise out of the Edison patents is now almost forgotten, Siemens Brothers, Jablokoff, Werdermann, Brush, and others have carried their several systems in some directions to a thoroughly practical success. The Thames Embankment, the British Museum, and other places, it appears from the accounts received, are now satisfactorily lighted by electricity; and at the British Museum it is stated to be a great success. Competitive trials of the relative merits of the Jablokoff and Werdermann systems have lately been made at the Opera-house, Paris, with a result somewhat in favour of Werdermann's system. Several of the large ocean steamers, the "City of Berlin," the "Potosi," and the "Chimborazo," have now been fitted with Siemens machines and lamps; and on board the "Potosi," which lately arrived here, the experiment is said to have resulted most successfully. In these and similar directions electric lighting seems to have a hopeful future, but for ordinary domestic purposes, or for those of street lighting, the prospect of its superseding our present commodity, gas, is, to my mind, still very remote.

I think I may safely state that electricity, generated by the dynamic methods of Siemens, Gramme, and others, as in the electric light, can now be used for the transmission of power to a distance, so that a current generated by such a machine, at the Exhibition, for instance, could be conducted, say, to the wharfs by suitable wires, and there made to operate on cranes, pumps, and other machines with comparatively small loss of original work. As an example of power transmitted in this way, Dr. Werner Siemens has actually driven a carriage along a short railway by an electric machine at one end of the line, using the rails as conductors for conveying the current to the carriage as it travels away. At a recent meeting of the Society of Telegraph Engineers in London, also, Mr. Siemens exhibited an electric furnace, in which heat was generated by one of his dynamo-machines, and of such intensity that a pound of broken files placed in a cold crucible were melted and poured into a mould in fifteen minutes.

By the introduction of the principles of the microphone into the transmitting part of the telephone, this instrument has become a practical success, and not only is it already in constant use over short circuits in several parts of Melbourne, but it is quite probable that it will soon become as widely adopted and convenient as a means of communication as it is in America.

The method of sending two or more telegraph messages simultaneously on a single line, called the "duplex or quadruplex system," has been successfully established, and Sydney and Melbourne are now communicating with each other on the duplex system.

A new era in photography appears to have set in, and the old collodion process, by which so much beautiful work has been done, seems likely to be entirely superseded by what is known as the gelatine or emulsion process. In this method the sensitive chemicals are mechanically combined with pure gelatine, and extremely thin films of this are dried on glass or some other impervious surface, and in this state they will keep sensitive for an indefinite period of time if kept in the dark and in a moderately dry atmosphere. The great feature of these films is that they are extremely sensitive to light, and that photographs can be taken with them in one-twentieth or even a thirtieth of the time occupied in the ordinary collodion process. This is an advance which only photographers know the full value of, and it will enable them to obtain practically instantaneous pictures of moving objects on the one hand, and on the other of objects only partially illuminated, such as the interiors of buildings, dark forest scenery, and so forth. Another great advantage they present is that after the picture is chemically impressed upon them by exposure, they remain unchanged, and can be as perfectly developed months after as at the time. This process has not, however, been fully developed in Australia yet, but I hear there is every prospect that it will very soon become familiar to our principal photographers, and replace, as it is rapidly doing in England, the collodion method. In conclusion, I would say a word or two concerning the approaching Melbourne International Exhibition, for it is an occurrence closely connected with the chief objects of this Society. The progress of science and art will there be illustrated in a far more forcible manner than is possible in any other way, and this Society will be keenly interested in its educational result on the people of the colony. The cost, magnitude, and importance of such an undertaking demand that no opportunity shall be missed of ensuring that the utmost possible good to the people shall be secured; and in order that this may be the case, I am sure you will join me in the hope that while the Commissioners, as in duty bound, will adopt means for obtaining as large a money return as possible, they will not regard this outcome as the only one which is desirable, and that liberal arrangements in the shape of season tickets, low admission days, and such like will be made, in order that the full instructing effect upon the mechanics, artisans, and the youth of our country may remain among us a kind of compound interest for the cost.

TRANSACTIONS.

ART. I.—*The Hodgkinson Goldfield, Northern Queensland.*

BY THE REV. J. E. TENISON-WOODS, F.G.S., F.L.S.; HON. MEM. ROY. SOC., N.S.W., TASMANIA; COR. MEM. ROY. SOC., VICT.; PRES. LINNÆAN SOC., N.S.W., &C., &C.

[Read April 15th, 1880.]

THE portions of the colony of Northern Queensland dealt with in this paper are the goldfields of the Hodgkinson, Walsh, and Mitchell Rivers, all of which streams drain into the Gulf of Carpentaria, on its eastern side. I give, also, a sketch of the country between these fields and the east coast, following the bridle track between Port Douglas and the diggings. Port Douglas is an anchorage at the mouth of a small mangrove creek, between the mouths of the Mossman and Mowbray Rivers. It is sheltered by a small peninsula, called Island Point. This is about a mile in length, and rises rather abruptly to a height of 200 feet above the sea. Its greatest length lies parallel with the coast, and it is scarcely a quarter of a mile wide, being, in fact, a mere ridge. It is composed of a metamorphic rock. The almost vertical dip of the strata can still be seen, as well as the almost north and south strike. In some places it is a coarse felspathic rock, like porphyry, with large crystals of hornblende and felspar. In addition to this, there are long streaks or irregular bands of black hornblendic rock, which pass through the line of stratification. The appearance is like streaks of pitch, and it is very vesicular; but whether that was its original state or due to the weathering action of the sea, where the rock is exposed, cannot be well made out. I should be inclined to describe it as a trap breccia, and the dark masses as more augitic than hornblendic. It may be one of those numerous ash beds or trap conglomerates which are so common in the silurian formation, to which period, from the dip and strike and general appearance, I suppose it to belong. It has certainly been subjected to metamorphic action since it was upheaved to its present vertical dip. I regard the peninsula itself as a former island only very recently reclaimed from the sea. At the land side, the hill slopes down to a wide and marshy mangrove creek. The intervening country between Island Point and the main range is a level plain, one to three miles wide, covered with an open forest of *Wormia alata, Thespizia populnea, Heritiera littoralis, Careya arborea, Acacia holoserica, Pandanus pedunculata ;* but the tree which prevails to the greatest extent is *Melaleuca leucodendron,* or paper bark tree, as it is called. As far as sections from rivers and creeks will enable one to judge, the plain is composed of an alluvial detritus from the main range, fringed by a bank of sand, which is derived from coral banks and the disintegration of the stone. There is a series of low coral islands about eight miles from the shore, some wooded, and some mere sandy patches, almost submerged at low water. The outer Barrier Reef is nearer to the coast here than further north and south, and from the summit of the dividing range can be seen plainly.

Proceeding in a southerly direction from the peninsula, or Island Point, as it is called, the mouth of the Mowbray River is crossed at about three miles. The interval is occupied by a hard, sandy beach, on which no rock shows. This beach is fringed by a very dense vegetation, in which *Wormia alata, Ficus macrophylla,* and *Thespizia populnea* hold the principal place, bound together by the common climbing cane, *Flagellaria indica.* At the back of the ridge, the mangrove creek already referred to holds its way for a long distance. In my track across the main range, I followed the course of the Mowbray to the ford. It is a narrow, tidal stream, with a fringing reef of coral, extending out to sea about four miles on one side of its mouth. Its course from the range is very short, and it can be seen coming over the divide in many long falls of white foam As the east side of the range is in general very precipitous, a large number of these falls can be seen at every opening. Some of them are of considerable extent, and in the rainy season, whenever the weather is clear enough, the cascades form beautiful adornments to the scenery.

On the east side of the divide the vegetation is very thick, and it is only in one or two places that sections of the rock are exposed. All that I saw were highly inclined chloritic slates, rather similar in appearance to the strata on the ranges near Glen Osmond, Adelaide, and which has been so largely used for building purposes in that city. The road ascends with great rapidity, the inclines being quite as steep as any on the spurs of the divide near Sydney. The height of the crossing-place of the road to the Hodgkinson is about

1700 feet, as told by my small aneroid. All west of this is western water, and flows into the Gulf of Carpentaria by the Mitchell River. The distance by road is about twelve miles; but in a straight line, probably not more than eight from Port Douglas. To the south of the crossing-place is a large hill, Mount Harris, which is called the Black Hill by the settlers in the neighbourhood. It is about 2200 feet high, and, as there are other hills with the name of Harris attached to them, there is some confusion about this. It is a remarkable object, as from one side of it the river Mowbray descends to the east coast, and from another, Rifle Creek, which joins the Mitchell, and flows into the Gulf of Carpentaria.

Rifle Creek is crossed at about three miles on the west side of the divide. It is a very deep and rapid stream, with precipitous banks, densely clothed with scrub, but not showing any outcrop of rock. Five miles further, Spear Creek is crossed. This is another tributary of the Mitchell. The intervening country is a plain of table-land, evidently subject to inundation, with a marshy surface, and no outcrop of rock. It is about 1400 feet above the sea level. After crossing Spear Creek, which is wider and more shallow than Rifle Creek, the country becomes undulating, and soon broken by the precipitous spurs of what is called the Slatey Range. This is entirely composed of slate rocks, with a dip and strike, and lithological character very similar to the lower silurian rocks throughout Australia. Quartz reefs occur in them, and in the gullies there have been formerly small alluvial workings, but the ranges have not been carefully prospected. These ranges are a series of very steep ridges, and consequently the creeks descending from them are nearly always dry. The soil is light, and supports a poor vegetation, principally stunted gum trees, coarse grass, and a few grass-trees. There is no scrub, but it is rather remarkable that at the summit of these ridges, at about 1700 feet above the sea, *Eucalyptus maculatus* occurs, and possesses that strong odour of lemon thyme which this species seems to have only when found in the tropics. The same tree is the commonest on the east side of the dividing range from Cape Howe to a considerable distance beyond Moreton Bay. The variety with the lemon scent is only found in the tropics and upon the ridges, and goes by the name of *E. citriodora*, being considered as a distinct species in the *Flora Australiensis*. I intend to publish a few notes separately on this remarkable variety.

Descending from the ridge, the level of the table-land is again reached, and this, as I have said, is about 1400 feet above the sea. The slate ranges are crossed quite unnecessarily. It is merely a spur from the south-west, belonging to the main range or divide, and Rifle Creek, after being joined by Spear Creek, flows round the north end of it to join the Mitchell. By following the course of Rifle Creek, after crossing the divide, the slate range must consequently be entirely avoided.

The valley of the Mitchell is an open plain, about ten miles across. The soil is poor and somewhat marshy, and the vegetation consists of open forest of *Melaleuca leucodendron, Eucalyptus platyphylla,* and *E. hœmastoma* and *Petalostigma quadriloculare.* The grass is luxuriant and abundant. The whole flora does not differ in any very striking manner from the open plains on the east side of divide, except in the absence of strictly littoral species, which the distance from the sea must lead us to expect. In this respect the upper valleys of the Carpentaria waters differ from all others on the western side of the Australian Cordillera which I have visited. Farther south, a most marked difference is seen between the vegetation of the eastern and western slopes of the watershed.

No section throwing any light on the geology of these plains is obtained near the crossing-place of the Mitchell. The banks are not steep, and they consist of alluvial detritus from the stream and beds of sand. The river itself, a fine broad, shallow stream of clear water, is always running. It is flooded in the rainy season, and is then difficult and dangerous to cross. The ford on the Hodgkinson track is between 300 and 400 miles from its mouth, in a straight line, so the importance of this river can be thus estimated. At the crossing-place it is about sixty yards across, and the running water in the driest seasons about one-third of that width. The East and West Hodgkinson, the Palmer, the Walsh, and many other streams, join the Mitchell in its course. When near the sea, it is a very broad and deep channel, but not much is known of it. Mr. Bartley Fahey, the Harbour-master at Cooktown, explored a good deal of its course, entering by its sea mouth. As well as I remember, he was able to sail up for about sixty miles. The natives were extremely numerous and hostile, which is their character for the whole course of the stream. As might be expected, crocodiles are also very numerous.

After crossing the Mitchell, the road traverses the plain for about three miles, and then commences to ascend a granite range. This is another spur from the divide, and the Mitchell passes round its northern end, so that it is crossed quite unnecessarily. The explanation of this is, that when the Hodgkinson Goldfield was explored, it was reached from Cooktown; and then a further exploration was made to find the sea coast and some more convenient port of shipment than Cooktown. The object of the explorers was to reach the coast in the straightest possible line, and thus they passed over many ranges which a better acquaintance with the geographical structure of the country will enable them to avoid.

The character of the range is exceedingly bold and picturesque. Huge boulders and bare surfaces of granite are very conspicuous. The crossing-place is over 2000 feet above the sea level; but to the south it rises to a height of between 3000 and 4000 feet. To the north-west, dark masses of still greater elevation are seen; but they are divided from this track by the valley of the Mitchell. The whole of this granite series, with numerous spurs, offshoots, and isolated ranges, belong to one formation, which probably has its greatest height in the Peter Botte Mountains, halfway between Cooktown and Port Douglas, and fifty miles from the coast at Cape Tribulation.

In ascending the range the cuttings made for the road enable one to see very good sections. The metamorphic character of the granite is beautifully shown. Slates, with a vertical dip, clothe the sides of some of the spurs. They are seen to pass gradually into schist, highly contorted, and then into gneiss, and finally into the hard, compact blue and grey granite of the range. Here and there are seen sections of granite, with small patches of slate, not completely transmuted, lying in the mass. It is thus abundantly evident that this granite is only the altered slates. It may be that the strata thus transmuted are a portion of the formation at the Slate Range and the auriferous slates of the Hodgkinson field. This cannot be asserted positively, though it is extremely probable. Remembering this, and that the reefs at Charters Towers and Ravenswood are both found in syenite, there is no reason why these immense formations at the Hodgkinson should not be auriferous also. In the transmutation of the stone from slate into granite many quartz veins are found; but I am not aware of any reefs, properly speaking.

The vegetation of the granite range is peculiar, and not like that of the plains or the slate ranges. It is often a scrub; but it must be remarked that there are two distinct kinds of vegetation to which, in this part of Queensland, the term is applied. One is the river scrubs, with a dense and very luxuriant growth of palm trees, vines, tree ferns, nettle trees, *Calophylla*, and tropical vegetation generally. Another is a thick, entangled growth of *Acacia*, *Vitex*, dwarf *Eucalypti*, and shrubs, none of which grow into trees, but spread out into twiggy bushes. The latter kind of scrub is only found in poor, sandy, or clay soils, dry, and in ridges where the water does not rest. This is the vegetation found on the granite range. The *Eucalypti* are stunted, and ferns rather numerous under the rocks. I regret very much that I was not able to make any collection while on the range. I was alone and unarmed, and could not safely venture off the track for the purpose of botanising. The distant ledges of granite, with their bushy surroundings, were very tempting; but I was obliged to leave them. There were no signs of natives about; but in the short history of this part of the world there are so very many sad illustrations of how the neglect of prudent precautions has resulted in loss of life, that one additional example in my case was not needed.

When the granite range is crossed, the track descends rapidly to a very broad, shallow stream, called the East Hodgkinson. It is principally conspicuous for its bed, which is made up of wide sheets of loose granite detritus, in which belts of *Casuarina equisetifolia* were growing. The level of all these streams is about the same; that is, between 1300 and 1400 feet above the sea. It is remarkable that the farther these rivers are from the coast they are less thickly lined with scrub. Those near the ocean are densely wooded, and those far from it, such as the West Hodgkinson, have scarcely any more vegetation on the banks than is seen on the ridges.

From the side of the East Hodgkinson the land is a succession of very steep, somewhat barren ridges of silurian slate, clothed with an open forest of *Eucalyptus corymbosa*, *Eucalyptus platyphylla*, *E. hæmastoma*, *Grevillia robusta*, and some other trees, all of a poor kind. The ridges vary in height from 2000 to 2600 feet above the sea. At about ten miles from the East Hodgkinson the Western Hodgkinson is crossed. The whole intervening country is more or less intersected with quartz reefs. The township of Kingsboro, or what is strictly termed the Hodgkinson Diggings, is at the crossing-place of the river. Like all new diggings in very remote places, it is extremely primitive in its architecture. The residents endeavour to do with as little as possible in the way of shelter and accommodation, yet, notwithstanding this and the extreme heat of a tropical climate (lat. 16° S.), the place is not unhealthy. The town is on a small ridge, about 1700 feet above the sea, but above and around it there are many peaks and elevations, rising abruptly to considerably over 2000 feet. The soil is not barren, being a reddish earth, but too steep and stony to be favourable for agriculture. The Hodgkinson winds around the town. It is never quite dry, but does not run all the year round. It is a shallow, rocky stream, with thin belts of bushes in its bed, and with very little alluvial detritus. There are boulders and water-worn stones in abundance, amid which the Chinese get small amounts of gold by cradling and sluicing; but, as it was the dry season at the time of my visit, there was very little of this going on.

Around the town many claims are visible, but not all of them working. The most successful were the Tyrconnell and the Grattan, both close to the town. Two conspicuous peaks close by have the Laird of the Hills and the Great Britain claims upon them. The first is a very elevated, narrow, almost peaked mountain, about 2100 feet above the sea. The rock exposed on the surface is entirely ribbon jasper and agate, of beautiful, interesting, and perhaps valuable structure. The quartz vein crops out near the summit. It has a north and south strike, and a considerable dip to the east. The quartz is a very wide seam, of rather favourable appearance. It has not been worked as yet profitably; but I think more for want of means and appliances than from the poverty of the stone. The Great Britain claim is on a lower peak to the southward. It seems a continuation of the vein which is worked so profitably at the Tyrconnell, but it does not show very payable results. The reef seems to be in close contact with a dyke, and is probably intersected by it. And here it may be as well to state that dykes of the stone to be described are very common on the whole of the field. They are igneous intrusions, but of a character difficult to arrange with any well-known form of intrusive rock. It is a dull bluish grey paste, enclosing a black mineral, which is found in large angular or rounded patches. There are also small fragments of white quartz and felspar, with almost a stratified appearance. In fact, the stone at first would be certainly taken for a conglomerate. The black masses I suppose to be hornblende. I have not been able to make any microscopic examination of sections of this rock, which I should think has acquired its present appearance by metamorphism. It is clearly an intrusive rock, as its appearance amongst the vertical slates and the way it cuts off the reefs show. I remarked that the black crystals are very similar to the peculiar black and pitch-like portions of the trap breccia at Port Douglas, and I think it must belong to the same formation.

The strike of the slates is about a point E. and W. of N.E. and S.W. This is very nearly the direction of all the ranges hereabouts. The dykes seem to follow the strike of the strata. The ranges are short, and divided by deep passes. There are many in parallel lines, and the sides are scored by many precipitous gullies. The strike of the reefs is nearly north and south, and therefore the edges of the slate strata abut diagonally upon them. The reefs consequently do not follow the line of the ranges, but cross them. The slate is very fissile at the outcrops, which are not numerous. At the Tichborne claim it passes into a hard flagstone, and at moderate depths is found to pass into beds of very black, shining talcose slate, and thence into black limestone. There can be but little doubt that in these slates we have a series of folds in which the same strata are often repeated in the anticlinal and synclinal flexures. There is no good natural section to enable one to judge of the exact position of the black limestone. It is found very abundantly, with numerous veins and strings of white calcite, and in the form of marble at the Grattan reef, which is a very rich claim; and the vein stone of quartz with gold is being worked now in the limestone country. As far as I could learn, no traces of fossils have been found in any of the slates, and, considering the evidence of disturbance and metamorphism that is here offered, it is very unlikely that any will be found. There are many geologists who regard limestone strata as of entirely organic origin, and most probably, should any fossils be discovered, they will be in the neighbourhood of these rocks. The black and shining appearance of the stone has induced many to think there were indications of coal, which the black hornblendic fragments in the dykes seemed to favour, as they are not unlike fragmentary plant impressions. No positive assertion can be made as to the age of these slates; but their resemblance to the Victorian auriferous strata, their lithological character and vertical dip, render it extremely probable that they are of lower silurian age. The parallelism of the dip of the strata, or rather folds, and the general direction of the ranges, render it probable that we have in the physical features of this country the few remaining relics of the corrugations or folds into which the earth's crust shrank subsequent to the lower silurian period. But we have evidence that there have been immense changes since. In the accompanying figure of Mount Mulligan, about twelve miles from Thornboro, we have another relic, but of a different kind, of the former geological history of the country. This is an isolated mass of tableland, the summit of which is composed of about 600 feet of horizontal sandstone, exactly like the Hawkesbury sandstone, as it is seen at the Port Jackson Heads or along the railway line over the Blue Mountains. From the occurrence of the formation at Mount Mulligan and numerous other places on the coast, there can be but little doubt that this horizontal sandstone once covered immense tracts of north-eastern Australia; but it is only seen now in isolated patches, all the rest having been completely denuded away. I cannot offer any direct evidence that the Mount Mulligan sandstones are the equivalents of the Hawkesbury sandstone, because I was not able to examine them closely; but lithologically there is no difference, and similar outlying patches are known to contain vegetable impressions, connecting them with the formation in New South Wales. It will be seen by the sketch annexed that the sandstone rests unconformably upon the upright edges of the vertical slates. These slates are full of quartz reefs, some of which are worked for gold.

I would here call attention to the large number of inferences which can be drawn from the Mount Mulligan formation. It is obvious that the silurian rocks were not only deposited but contorted so as to be tilted to their present vertical dip before the sandstones were deposited upon them. The quartz reefs were also formed on them. But we know from the geological record elsewhere that an immense number of formations and a number of distinct epochs intervened between the slates and the age of the

Hawkesbury strata. Thus the upper silurian formation, with its peculiar forms of life, the lower, middle, and upper Devonian, the lower and upper carboniferous strata, are all wanting, with probably others which I do not specify, so as not to define the age of the Hawkesbury beds too closely. All these formations represent distinct animal and vegetable fauna and flora. They may not all of them have been deposited on the slates, but it is extremely probable that some of them were, and to the extent of many thousand feet of rock. They have come and gone, and very few traces of them remain. Slow as the process must have been which removed them, slower still must have been their gradual deposition. Then, again, the Hawkesbury sandstone itself has accumulated to the thickness of at least 2000 feet, and it has left no traces of its former existence except a few outliers, such as Mount Mulligan. We have no evidence here of the changes to which the beds have been subjected during the mesozoic and cainozoic periods, or how much of these rocks may have overlaid them, but that they have been in the place where we find them during that long, untold period of the earth's history. The ranges and the folds of the strata are anterior to the sandstone, and so are the veins, but they are not contemporaneous. The dykes are the last parts of the history of the strata, but they do not penetrate the sandstone. The whole subject of the geological changes evident in Northern Queensland cannot be dealt with in this paper, so I shall not pursue the obvious conclusions suggested by the interesting features of this auriferous region.

The Hodgkinson Goldfield is estimated to about 600 square miles, but probably this is much below the truth. Up to the end of the year 1878 there were 330 reefs proved to be auriferous, and this also must be below the truth, though some of the reefs looked upon as distinct belong to one and the same. It has never been much of an alluvial field. In this respect it offers a remarkable contrast to the Palmer diggings, which has been always richest in alluvial gold. The latter covers an area of about 2000 miles, with only 112 known reefs. The alluvial finds in the field were enormous; but now that this is beginning to be worked out the population has decreased. The gold reefs on the Hodgkinson are not exceeded in the number of reefs by any field except Charters Towers and the Etheridge and Gilbert, and in the yield of gold it exceeded, in 1878, every field except the Palmer and Charters Towers. Its gold is, however, of poorer quality, being only worth, on an average, in 1878, £3 8s. per ounce. The Palmer gold is almost pure, being worth £4 2s. 6d. In Queensland generally the gold is much alloyed with silver, and if the Palmer is an exception, it must be remembered that the average was taken principally from alluvial gold, which is generally nearly pure. Only 8233 ounces was of reef gold, out of 120,233 from the Palmer, while at the Hodgkinson 44,435 ounces, exported in 1878, contained about 4000 ounces of gold from alluvial sources. The Hodgkinson gold is pale in colour, and much alloyed with silver. Other metals are present in small quantity, such as copper and antimony, but in the assay only the silver is estimated. Iron and lead show traces in some mines, and there is a little sulphur, and sometimes arsenic. In a specimen taken by me from the Explorer reef, I saw blue and green carbonates of copper (azurite and malachite), sulphide of iron, sulphide of copper, and carbonate of iron and lead. The carbonates, no doubt, were derived from the carbonate of lime in the strata.

The average yield of the gold quartz from the Hodgkinson is per ton 1 oz. 11 dwt. 3 grs. In the Palmer the average is higher, being 2 oz. 13 grs.; but the average is taken from smaller parcels in the latter case—about one-fifth of the quantity crushed on the Hodgkinson. The yield had decreased on most of the diggings in 1878 from what it was in 1877. The cost of crushing is about £1 per ton at both diggings, but at Ravenswood the price charged is about 7s.; yet the miners' wages averaged higher in 1878 on the Hodgkinson than any other diggings except Charters Towers.

The quartz veins on the Palmer River are in silurian slates. There are no dykes like those on the Hodgkinson, but there is a very slight capping at one place of what may be considered a trap rock, probably tertiary, and like phonolite. At Gympie the gold is in Devonian or lower carboniferous slates, with fossils and dykes of diorite. The dykes at the Hodgkinson are entirely of a different character, and not in the least like the diorites of Gympie, which are very similar to those seen at Gaffney's Creek, in Victoria. In Charters Towers the reefs are worked in hornblendic porphyry and syenite, which is seen to be derived from altered slates. In Ravenswood a similar formation is worked for gold; but there can be no doubt that the so-called reefs are mineral veins, which become, at the water level, true copper and zinc lodes, with a little gold.

The mining operations on the Hodgkinson are of the simplest and poorest kind. Few of the claims have been followed to any depth, and only where the stone has proved rich. The reefing has been entirely carried out by a few working men in small parties. It need hardly be said that mining can never be successfully carried out in that way. There was at the time of my visit only one winding and pumping engine on the whole field, and that is only a small one on the Rob Roy claim. There are only two whims erected. In fact, there are no systematic mining operations carried on in this very rich and extensive tract of auriferous quartz. As yet, capital has not been employed on this field, and it may scarcely be said to be prospected. The little quartz that has been extracted has been got out in a slow and most expensive way, for the most part in buckets by hand windlasses, and unless the stone had been really good it never could have kept so many men employed in this way, and with these appliances, for so long a time. There are 13 machines employed on the field, with an aggregate of 155 horse-power, and 121 stamp heads. There are no buddles. One great reason for the small number of appliances is the great expense of cartage to the field. The Hercules crushing mill at Thornborough was brought from the coast almost entirely on pack-horses, at a cost of £40 a ton, though the distance is not seventy miles by road. The most of the carriage is still done by pack-horses. The road is excessively steep on the seaward side of the coast range, and, even where it has been cut, impracticable for drays in wet weather. The expenditure of a small amount of money would easily remedy this. The great want of the field at present appears to be a good road, and with that capital will soon develop its resources.

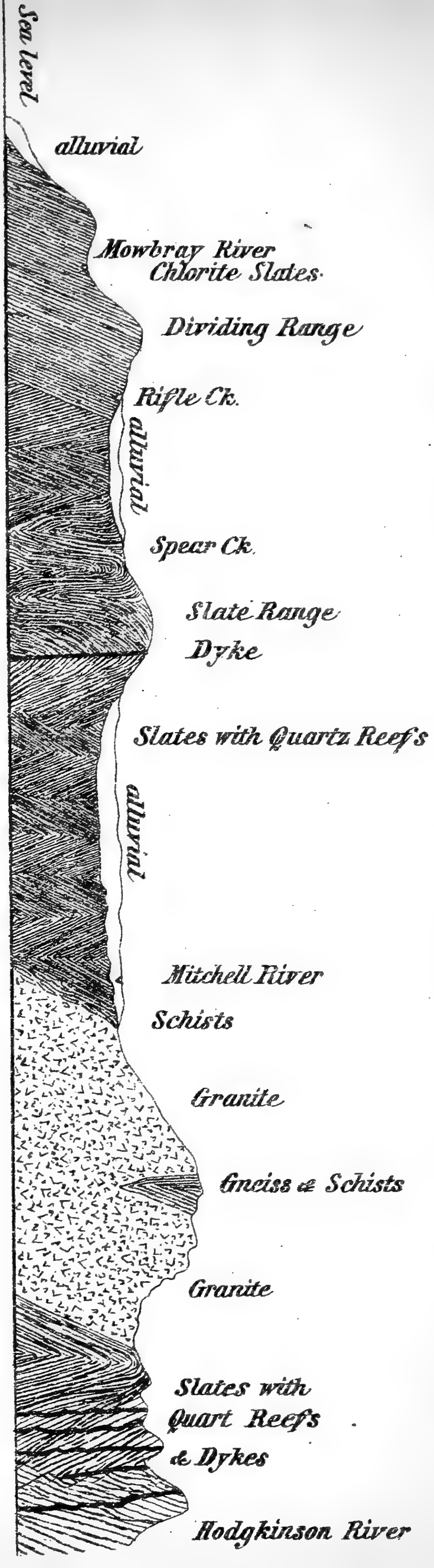
As far as experience has taught the miners, the reefs have been found richer at the surface than deeper down. An opinion prevails among the miners that the gold is only found in "shoots," or particular lines of varying direction. Thus the gold in a reef is thought to be restricted to a very limited portion of the stone, and when this "shoot" is lost the reef is often abandoned. It is quite certain that the stone becomes suddenly poor in a great many instances. The miner is not able to expend much money in searching for it again, and thus many good claims are deserted. Some have been taken up again by men of more means, and have been found to pay well. The Homeward-bound reef is a remarkable instance of this. There does not seem to me sufficient reason for the opinion that the gold is found only in "shoots." It very often happens that the miner rejects or crushes the stone for very arbitrary reasons, and some of what he throws away is often as rich as what he sends to the mills as part of the "shoot." An instance of this was related to me by Mr. Martin, the intelligent proprietor of the Hercules quartz mill. A parcel of stone was crushed by him for some miners, which yielded well. The miners then brought some more stone which they had put aside as of poor character. They would not run the risk of having it crushed unless at half profits. Mr. Martin took the stone on these terms, and it went higher than the other parcels, giving nearly 4 ozs. to the ton. For my own part, I do not believe in the "shoot" theory. The truth is, the miners cannot afford to crush all the stone they raise, and they pick out what seems to be the best, but are often mistaken in their estimate.

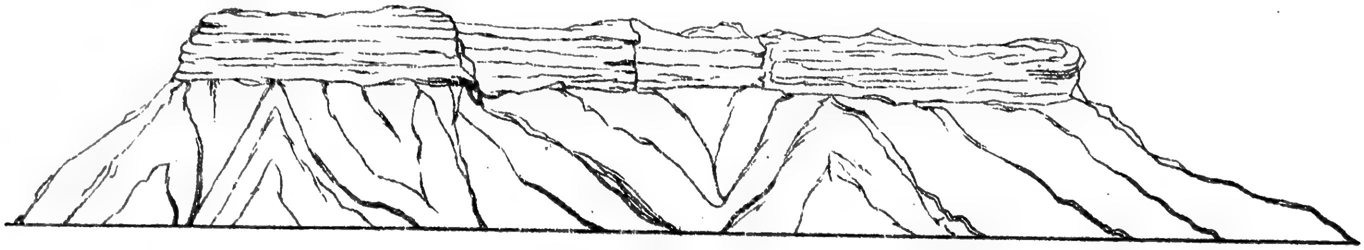
Some of the mining experiences have been most peculiar. In a claim which is on the summit of a hill, 300 feet above Thornborough, a very rich mass of stone was found. This was the celebrated reef which bore the ridiculous name of the "Flying Pig." After getting some distance down the stone became suddenly barren, though it had yielded 19 ozs. to the ton. It is easy to assign a reason for this. The surface of the reef contains the accumulation of the gold, which has dropped gradually down as the reef itself has weathered away. Seeing the immense amount of denudation that has taken place, and which has perhaps removed hundreds of feet of auriferous quartz, we might naturally expect some fragments of the golden detritus to remain entangled in the weathered surface and oxidized stone. It by no means follows, however, that the stone below will prove entirely barren, and a search as far as the water level is generally rewarded with better ore.

A question which concerns the miners of this field very much is that of the tailings. It is well known that the whole of the gold in the quartz does not get caught by the quicksilver, especially as some of the machines used are of a rough and imperfect kind. The gold thus missed remains in the tailings. I was informed that a fire assay of the tailings from one mill yielded as much as 6 ozs. to the ton. But the question is how to deal with them. A good deal of the gold is very probably in the form of minerals which the mercury will not touch, such as combinations of sulphides, antimony, arsenic, &c. I have suggested roasting the quartz, and in some of the claims the ore would be much benefited by such a process. But I admit that the kind of roasting, and the amount of it, will have to be learned by experience, which, no doubt, will include many failures.

Upon the whole, I consider the Hodgkinson to be one of the most important mining districts in Queensland, because of its richness, its large extent, and permanent character. Being so near the coast—for the actual distance is under fifty miles—it possesses advantages over nearly every other field. What is wanted is a good, easy road, and when this is made, capital will soon take up the matter of fully developing the resources of a diggings, the ultimate success of which can only be a question of time.

Sketch section from sea to Hodgkinson diggings.





Mount Mulligan from the East

Horizontal (Hawkesbury) sandstone resting unconformably on vertical slates.

Art. II.—*On Two New Genera of Polyzoa.*

By P. H. MacGillivray, M.A., M.R.C.S.

[Read April 15th, 1880.]

The two polyzoa which I describe in the present paper are found encircling the stems of *Cymodocea antarctica.* The first seems to be identical with a form from St. Vincent's Gulf, very briefly described by Mr. Hutton, in the *Transactions of the Royal Society of Tasmania* for 1877, under the name of *Membranipora cincta.* Mr. Hutton remarks that, from the exact regularity of the position of the cells, it ought, perhaps, to be made the type of a new genus. In addition to, and of more importance than the regularity of the arrangement, the structure of the cells is remarkable; and although I have placed it provisionally among the Membraniporidæ, it will probably be necessary to refer it to a distinct family. The other genus is also a very interesting one, and seems not to have been hitherto noticed.

Family MEMBRANIPORIDÆ. (?)

Genus Diplopora.

Polyzoary encrusting; cells occupied by a calcareous membrane in front, and divided into two parts, the posterior half being very much elevated; a narrow transverse portion, a little distance behind the mouth and in front of the elevated part, deficient in calcareous matter, and entirely membranous.

D. cincta, Hutton sp.

The cells are large, oblong, separated by raised margins, and arranged in transverse rows encircling the stems of *Cymodocea antarctica,* either spirally, or as continuous rings. They also form longitudinal series, occasionally bifurcating. The mouth is large, arched above, hollowed below, with a small tubercle on each side for the attachment of the operculum. Above the mouth on each side is a thick, rigid, vertically-grooved process, usually of a brown or purplish colour. These are so arranged that the spine on one side is further forward than the corresponding one of the next cell on that side, while the opposite spine is posterior to the corresponding one of the adjacent cell. The posterior half of the cell forms a lofty convex or ridged elevation, the surface of which is finely granular. Along each margin on the summit is a flattened, semipyriform, bullate process, the rounded surface being turned towards the inside of the cell. On one side the thick end is posterior, the pointed extremity being continuous with the raised margin; while on the other side the arrangement is reversed, the rounded extremity being anterior. A short distance behind the mouth the calcareous matter is deficient, leaving a space extending the whole width of the cell entirely membranous. The avicularia are of two sorts. The usual form has a large triangular mandible directed forward, is situated at the base of one of the small cells at a bifurcation of a series, and occupies the cell to the top of the elevation. The other, of which I have only seen a single example, occupies the whole width of two cells at a bifurcation, and has a broad, shallow mandible, hollowed in the middle.

Locality.—Queenscliff; Portland, Mr. Maplestone.

The regular transverse arrangement of the cells, the raised continuous posterior parts with the bullate processes, and the dark colour of the large, prominent, grooved, oral spines render this one of the most beautiful of the polyzoa. When broken, the fracture takes place through the membranous part of the cells, so that a detached row may consist of the anterior and posterior halves of the cells of two distinct transverse series.

Family DIASTOPORIDÆ.

Genus DENSIPORA.

Polyzoary forming an encrusting mass, discoid when young, composed of numerous long, closely-packed, tubular cells, continuous throughout the whole thickness, and with the orifices not projecting.

D. corrugata.

This species forms calcareous masses, more or less surrounding the stems of *Cymodocea antarctica,* varying in length up to about an inch, and in diameter to nearly half an inch. The surface is raised into numerous ridges, variously inosculating, and irregularly surrounding the polyzoary. The summit of these ridges generally forms a raised border, composed of a series of vertical, blunt processes, united side to side, except at the rounded extremities. The usual thickness of the polyzoary from the inner surface is about an eighth of an inch. The cells are very narrow, continuous throughout the whole thickness, and closely united, the walls of the contiguous cells being coalescent and indistinguishable. The interior of the cells is obscurely and irregularly transversely ridged, and is sparsely perforated by minute rounded pores. The orifices are circular or polygonal, with several thick calcareous processes from the margin. These are more numerous and larger towards the summits of the ridges, the raised border of which seems to be formed by the peculiar arrangement and union of similar larger processes. The size and shape of the orifices of the cells vary greatly, and between them are frequent smaller pores. The cells are so closely packed and the walls so thin, that the whole surface has a honey-combed appearance.

The examination of full-grown individuals would leave the exact position of this species doubtful, but an inspection of young specimens shows its Diastoporidan characters. The smallest specimen I have is about one-twentieth of an inch in diameter, is discoid, of considerable thickness in the centre, with the cells closely connate, vertical in the middle, and oblique towards the circumference. Among the marginal cells a few small pores are to be seen. The elevated ridges are early developed, and in a specimen an eighth of an inch in diameter are well marked. In completely encircling specimens, the line of coalescence of the margins of the polyzoary is generally readily discernible by the presence of a tortuous ridge, similar to the other corrugations.

Locality.—Queenscliff; Portland, Mr. Maplestone; Warrnambool, Mr. Watts.

EXPLANATION OF PLATE.

Fig. 1. *Diplopora cincta,* magnified 50 diameters.

Fig. 1*a*. Side view of two cells.

Figs. 1*b* and *c*. Two views of the same specimen, showing the avicularia, magnified 25 diameters.

Fig. 2. *Densipora corrugata,* natural size.

Fig. 2*a*. View of surface, showing the opening of the cells, magnified 50 diameters.

Fig. 2*b*. Section of the same in depression, showing—at *a* the tubular cells extending the whole thickness, at *b* the openings of the cells on the sides of a ridge viewed very obliquely, and at *c* the projecting summit of the ridge, magnified 25 diameters.

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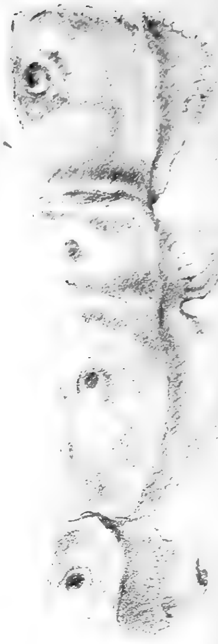
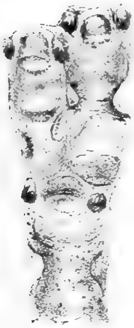
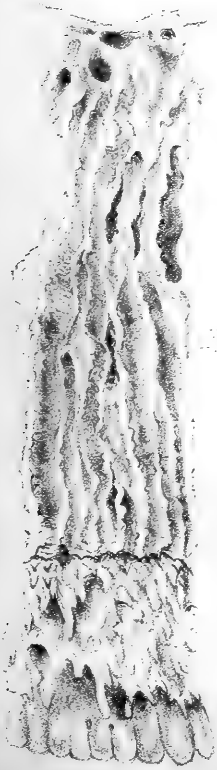
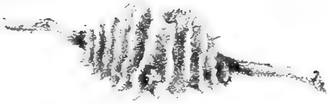








P. H. Mac Gillivray, del.

ART. III.—*On the Best Form for a Balance-Beam.*

BY W. C. KERNOT, M.A.

[Read May 13th, 1880.]

THE desirable properties of a balance for accurate weighing will be found set forth in most physical text-books; and for the purposes of this paper reference may be made to Thomson and Tait's *Natural Philosophy*, Articles 430, 431, and 572; and Deschanel's *Natural Philosophy* (Everett's translation), chapter vii. From these sources the following quotations are taken:—

"The balance-beam should be as stiff as possible, and yet not very heavy."—*Thomson and Tait*, Article 430.

"Thus the stability is greater for a given load—(1) the less the length of the beam; (2) *the less its mass;* (3) the less its radius of gyration; (4) the further the fulcrum from the beam, and from its centre of gravity. With the exception of the second, these adjustments are the very opposite of those required for sensibility. Hence all we can do is to effect a judicious compromise; but the less the *mass* of the beam, the better will the balance be in *both* respects." —*Thomson and Tait*, Article 572.

"The problem of the balance, then, consists in constructing a beam of the greatest possible length and lightness, which should be capable of supporting the action of given forces without bending."—*Deschanel*, page 82.

The question, then, is to devise a form of beam which, with sufficient strength and rigidity, shall combine a mininum mass—a problem similar to that with which the engineer has to deal, on a larger scale, in designing bridges, roofs, and other framed structures—the principal difference being that while the majority of our roof and bridge frames are supported at the ends, and loaded at intermediate points, the balance-beam is supported at the centre, and loaded at the ends.

A fundamental fact that lies at the basis of all economical design is that the longitudinal strength of comparatively long and narrow pieces of ordinary materials is very large indeed, compared to the transverse strength. A wooden lath or rod that would endure a longitudinal compression of hundredweights will break with a transverse force of a few pounds; and a metal wire—a telegraph wire, for instance—that will safely bear a pull of, say, half a ton, may, when supported on points a yard apart, be bent by a force that can be easily exerted by the hand. The first point to be regarded, then, is so to arrange matters that the parts of the structure, be it bridge or balance-beam, shall be strained longitudinally, and not transversely. To fulfil this condition it is necessary that, if all in the same plane, they shall form a series of triangles, the triangle being the only polygon the form of which is absolutely fixed when the lengths of the sides are given. The simplest and lightest arrangement possible is that of two triangles, as shown in Fig. 1, where A is the fulcrum, and B and C the points from which the loads are suspended. Under the action of the loads the parts B D, D C, and A E endure tensions, and B E, E C, D A compressions, the magnitudes of which are calculable by the methods of statics on the assumption that the points B D C E are hinges. Should these points not be hinged, the actual stresses will be complicated by certain elastic actions, but to an extent that is quite unimportant when the lengths of the parts are large, compared with their transverse dimensions in plane of the beam, as is the usual case in framed structures.

Beams of a design somewhat similar to Fig. 1 in form are frequently met with. They are, however, usually open to objection on the following grounds:—

1. The bars, instead of meeting strictly at points at B and C, often terminate at different levels, as in Fig. 2, thereby losing to a large extent the benefits of the triangular system, and introducing transverse bending moment, and complicated elastic actions inimical to rigidity.

2. A number of vertical connections are introduced, adding to the mass, but not enduring any definite calculable stress.

3. Instead of one vertical diagonal D E, two bars are used, F G and H I, the portions F H and G I being bent as shown. This is a departure from all sound principles of design. If the bars F G and H I be used, as is, perhaps, desirable in order to accommodate the usual arrangement of fulcrum, then G I should be made perfectly straight and F H specially strengthened to endure the bending moment due to the upward reaction of the fulcrum. This last defect is very manifest in Figs. 42 and 43, pp. 85, 86, of *Deschanel,* representing a "balance of great delicacy."

The next question is to determine the magnitude of the angles B D E, B E D, &c., for which the mass of a beam of given strength is a minimum, and this can be accomplished by the use of the methods of the differential calculus as follows :—

Let us suppose the material of the beam to possess equal strength in compression and tension, then the beam will be symmetrical about the line BC, the lower half being the exact counterpart of the upper; let the length BC $= 2l$, DE $= 2x$, then under a given load W acting at B, the tension on BD will be

$$\mathrm{W}\,\frac{\mathrm{BD}}{\mathrm{DE}} = \mathrm{W}\,\frac{\sqrt{l^2 + x^2}}{2x}$$

The amount of material in each part of the frame will be proportional to the product of the stress into the length, therefore, the amount of material in BD will be

$$c\mathrm{W}\frac{\sqrt{l^2 + x^2}}{2x}\,\sqrt{l^2 + x^2} = c\mathrm{W}\,\frac{l^2 + x^2}{2x}$$

By symmetry the stresses on the four bars BD, DC, CE, EB will be equal, and the material required for them will be

$$4\,c\mathrm{W}\,\frac{l^2 + x^2}{2x}$$

The compression on DA and the tension on AE will each equal W, and the amount of material in them will be $2c\,\mathrm{W}x$

The total material in the frame is

$$4\,c\mathrm{W}\,\frac{l^2 + x^2}{2x} + 2c\,\mathrm{W}x \qquad (1)$$

$$= 4\,c\mathrm{W}\left(\frac{l^2 + x^2}{2x} + \frac{x}{2}\right)$$

$$= 4\,c\mathrm{W}\left(\frac{l^2}{2x} + x\right)$$

And we wish to find the value of x, for which the quantity in the bracket is a minimum.

Let

$$y = \frac{l^2}{2x} + x$$

$$\frac{dy}{dx} = -\frac{l^2}{2x^2} + 1 \qquad (2)$$

When y is a minimum or maximum $\dfrac{dy}{dx} = 0$

Therefore—

$$-\frac{l^2}{2x^2} + 1 = 0$$

$$\frac{l^2}{2x^2} = 1$$

$$2x^2 = l^2$$

$$x = \pm l \frac{1}{\sqrt{2}}$$

Consequently the economic form is a rhombus, as in Fig. 3.

Cast steel can be obtained having a resistance both to crushing and tearing of at least 100,000 lbs. per square inch. Let such steel be used, and let the length B C be 20 inches; the sectional area of B D, D C, C E, and E B, $\frac{1}{77}$ of a square inch; and of A D, and A E, $\frac{1}{70}$ square inch; then the volume of the beam will be ·85 of a cubic inch, and its weight about one-fifth of a pound avoirdupois. The weight that would have to be placed at B and C in order to cause fracture would be, in round numbers, 1400 lbs., and a load of one-fourth of this amount, or 350 lbs., should be perfectly safe if carefully imposed. Thus we should have a beam 20 inches long, and weighing less than one-fourth of a pound, supporting safely at each end 1400 times its own weight. If made of iron, the strength of which would be from one-third to half that of the steel, it would support safely about 150 lbs. at each end; and if of brass, about 80 lbs.

Of course, the parts in compression would need to be of tubular or girder section to give lateral stiffness.

Two practical objections suggest themselves at this stage—

1. That the vertical bar D E would interfere with the necessary arrangements for the fulcrum. This difficulty may be met with by the modification shown in Fig. 4, with but inconsiderable increase of weight.

2. That this form of beam would not permit the use of the ordinary "rider." This objection may be met by stretching a fine wire from A to B and from C to D, and placing the rider on this.

In conclusion, the form of beam proposed secures the minimum mass for a given safe load, and also, by virtue of its great depth, will be exceedingly rigid. Its construction should present no special difficulty, and I see no reason why it should not be generally adopted.

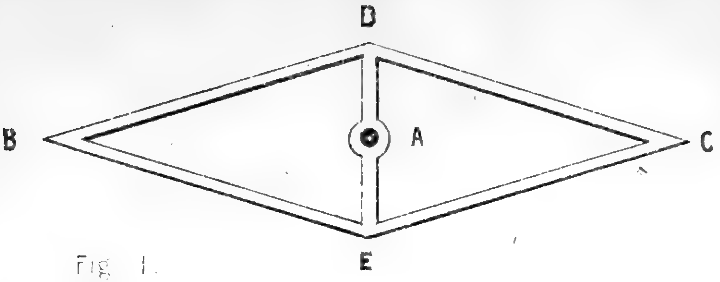


Fig : 1.

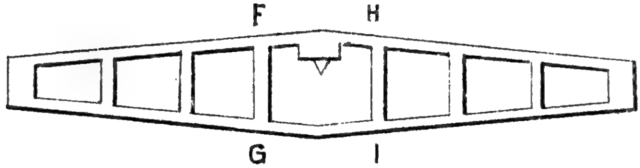


Fig : 2.

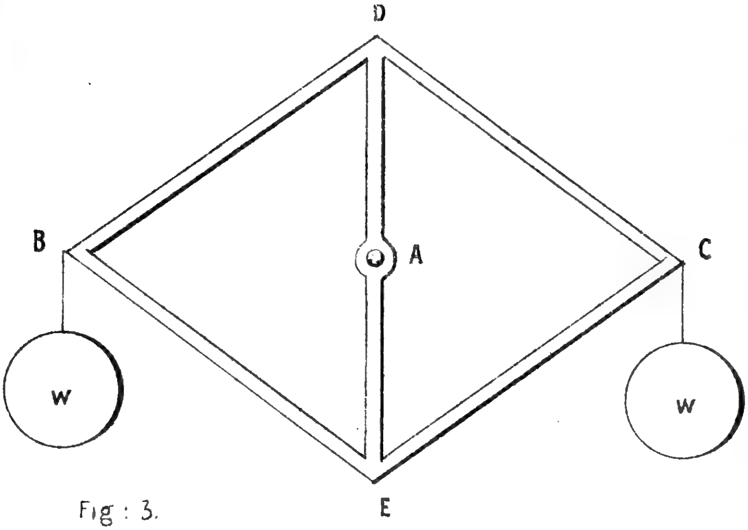


Fig : 3.

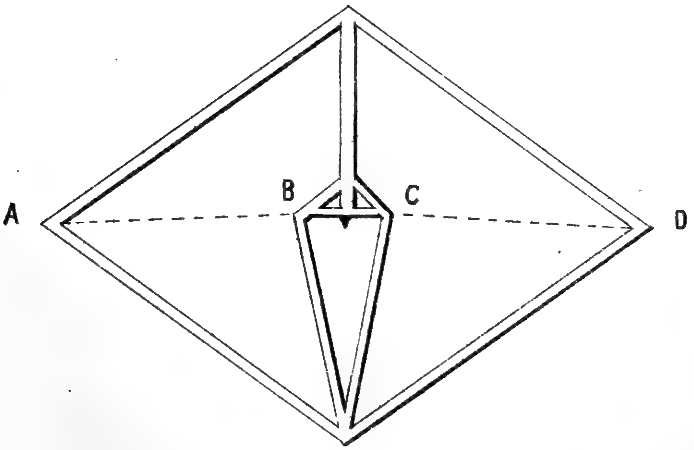


Fig : 4.

ART. IV.—*A New Process of Purifying Water discovered by M. Birkmyre.*

BY MR. C. R. BLACKETT.

[Read May 13th, 1880.]

ART. V.—*The Tay Bridge.*

BY W. C. KERNOT, M.A.

[Read July 8th, 1880.]

THE object of the present paper is to give a brief account of a structure which, from its size and the nature of its construction, is one of the most remarkable in existence, and of a disaster, the consequences of which, in respect to loss of life and destruction of property, are probably without parallel in the history of railway engineering.

The Tay Bridge crosses the Firth of Tay at Dundee, and is a portion of the direct line of railway connecting that city with the more southern parts of Great Britain. The Firth itself is an arm of the North Sea, about 25 miles long, and at the bridge nearly 2 miles in width; the site being some 10 or 12 miles inland.

The bridge, which carries a single line of railway of 4-feet 8½-inch gauge, is straight for a length of considerably more than a mile, the ends being curved, the northern extremity contiguous to the town of Dundee forming a quadrant in plan. The straight portion lies very nearly north and south.

The exact length of the structure, as given in the *Engineer* of the 2nd January last, is 3450 yards, or 70 yards less than 2 miles, and is divided into 85 spans, or openings, varying from 29 to 245 feet. The piers numbered 1 to 14, counting from the southern end, are entirely of brick, the remainder being, with a few unimportant exceptions, open frames, consisting of a group of cast-iron columns connected together by wrought-iron bracing.

The girders are of wrought-iron, with, in most cases, parallel top and bottom members, and a double triangulation between at an angle of 45° with the horizontal.

For the greater part of the length the rails are supported on the upper member of the girders, but for a distance of 3149 feet in the centre of the stream the *sunk platform* type of bridge is adopted, the traffic passing between the girders, which are braced together overhead so as to form a lattice tube or cage. This is intended to secure head-way for navigation.

This portion is perfectly straight, and contains all the larger openings, the length being composed of **11** spans of 245 feet each, and 2 of 227 feet.

The height of the bridge above the water varies considerably, the greatest altitude being attained in the portion last described, where the soffit of the girders appears to have been about 90 feet above high-water mark.

To give a clearer idea of the magnitude of the structure, we may state that the total length would reach from the gate of the University grounds, in Grattan-street, to the barracks on the St. Kilda-road, while the "high girders," or sunk platform part, would correspond to the distance from the Public Library to Prince's Bridge, and the total height above high-water mark to that of the top of the flagstaff at the General Post Office above the pavement in Elizabeth-street.

On Sunday evening, 28th December, 1879, a train left the southern end of the bridge for Dundee. The night was cloudy, and a heavy gale was blowing from the westward. The lights of the train were watched until the high girders were reached, when they disappeared, and the moon shining out shortly after, revealed the appalling fact that the whole of the larger spans had fallen, and with them the train. A closer examination showed that the foundations of the piers, which were constructed of brickwork up to a height of about 5 feet above high-water mark, remained intact, while the upper portions, consisting, as before mentioned, of cast-iron columns, were almost entirely destroyed, and the cage, 3149 feet long, formed by the girders, cross-girders, and horizontal bracing, lay bruised and twisted, but still recognisable, with the train inside it, about 20 yards to the leeward of the brick foundations.

Detailed views of the wreck and other particulars are to be found in the *Engineer* of January 2nd, 9th, 30th of the present year, and *Engineering* of the same dates. As soon as the particulars of the disaster became generally known, various theories were proposed to account for it, the principal of which we shall now proceed to consider.

1. *That the train was blown off the rails, and, coming into collision with some important member of one of the girders, broke it, and so let the structure fall.* The first question to be settled with reference to this hypothesis is whether the force of the wind was likely to effect such a displacement.

The velocity and pressure of wind have long been a subject of continuous observation at meteorological observatories, and values of the latter of about 40 lbs. per square foot have been recorded on various occasions, while 55 lbs. is given in Trantwine's *Engineer's Pocket Book* as having been once realised at Glasgow. The highest result on the books of the Melbourne Observatory is 35 lbs. A value higher than any of those mentioned was obtained at Sydney during the great "Dandenong" gale, but has not yet been confirmed by any corroborative testimony. During the Tay Bridge gale a pressure at Glasgow of 25 lbs. was registered more than once, and occasional gusts of even greater intensity are believed to have occurred.

Taking a general view of the data available, it appears that we may certainly anticipate in exposed positions occasional wind pressures of 40 lbs. to the square foot, and that it would be prudent in such cases to design structures so as to be safe up to half a hundredweight to the square foot, or a ton to 40 square feet. These numbers have the advantage of facilitating computation.

We next inquire what wind pressure would be needed to overturn ordinary railway rolling stock. Taking an ordinary first-class carriage, as used on the Victorian railways, we have the following results :—

Weight, empty ... ... 7·5 tons.
" with 32 passengers, at 168 lbs. ... 9·9 tons.
Moment of stability = weight × ½ distance of centres of rails.
= weight × 2·5 ft. (if the gauge be 4 ft. 8½ in.)
= 18·75 ft.-tons, if empty, or 24·75, if full.
Area of side of carriage, 24 ft. × 8 ft. = 192 sq. ft.
Height of centre of pressure from rails, 7 ft.
Moment of overturning, in ft.-tons = $7 \times 192 \times p = 1344p$.
When p = wind pressure in decimals of a ton to the sq. ft.

Equating this expression with the values of the moment of stability last obtained, we have—

$$p = \frac{18\cdot75}{1344} = \cdot0139 \text{ ton} = 31 \text{ lbs.}; \text{ and } p = \frac{24\cdot75}{1344} = \cdot0184 \text{ ton} = 41 \text{ lbs.}$$

as the pressures at which the carriage would be on the point of overturning when empty or full respectively. Both of these values, it will be seen, are within the limits of actually recorded observations, and from this point of view the theory is a perfectly admissible one. There are, however, certain considerations tending to show that the theory, though reasonable, is not the true one—First, the wind was much more likely to overturn the carriages when running over the first, or southern, part of the bridge than when partially sheltered inside the cage, and yet we know that that part was traversed in safety. Second, the diagonals of the girder were few in number, and of massive construction; so that it is probable that the comparatively slight wooden body of a railway carriage would be powerless to injure them, especially as it would not strike a fair blow against a bar inclined 45° to the horizon. The engine itself, weighing four times as much as a carriage, and presenting less surface to the wind, would not incur any danger of displacement. Third, in accordance with this view the injured span only should have fallen, and not 3000 feet of bridge. Fourth, the wreck would have been found on the site of the bridge, and not some twenty yards to the east.

But while this theory is rejected as an explanation of the Tay Bridge disaster, its consideration is useful as directing attention to what is, possibly, a serious danger to railway traffic. Suppose, for example, a partially empty train were caught on the Moorabool Viaduct by a heavy gale; it is not at all impossible that the carriages might be swept into the valley beneath. It is true that our somewhat wider gauge gives our rolling stock a little more stability than possessed by English vehicles, but allowing for this and computing as above, the critical pressure is found to be only 34½ lbs. per square foot for ordinary carriages when empty, and only 26 lbs. for the large American bogie stock, both of which are within the range of recorded pressures at the observatory. Under these circumstances it becomes a question whether a special semaphore actuated by wind pressure should not be erected on our largest and most exposed structures. Such a machine could be simply constructed of a semaphore arm, a plate at right angles to the bridge to receive the wind pressure, and a balance weight; there need be only one axis of motion, and this could be of small diameter and loose fit, so as to need no lubrication, and if of gun-metal there would be no danger of its being stuck fast by rust. The balance-weight should be such a size that it would turn over and stop traffic whenever a wind blowing across the bridge exerted a pressure of more than 20 lbs. per square foot. The contrivance would be inexpensive, and might prevent an appalling catastrophe.

2. *The second theory is that the girders themselves were overturned by the pressure of the wind on their upper members, turning about the lower leeward edge of each lower member as axis.* This theory is favoured by the circumstance that, owing to the space between them being utilised for traffic, it was impossible to adopt the usual transverse tracing in a vertical plane. This sort of overturning would be antagonised by the combined moments of resistance of all the cross-girders, distance-pieces, &c. The exact amount of this aggregate moment we have not sufficient data to compute, and therefore cannot follow up the theory further. It is, however, completely negatived by the appearance of the wreck, which shows the main girders and their cross-girders still united at right angles. The suggestion, though thus not applicable in the present case, is worth keeping in view, for it is quite conceivable that large plate-girder bridges might be very heavily strained in this way, and should be correspondingly braced.

3. *The third theory is that the bridge was overturned as a whole by the wind, the skeleton piers turning about the base of the leeward column as a hinge.* In order to test this view by computation we must ascertain the weight and dimensions of the structure. There appears to have been, according to the best information we have, about 380 tons of material in each iron pier with 245 feet length of girder. The width of the base, taken to the centres of the columns, being 22 feet, the moment of stability becomes 380 × 11 = 4180 ft.-tons.

It is difficult to determine the exact area of the structure which was effectively exposed to the wind. Each girder presents a surface of 1960 square feet, but the question arises to what extent the leeward girder will be sheltered. Some have assumed that the windward girder alone was affected, but this is manifestly a mistake, for the bars of which the girders were composed being from 6 to 20 inches in width only, and the spaces between them triangles and squares of from 70 to 400 square feet each, the amount of shelter given would be but small at a distance of 15 feet—about as much, as has been humorously remarked, as a man would experience on a windy day, if standing 5 yards to the leeward of an ordinary street-lamp. Indeed, if the direction of the wind varied by 5° from a line at right angles to the structure all the diagonals of the lee girder would be fully exposed, and if at the same time it varied a few degrees from the horizontal the exposure of the whole of it would be practically effected. It will, I think, be admitted that the case is favourably stated if the diagonals and vertical members of the lee girder are regarded as fully exposed, and the horizontal members fully sheltered. Taking this view, we have 1960 square feet for the windward, and 800 feet for the leeward girder, giving a total of 2760 square feet. The effect of the wind on the pier itself will not be large, the columns being circular, and the flat braces in no case being presented at right angles. Neglecting it, we shall considerably simplify the calculation, and the small error introduced will be in favour of the stability of the structure.

The centre of pressure will be 96 feet above the base of the columns, and the moment of overturning will be $p \times 2760 \times 96 = 264{,}960p$. Equating this with the moment of stability previously determined, we have—

$$p = \frac{4180}{264960} = \cdot 0157 \text{ ton} = 35 \cdot 2 \text{ lbs.}$$

This, then, is the critical wind pressure at which the structure would overturn, assuming that there was no connection other than simple contact between the iron columns and the brick foundation, and that the pier itself was strong enough to maintain its shape during such overturning.

But these assumptions are not strictly correct; the iron pillars *were anchored down* by bolts to the foundation, so that the pier could not overturn without carrying a part of the foundation with it. Had these holding-down bolts gone 25 or 30 feet down so as to embrace several hundreds of tons of brickwork, sufficient stability could have been obtained. However, it is evident from the drawing that such a proceeding was not contemplated, the bolts going down only from 2 to 3 feet, and being small and imperfectly secured. Allowing that they were capable of lifting all the upper courses of the pier, the critical pressure, as previously calculated, will be increased by about one-sixth, and will still remain well within the range of actually recorded observations.

The effect of the train upon the bridge is, from this point of view, comparatively unimportant. Its weight tends to increase the moment of stability, while the sides of the carriages partly block up the openings, and so increase the area exposed to the wind. The increase in the overturning moment from the latter cause is rather greater than that of the moment of stability, and the result of the whole when calculated out is to reduce the critical pressure by about 3 lbs. per square foot.

Here, then, we have a perfectly consistent and logical explanation of how the accident might have happened, *supposing the structure to have been perfectly sound in every other respect.*

An inspection of the wreck, however, leads us to doubt whether this was the precise mode of fracture, for, first, the foundations, as a rule, are quite undisturbed, the columns being broken transversely just above their bases; and, second, some of the piers yet remain comparatively uninjured for a considerable height, the upper portion only being absent. This could hardly have occurred were it a case of pure overturning.

4. We are now led to the last, and as is, I think, now generally admitted, the true explanation, and it is this—that *the bracing of the piers gave way and allowed each column to turn about its own base as a centre, the columns meanwhile remaining parallel like the two bars of a parallel ruler.*

Each pier was composed of six columns, placed at the angles of a hexagon, two sides of which were at right angles to the length of the bridge, while the others were at an angle of 45°. At every 11 feet in height the columns were connected together by massive double channel irons, and the square openings formed by the columns and channel irons were provided each with two diagonal braces, upon which was imposed the duty of keeping the columns vertical under the action of any lateral force. The braces were far too weak, and, giving way, permitted the columns to fall laterally.

We have first to ascertain, in order to test this view mathematically, what was the pull on each brace under 1 lb. of wind pressure on the structure above. In this case the surface of the train will be added to that of the girder, while its weight will in no way affect the stress on the bracing.

The total area exposed in each 245 feet length of bridge now becomes, including total area of windward girder, area of train, and area of upper half of diagonals of leeward girder, 3800 square feet, which at 1 lb. per square foot wind pressure gives 3800 lbs., or 1·696 tons. This will exist as a horizontal shearing force on the upper story of the pier. Lower down it becomes slightly larger, owing to the pressure on the columns themselves and their bracing, but the increase will be insignificant; by neglecting it we shall simplify calculation, and the error will be very slight, and favourable to the structure.

The braces are so constructed as to act in tension only; those, therefore, that slope downward away from the wind will be altogether inoperative, and may be omitted in our investigation. We will further suppose that all the braces are carefully adjusted, so that each does its fair share of work. It can then be shown that under a given small lateral displacement of the structure that the elongation of the braces in the diagonal faces of the hexagon, the panels of which average 11 feet high and 8 feet wide, will bear to that of those in the transverse faces, the panels of which are 11 feet high and 10 feet wide, the ratio of 12 to 19, and that, therefore, when the diagonals in the transverse faces experience a tension of 19, those in the diagonal faces endure only 12. Let, now, x equal the tension on the diagonals in the transverse faces, then $\frac{12}{19}x$ will be that of those in the diagonal ones. Thus we can state the subjoined equation where x will be the tension for 1 lb. wind pressure on the structure and train.

Taking resolved parts of all the tensions horizontally at right angles to the bridge, we have—

$$2 \times \frac{10}{15} x \times 4 \times \frac{12}{19} \times \frac{8}{13{\cdot}6} x = 3800 \text{ lbs.}$$

Or,

$$x = 1347 \text{ lbs.}$$

Now let us examine the construction of the braces. They consist of flat bars of wrought-iron, $4\frac{1}{2}$ inches wide and half an inch thick, secured at each end by a bolt $1\frac{1}{8}$ inches in diameter, which appears to have fitted tightly into a hole in the flat bar and loosely in a pair of lugs cast on the column between which the end of the bar was placed. Such a joint might break by shearing the bolt, and such fracture would take place under a pull of $2 \times (1\frac{1}{8})^2 \times {\cdot}7854 \times 50{,}000 = 99{,}400$ lbs. = 44 tons, nearly; or it may give way by tearing the metal on each side of the bolt hole; the area so torn through will be $(4\frac{1}{2} - 1\frac{1}{8}) \times \frac{1}{2} = 1{\cdot}68$ square inches, which, at 60,000 lbs. per square inch, would require 100,800 lbs., or 45 tons, if the stress were uniformly distributed over the whole section. The experimental researches, however, of Sir C. Fox and Mr. Berkley have shown that the stress is unequally distributed in this case, and have determined a certain set of proportions by adopting which an eye of equal strength against all possible kinds of fracture is secured. Following the lines laid out by them, we find that the best eye that can be delineated within the limits of a bar $4\frac{1}{2}$ inches wide around a $1\frac{1}{8}$-inch bolt is one the actual strength of which is equal to that of a uniform straight rod not more than 2 inches wide, and having, therefore, an area of 1 square inch, which would tear through with 60,000 lbs., or 26·7 tons. Having already computed the value of x for each pound of wind pressure, we find that any force exceeding 44·5 lbs. per square foot should destroy the structure on its first application, while any pressure exceeding about half of this, or 22 lbs., would effect the same result after a certain sufficient number of repetitions. This result is without allowing any margin whatsoever for defective material or errors of workmanship. Making the usual allowance, we may confidently say that the structure was unsafe at any pressure above 15 lbs. per square foot. In view of this last result, we may well ask, not why the Tay Bridge fell, but why it stood as long as it did. According to this view, the tendency to fracture should increase but slowly from the top of the pier downward; so that, while we should anticipate the majority of the columns to break off at their bases, we should be quite prepared to see a higher fracture in some cases, due to local peculiarities of adjustment. It is also interesting to note that in those piers of which parts still exist those braces which, according to the preceding investigation, are most heavily strained are in almost every case fractured, while the others remain intact.

As a matter of fact, it seems that the cast-iron lugs themselves have usually fractured, and not the wrought-iron bars. We have not sufficient particulars to calculate the strength of these lugs; but this only shows that there was a weaker place still even than the eye at the end of the bar. The strength of the latter, however, is calculable, and constitutes a gauge of the weakness of the whole structure.

Thus we have been led to the subjoined conclusions:—

1. That during heavy gales railway traffic should be stopped on high bridges and exposed parts of the line.
2. That the Tay Bridge fell under a gale of by no means unprecedented severity owing to the weakness of the bracing of its piers.
3. That this bracing should have been about four times as strong as it actually was made.
4. That had the bracing been satisfactory the bridge would have been in danger of overturning bodily under a wind pressure less than has repeatedly been observed.
5. That such overturning could be prevented by proper anchorage, which anchorage did not exist in the structure as built.

It may be asked, How came so important a structure to have been built in ignorance or defiance of the laws of statics—laws which have been known and taught in universities and elsewhere for centuries ? and how came it that no one detected the error during all the years that were occupied in building it ? To these questions a positive answer cannot be at present given. I strongly incline, however, to the belief that the Tay Bridge is a conspicuous but by no means solitary result of an imperfect system of education, which ignores the necessity of accurate training in dynamics on the part of those who enter the engineering profession. It is currently believed that a mysterious aptitude gained by long acquaintance with professional matters is an effective substitute for mathematical knowledge. The Tay Bridge, probably, is only one of many instances proving that, while ordinary practical experience, unaided by accurate scientific knowledge, may suffice for the routine of daily work, it is liable to fall into the most dangerous errors in structures of special form, and under unusual conditions. For the higher and more special class of engineering problems we need scientifically educated men, not mere empirics.

With regard to the second part of the question—why the error was not detected—it may be stated that, contrary to the usual and excellent practice in the case of important structures, no details of the construction were made public in the engineering journals or otherwise ; and from its position the bridge was not readily accessible to visitors.

The evidence taken so far as to the accident shows that the workmanship was far from being as perfect as is usually thought desirable. The fact, however, that the bridge stood as long as it did, and that so much of it escaped destruction, appears to show that either the gale was not so heavy as reported or that the defects of workmanship did not to any very large extent affect the strength of the structure.

NOTE.—Since this paper (which was originally prepared for the June meeting of the Society) was written, certain further particulars have come to hand, including the designer's own evidence, and the calculations of Dr. Pole, F.R.S., all tending to confirm the preceding conclusions. A telegram in the *Argus* of the 6th July states that the Board of Inquiry has just made its report public, which "arrives at the conclusion that the general design of the bridge was such as to call for strong censure," and that the engineer "is accordingly severely blamed for the construction of such a bridge, to which the disaster to the train is considered to be mainly attributable."

ART. VI.—*Proportional Representation.*

BY PROFESSOR E. J. NANSON.

[Read July 8th, 1880.]

VARIOUS plans have been proposed for obtaining a nearer approach to proportional representation than is afforded by the majority system in common use. These plans have been classed by M. Ernest Naville under two heads, "Empirical Systems," and "Scientific Systems." Under the first head are included the single vote, the cumulative vote, and the restricted vote. These systems are in many respects superior to the majority system, but they are one and all open to a very serious objection. It is that the electors are compelled to submit to the dictation of party leaders, and adopt some process of organisation under pain of compromising their party, and depriving it of its fair share of representation. Besides this, if it should happen that the calculations of the leaders are wrong, the party does not obtain its fair share of the representation. Thus, in a three-cornered constituency, two-fifths of the electors may easily return two of the representatives, leaving the majority of three-fifths with one representative only.

Again, the single vote and the cumulative vote are liable to an enormous waste of voting power. Thus, for instance, at the School Board elections in 1870, for Marylebone, Lambeth, Sheffield, and Birmingham, the percentages of wasted votes were 66, 57, 54, and 48 respectively.

Under the head of "Scientific Systems," M. Naville includes the preferential vote, the independent ticket vote, and the uninominal vote.

The first of these, due to M. Andrae and Mr. Hare, is fully explained in the subsequent part of this paper. The second and third are modifications of the preferential vote. In the second, any body of electors exceeding a given number (say 30) can put forward a "ticket." The electors are then permitted to vote for any of these tickets. In the third, instead of each elector making a list of candidates to whom his vote may be successively transferred, each candidate makes a list of the other candidates to whom the superfluous or useless votes given to him are to be transferred. These lists are published before the election, and each elector votes for one candidate.

The preferential vote is the only plan which will make the electors entirely independent of party leaders and party organisation, and it appears to be the most perfect system which can be devised for approximating to proportional representation. It is to be particularly noticed that the preferential vote applies to all cases alike, whether there be one, two, three, or a hundred vacancies to be filled. Hence it might be applied to the present electorates of this colony. But a great advantage would be gained by doing away with electorates returning one member. For with equal electorates returning one member apiece, it is possible under any system of voting for a trifle over 25 per cent. of the electors who vote to return a majority of the representatives; and if the electorates be not equal, a still smaller percentage might return the majority. Now, although exactly the same result could happen under the majority system if the electorates have more than one member apiece, the case is very different with the preferential vote. Under that system, with equal electorates returning each n members, it would not be possible for less than $\frac{1}{2}\frac{n}{n+1}$ of the whole number of voters to return half of the representatives. Thus, if each electorate had five representatives, it would require at least 42 per cent. of the voters to return half the representatives; whereas, under the majority system, 25 per cent. could return half the representatives.

With single electorates we see, then, that the majority system and the preferential system are alike subject to the anomaly just pointed out. But the preferential vote would be superior in two respects. First, we should be sure that the majority would rule in each electorate, whereas, under the so-called majority system, we have no such certainty; and, secondly, the electors themselves would be able to decide who was the best candidate on their own side, whereas at present the candidates have to be chosen and nominated by party leaders. If, however, the preferential vote be applied to electorates returning two or more representatives, the anomaly just described is got rid of to a very great extent, and if the number of representatives be made sufficiently great, it disappears completely.

In illustration of the preceding remarks on the majority system, it may be mentioned that, at the last general election in this colony, the successful party had a majority of 9 in the 27 single electorates where contests took place, whilst the voting powers of the two parties in those electorates were approximately in the proportion of 19 to 17. The representatives returned by the larger electorates were very evenly divided between the two parties; but, in the absence of an analysis of the voting in each electorate similar to that supplied by the scrutineers at Sandhurst and at West Melbourne, it is quite impossible to estimate accurately the relative voting powers of the two parties. So far as any conclusion can be drawn from the published returns, it would appear that the voting powers of the two parties were very evenly balanced. Hence we may infer that the state of representation obtained in the large electorates was much more perfect, taken on the average, than that obtained in the single electorates. There is, however, no reason why this should be so. In fact, the single electorates might have been expected to give the better average result; for if a given number of representatives have to be elected, the smaller the number of electorates, and the larger the number of representatives returned by each, the greater would the anomalies of representation probably be. In particular, if there were only one electorate, it is highly probable that all the representatives might be returned by one party.

We may conclude, then, that if the preferential vote were applied to the present electorates of this colony the representation would be much more perfect than it can be under the present plan; that it would be still more perfect if the electorates were enlarged, and their number decreased, and that if each electorate returned at least five representatives we should have a very fair approximation to proportional representation. By limiting the number of representatives returned by each electorate to five, six, or seven, we should not have any difficulty in filling any vacancies which might arise from time to time; whereas, if the whole colony were thrown into one electorate, some totally new principle would have to be adopted for dealing with such cases.

The methods hitherto given by Mr. Hare and others for dealing with the contingent votes are open to certain objections. These may be briefly stated as follows:

(1.) The result of the election depends to a certain extent upon chance.

(2.) In the course of the election a number of votes are generally wasted unnecessarily.

(3.) At the end of the election candidates are returned on fewer votes than those required for the return of candidates who are elected at an earlier stage of the election.

The object of this paper is to examine some of these points, and to give a process, from which the element of chance is completely eliminated, by which no votes are wasted unnecessarily, and by which all the representatives are returned on as equal terms as possible.

In the system of representation proposed more than twenty years ago by Mr. Hare each elector has one vote only. But, in order to guard against waste of voting power, each elector is permitted to indicate other candidates in successive order for whom he would be willing to vote in case his vote is not required for the candidate of his first choice. Thus, each elector is furnished with a ballot-paper containing the names of the candidates in alphabetical order, and the elector places the figure 1 opposite the candidate of his first choice, *i.e.*, the candidate for whom he wishes to vote. He is also permitted to place the figures 2, 3, 4, &c., opposite the names of other candidates, for whom in their successive order he would be willing to vote in case his vote is not required for the candidate of his first, second, third, &c., choice. It is better to use this form of ballot-paper than to require the electors to write down in successive order the names of the candidates they are willing to vote for. Further, it is not wise to place any limit upon the number of names which may be indicated; any such restriction would be a direct inducement to party organisation. When the voting is over, the first thing to be done is to ascertain the number of votes cast for each candidate, counting only the names marked with the figure 1, and thence the total number of votes cast. The papers polled for the several candidates are placed in separate heaps and the heaps arranged in order, placing first those containing

Form of Ballot Paper.

Order of Preference.	Names of Candidates.
4	A
2	B
	C
3	D
1	E
	F

most papers. In case of equality the Returning Officer must exercise a casting vote. A list of the candidates in the order in which their heaps are arranged is then made out. The order of the candidates on this list will be frequently referred to as the order of priority of the candidates on the first count, and use will be made of it in all cases where otherwise it would be necessary for the Returning Officer to exercise a casting vote.

The next step is to determine the *quota*, or number of votes sufficient for the return of a candidate. This is done by the following rule.

Divide, to the exclusion of fractions, the number of votes polled by a number greater by one than the number of seats to be filled, and add one to the result.

Thus, if there be 15 seats the quota would be 100 if the number of votes polled were 1584 or 1599, or any number intermediate to these two.

Having determined the quota, the next step is to ascertain what candidates, if any, have attained the quota. Here, then, two cases arise. First, let us suppose that no candidate has more than the quota. Then the next step is to exclude the candidate who is lowest on the first count. The heap of the excluded candidate is then examined, and the papers in it are transferred to the heaps of the candidates, if any, who are indicated as the second choice of the electors. For example, let A, B, C, &c., denote the candidates, of whom Z is the lowest, and suppose, on examination, we find that $ZA = 12$, $ZB = 10$, $Z1 = 23$, where ZA is used to denote the number of papers on which Z is marked 1 and A is marked 2, and so on, whilst Z1 denotes the number of papers on which no name is marked except that of Z, we should then transfer the 12 ZA papers to A's heap, and the 10 ZB papers to B's heap. The 23 Z1 papers are of no use, and are lost.

We should now proceed to a new scrutiny. If, however, any papers are lost, as in the preceding example, the total number of papers which can have any effect on the election is diminished, and we should determine a new quota, taking account only of the useful papers left. For example, if the number of votes cast be 1599, as supposed above, we have now in the example just given 1576 useful papers left, and the new quota would be 99.

This process of excluding the lowest on each count, and distributing any papers which can be distributed, and diminishing the quota every time a sufficient number of papers are lost, would have to be repeated until either there remain no more candidates than vacancies, or until some one obtains more than the quota.

If there is only one vacancy to be filled, the whole process of the election falls under this case. The quota for any count is an absolute majority of the useful votes left.

It is also to be noticed that if at any stage a candidate has a number of votes greater than the sum of the votes of all the candidates who have less than he has, then all such candidates may be at once excluded; in particular, if any candidate has an absolute majority on the first count he is elected.

Next, let us suppose that at least one candidate has more than the quota. Let A, B, C, &c., denote the candidates who have a quota or more, and let P, Q, R, S, &c., denote the candidates who have less than the quota. The first thing to be done is to examine the heaps of A, B, C, &c., so as to arrive at the information shown in the following table:

TABLE I.

		P	Q	R	S
A	A1	AP	AQ	AR	AS
B	B1	BP	BQ	BR	BS
C	C1	CP	CQ	CR	CS

Here A1 denotes the number of papers on which A is marked 1 and on which no other names, if any, are marked, save those of the elected candidates, B, C, &c., and so for B1, &c. AP denotes the number of papers on which A is marked 1, and on which P is marked as the prior choice of the elector amongst the unelected candidates, P, Q, R, S, &c.; and so for AQ, and BP, &c. The heaps of A, B, C, &c., are broken up into corresponding parcels.

For convenience, the numbers A, B, &c., are written at the ends of the rows, and P, Q, R, &c., at the heads of the columns, each set being written down in the order of priority of the candidates on the first count. The number by which the number of votes of an elected candidate exceeds the quota is called the surplus of that candidate. Thus, the candidates A, B, &c., having a surplus, we see that, (1) that surplus can be transferred to the unelected candidates, P, Q, R, &c.; (2) there are many ways in which this can be done; (3) the result of the election may depend very materially upon the way in which it is done.

M. Andrae proposed to make this distribution by lot. Mr. Hare proposes to make it by a series of rules, depending on, (1) the different electoral divisions, &c., in which the votes were polled; (2) the number of names indicated on the voting-papers; (3) a prescribed order among the different polling-booths at which the votes were polled; (4) the order in which the papers were polled. The first of these principles was adopted in order to preserve local representation as much as possible. The second principle seems to be very objectionable, on the ground that it makes it necessary for a voter to mark a large number of names on his voting-paper in order to give the paper a reasonable chance of being transferred, and hence a great inducement is held out to voters to mark a large number of names indiscriminately. The third and fourth principles introduce the element of chance, so that, in fact, the result of an election may depend upon the order in which the voters go to the poll, or upon the arbitrary decision of the authority that prescribes the order of the polling-booths. It can scarcely be doubted that a method of distribution which depends only upon the voting papers themselves, and not upon any external circumstances, such as the order of polling, place of polling, &c., would be more satisfactory. Several such methods might be suggested; but any method to be satisfactory must satisfy the following conditions:

I. It must be reasonably simple.

II. It must not put a premium upon organisation, such as voting on a uniform ticket.

III. It must be as equitable as the circumstances of the case admit.

So far as I know no such method has been published; and it is one of the principal objects of this paper to describe a method which, I hope, will be found satisfactory.

In the method proposed the first principle is to divide the surplus of an elected candidate as equally as possible amongst the unelected candidates, who are indicated as the next choice of the electors on the papers of the elected candidate. An immediate consequence of this principle is that as small an alteration as possible is made in the order in which the unelected candidates stand. When the surplus of a candidate is distributed all the unelected candidates next indicated on his papers are helped forward, and each, as far as possible, to the same extent. Thus, indirectly, greater weight is given to the first choice of each elector.

In order to show the mode of carrying out this principle, the following table is constructed.

TABLE II.

	P	Q	R	S	
	P	Q	R	S	
A	ap	aq	ar	as	a
B	bp	bq	br	bs	b
C	cp	cq	cr	cs	c

The names at the ends of the rows and columns are the same as in Table I. *a* denotes A's surplus, *ap* denotes the number of papers which are to be transferred from A to P, and so on. The letters P, Q, &c., in the first row of the table, denote the numbers of papers in the heaps of P, Q, &c. The sum of the numbers *ap, aq, ar,* &c., is equal to *a*, or to the sum of the numbers A P, A Q, A R, &c., whichever is the smallest. No one of the numbers *ap, aq,* &c., can be greater than the corresponding number in Table I.; those which are less are all equal to one another, or differ by unity at the most. The method of finding these numbers is as follows. Suppose papers taken one by one from the parcels A P, A Q, &c., in this order, and let the process be continued and repeated until either the number of papers so taken is equal to A's surplus, or all the heaps, A P, A Q, &c., are exhausted. Then *ap* denotes the number of papers taken from the parcel A P, and so on.

This merely shows how the numbers *ap, aq,* &c., are arrived at; it does not show us what papers are to be taken from the parcel A P and transferred from A to P. Before considering the rule by which we are to select the *ap* papers from the parcel A P, it is as well to notice one or two points in connection with the method just described. It will be noticed that papers are transferred to all candidates to whom it is possible to transfer any. The magnitude of the numbers A P, A Q, &c., has not much influence on the magnitude of the numbers *ap*, *aq*, &c. Thus, for instance, if there be a large vote on a party ticket on which the first name marked is A, and the second P, this ticket is not permitted to overpower the electors who have also voted for A, but have not followed the ticket. Nor, on the other hand, can it be said that any injustice is done to the electors who voted on the ticket, for at least as many papers are transferred from A to P as from A to any other candidate. Thus it will be seen that the method is such that no inducement is held out to the electors to vote on a ticket.

It is now to be noticed that, if the papers transferred from A to P have not subsequently to be transferred from P to some other candidate, it is quite immaterial what particular *ap* papers we transfer from the parcel A P to P. If, however, by means of this transference and other transferences from B, C, &c., to P, P's votes be raised above the quota, P will have a surplus to distribute. But, as already pointed out, the names indicated after P on the papers in P's heap have not very much influence on the numbers to be passed on from P to the remaining unelected candidates. Hence we see that we can, without influencing to any great extent the subsequent course of the election, adopt a simple but somewhat empirical rule for selecting the papers from the A P parcel to be passed on to P. The rule proposed is as follows:

Break up the parcel A P into smaller parcels, according to the names next indicated, *ignoring* the names of elected candidates. Let the parcels be denoted and arranged as follows:

A P Q, A P R, A P S, . . . A P1.

Here A P Q denotes the parcel in which are placed all the papers on which Q is the unelected candidate indicated next after P, and so on for the rest; whilst A P1 denotes the parcel in which are placed the papers on which *no* unelected candidates are indicated after P.

We now transfer to P as many of the above parcels as we can without surpassing the number *ap* of papers which are to be transferred, taking the parcels in the order above indicated. It may happen, of course, that we thus get a number of parcels making up exactly the number *ap* of papers to be transferred; but this will not always occur. Let us suppose that, after taking as many parcels as possible, as directed above, the parcel next in order is the parcel A P S: we have then to select the balance of the surplus, *aps* suppose, from the parcel A P S.

We now repeat the process just gone through, *i.e.*, we break up the parcel A P S into the smaller parcels A P S Q, A P S R, &c., A P S1, where, from what has gone before, the notation will be obvious. Just as before, take as many complete parcels as we can in the order indicated without surpassing the number, *aps*, to be transferred. We can continue this process until we either get the number of papers we want to transfer made up exactly by a number of whole parcels, or until we exhaust the names of the unelected candidates. In the latter event, the papers in the parcel we have to select from are all exactly alike, if no attention be paid to the names of elected candidates which may be indicated on such papers.

In all previous methods all such names are completely ignored from this stage, so that the papers are, for all purposes of this election, exactly alike. Hence we can pick out exactly the number we want without exercising any discretion.

But in the method now proposed, as explained later on, use may be made of the names of such elected candidates.

Hence, then, it is necessary to prescribe a further process of selection. This process is exactly the same as that just described, substituting names of elected candidates for names of not-elected candidates. Thus, ignoring the names of not-elected candidates, the parcel we have to select from is broken up as follows:

A B, A C, A D, . . . A1,

and the rest of the process, being exactly similar to that already given, need not be further described.

This process can be continued, if necessary, until we have exhausted the names of the elected candidates. We shall then find that the papers in the parcel we have to select from are all exactly alike, except as regards the order in which the names of the elected candidates are arranged amongst the names of the not-elected candidates.

Thus, writing down only the names of the indicated candidates in the order in which they are indicated, the parcel we have to select from might contain papers such as

A P S B R C T D
A B P S C R T D
A B P S C R D T

Accordingly, one more process of differentiating the papers must be described. The parcel we have to select from is broken up into two, the first parcel consisting of papers in which the second indicated name is that of a not-elected candidate; the second consisting of papers in which the second indicated name is that of an elected candidate.

As before, we now transfer the whole of the first parcel, if we can do so without surpassing the number to be transferred, and break up the second parcel according to third indicated names on the plan just described; or we may have to break up the first parcel in that way. This process can be continued, if necessary, until it exhausts itself; and in that event the papers in the parcel we have to select from will be all exactly alike, so that we can take exactly as many papers as we want without the exercise of any discretion.

This, then, brings us to the end of a uniform and systematic process for distributing surplus. We see, then, that unless one or more of the numbers A1, B1, &c., be greater than the quota, every surplus can be completely distributed by this process. Let us assume, then, for the present, that such cases will not occur. Then, after distributing the surplus of every elected candidate by the process just described, we must ascertain the number of papers in the heaps of the unelected candidates, P, Q, &c. These numbers are at once ascertained by adding up the numbers in the different columns of Table II. If any candidates are now raised above the quota, we must apply again the same process of distributing surplus, and repeat the process until a distribution has been made which does not give rise to a fresh election. After this, the candidate who is now lowest on the poll must be excluded; all papers in his heap, which can be so transferred, must be transferred to not-elected candidates; those which cannot be so transferred, but which can be transferred to elected candidates, must be so transferred; and the remainder, if any, being lost, must be withdrawn from the election and a new quota determined. If by this process any candidate be raised above the quota, the process of distribution must be applied; but if no one be raised above the quota, the process of exclusion must be again applied.

Thus we must proceed by successive applications of the processes of distribution of surplus and transference of papers of excluded candidates until all the vacancies are filled, or there remain no more candidates than vacancies.

It is of importance to notice that the process of selecting the *ap* papers from the parcel A P may be postponed under certain circumstances. For if, after constructing Table II., we see that the distribution will not cause any fresh election, we may at once pass on to the process of exclusion.

In illustration of the above process, suppose that there are 11 candidates for 7 vacancies and that the whole number of votes polled is 799, so that the quota is 100. The result of examining the parcels of papers is shown in the table marked (*a*).

(*a*)		P	Q	R	S	T	U	V	Total.
		13	10	7	6	5	3	2	46
A	47	101	10	15	111	8	7	3	302
B	3	14	20	31	30	17	25	19	159
C	17	32	21	49	11	7	5	4	146
D	31	2	43	57	7	2	3	1	146
	98	162	104	159	165	39	43	29	799

This table is the table described above as Table I., with the addition of two rows and one column. The first of these rows shows the number of papers in the heaps of the unelected candidates, P, Q, R, S, T, U, V, and the last shows the sum of the numbers above it in each column. The new column, marked "Total," shows the sum of the numbers in each row. The last row and the last column when added up give each 799, which affords a verification. Constructing now Table II. as described above, with the addition of a fresh row containing totals, we get the table marked (β),

(β)	P	Q	R	S	T	U	V	Total.
	13	10	7	6	5	3	2	46
A	80	10	15	79	8	7	3	202
B	9	9	9	8	8	8	8	59
C	8	8	7	7	7	5	4	46
D	2	16	15	7	2	3	1	46
	112	53	53	107	30	26	18	399

and see that P has a surplus of 12, and S a surplus of 7. We then transfer papers from the heaps of A, B, C, D to those of P, Q, &c., by the rules explained above.

The next two tables, (γ), (δ), show the process of dis-

(γ)		Q	R	T	U	V	Total.
		53	53	30	26	18	180
P	2	8	50	28	13	11	112
S	3	50	40	11	2	1	107
	5	111	143	69	41	30	399

(δ)	Q	R	T	U	V	Total.
	53	53	30	26	18	180
P	3	3	2	2	2	12
S	2	2	1	1	1	7
	58	58	33	29	21	199

tributing the surplus of P and S. All surplus is now distributed, and the election is completed in two more steps, shown in Table (ε). V, being the lowest, is excluded. His

(ε)

Q	R	T	U	V
58	58	33	29	21
8	13	0	0	—
66	71	33	29	—
24	38	—	—	—
90	109	—	—	—

21 papers are transferred to Q, R, as shown in the second row of Table (ε). We now notice that the two lowest, T, U, having only 62 votes between them, whilst the next lowest has 66, may both be excluded. This being done, the fifth row shows R to have 109, which is more than the quota, so that the election now terminates with the election of R.

We have now to consider what is to be done if any of the numbers A1, B1, &c., be greater than the quota. If any such cases occur, they afford a simplification of the process previously described. For if A1, B1, be each greater than the quota, the whole of the parcels A P, A Q, &c., B P, &c., can be at once transferred to P, Q, &c., and no selection is necessary. Let us now consider how such cases can arise. It is plain that electors may decline to indicate more than one name, or, as it is commonly expressed, they may "plump." If, then, A has more than a quota of plumpers, the case in question will occur. But it may also occur in other and much more likely ways.

Suppose, for instance, that more than two quotas of electors vote only for A and B, then if at least one quota vote for A, and at least one quota vote for B, the case in question will occur; and similarly for a larger number of candidates. It is obvious that in all such cases votes would be lost; and in order to obtain proportional representation as nearly as possible, these lost votes should be withdrawn from the election, and a new and smaller quota obtained for filling the remaining vacancies, if any.

But, further, in the instance just given, suppose that some of the electors voted for C, as well as for A and B, then it is plain that the votes are not necessarily lost; if C1 be less than the quota, such votes may be transferred to C, and thus C will again have a surplus, some or all of which can be transferred to not-elected candidates. Thus, suppose we have, writing down only the names of the candidates voted for, 120 papers A B, 100 papers B C, 100 papers C P, the quota being 100, and P not elected, then the case in question occurs; but A's surplus of 20 is not lost, for although we cannot transfer any papers from A to not-elected candidates, yet we can transfer 20 from A to B, then 20 from B to C, and then 20 from C to P.

I proceed then to describe a systematic process for detecting and allowing for all such cases so as to obtain as near an approach to proportional representation as the nature of the votes polled will allow of.

It is obvious, by considering extreme cases, that in a given election we may fall far short of proportional representation; but if such an event occurs, it is due entirely to the fact that the electors have not given a sufficient number of contingent votes. This, no doubt, may occur the first time the method is tried on a large scale, but the electors themselves will soon see and apply the remedy.

After distributing surplus as far as possible by the rule already given, let us suppose that we have A1, B1, C1, &c., greater than the quota, but I1, J1, K1, &c., less than the quota.

We must now seek to distribute the surplus of A, B, C, &c., amongst I, J, K, &c. This can be done by the process already described, substituting the elected candidates, I, J, K, &c., for the unelected candidates, P, Q, R, &c., in the former process. After completing this process, we distribute the newly created surplus of I, J, K, &c., by the former process amongst the unelected candidates, P, Q, &c.

If this process fails to completely distribute the surplus of A, B, C, &c., one or other of two events must occur, viz.:

(1.) We may find A1, B1, C1, &c., still each greater than the quota. Under these circumstances the votes now credited to each of the candidates A, B, C, &c., in excess of the quota are absolutely useless and lost; so that A, B, C, &c., may be withdrawn from the election with their quotas and lost papers, and a new quota be determined and a fresh start be made.

(2.) The candidates A, B, &c., may divide themselves into two groups, A, B, &c.; D, E, &c., so that A1, B1, &c., are each greater than the quota, and D1, E1, &c., are each less than the quota. Under these circumstances, we transfer from A, B, &c., to D, E, &c., as before described, with the same alternative consequences. It is clear, then, that by a repetition of this process we can go on until we either completely distribute all surplus or withdraw a certain number of candidates with a certain number of lost votes, and so obtain a new quota, and commence *de novo.*

So far these processes of distribution have been briefly described. In order to prevent the Returning Officer exercising any discretion, the exact order in which they are to be made must be described. It will be seen that three different cases have been described in which papers can be transferred from the heap of one candidate to the heap of another candidate. These are as follows:

(1.) When a candidate is excluded. This process will now be called "transference."

(2.) When a candidate has a surplus, and, in order to distribute his surplus, it is necessary to use the process of selection. This process will be called "distribution by selection."

(3.) When a candidate has a surplus, and, in order to distribute, it is not necessary to use the process of selection. This process will be called "distribution."

It has already been stated that when we have A1, B1, &c., greater than the quota a simplification occurs, inasmuch as we can distribute to a certain extent without selection. It is now to be further noticed that if we make these distributions and proceed to a new count before making a distribution by selection, we may postpone this last process from time to time, and that it may not be necessary to resort to it at all; and that if we have to resort to this process, it will, in many cases, be much more easy to perform then than if it had been entered upon at the earlier stage. Hence, then, in the plan of operations proposed, as many distributions as possible are made before resorting to the process of distribution by selection. The systematic process which can be applied to all cases is as follows:

The papers are first to be arranged in separate heaps, as already described, and a list of the candidates made out in the order in which they stand on the first count. A series of scrutinies is then to be made, and continued till all the vacancies are filled, or there remain no more candidates than vacancies. Any scrutiny except the last will involve either a transference, or distribution, or distribution by selection from at least one heap to other heaps, or a withdrawal of at least one heap of exhausted papers.

At the end of each scrutiny the papers will be left arranged in heaps for the next scrutiny. Each scrutiny will be made according to the following rules:

At the commencement of each scrutiny the quota for that scrutiny is to be determined by the following rule:

From the number of votes polled subtract a number equal to the sum of the number of exhausted and lost votes, and divide, to the exclusion of fractions, the difference by a number equal to the number of vacancies to be filled, increased by one and decreased by the number of candidates withdrawn from the election on exhausted heaps of papers. The quotient so obtained, increased by one, shall be the quota.

After determining the quota two cases arise, first, the case where there is a surplus; second, the case where there is no surplus. In the first case, an exhaustive division of the candidates, combined with a series of distributions, is to be made, as follows:

First divide the candidates into two sets, Class O and Not-Class O; Class O consisting of those who have less than the quota (hitherto called not-elected). Next divide Not-Class O into two sets, Class I and Not-Class I; Class I consisting of those whose parcels of papers which are not transferable to Class O are respectively less than the quota; then make distributions from Not-Class I to Class O. Next divide Not-Class I into two sets, Class II and Not-Class II; Class II consisting of those whose parcels of papers which are not transferable to Class I are respectively less than the quota; then make distributions from Not-Class II to Class I. This process is to be continued as far as possible, the general rule being that after distribution from the set Not-Class r to Class $(r-1)$, the set Not-Class r is divided into two sets, Class $(r+1)$ and Not-Class $(r+1)$; Class $(r+1)$ consisting of those whose parcels of papers which are not transferable to Class r are respectively less than the quota; then distributions are made from Not-Class $(r+1)$ to Class r.

After the last division and distribution, if the candidates all fall into the set Not-Class n, they are to be withdrawn from the election, and their heaps set on one side as exhausted, and a new scrutiny proceeded with. But if the candidates fall into the set Class n, then, (1) if any distribution has been made, a new scrutiny is to be proceeded with; (2) if no distribution has been made, a distribution by selection is to be made from the highest class in which there is any surplus to the next lowest class, and a new scrutiny proceeded with.

In the second case, where there is no surplus, the candidate who now stands lowest is to be excluded, and his papers are to be dealt with as follows:—

All which can be transferred to any candidates who have not been withdrawn or excluded are to be transferred to candidates in the lowest class to which they can be transferred.

Those which can be transferred only to excluded candidates, or cannot be transferred at all, are to be set on one side as lost.

The remaining papers, if any, are to be set on one side as exhausted.

In case of equality, that candidate who is lowest in the order of priority on the first count shall be excluded.

If in this case it should happen that any candidate has a number of votes exceeding the sum of the votes of all who stand lower than he does, then, instead of excluding the lowest, we may at once exclude all who stand lower than the said candidate.

When any candidates have been excluded, we need pay no attention to their names when we find them indicated on any voting papers, nor, when any candidates have been withdrawn, need we pay any attention to their names when distribution by selection takes place.

At the end of the election the total number of votes lost will give the number of electors who are not represented.

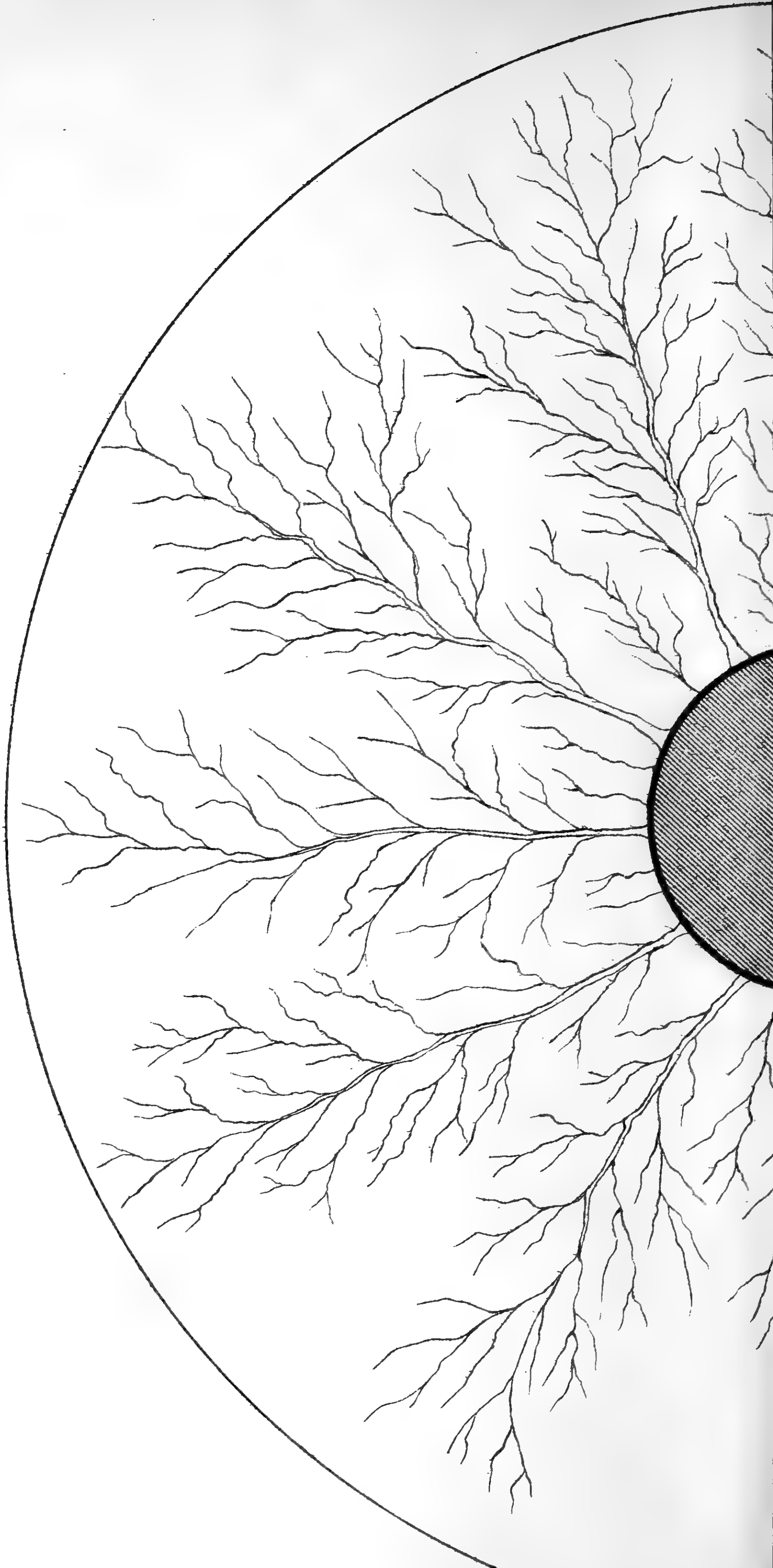
In order to test the method here described voting-papers were written out for a trial election. Care was taken to ensure that 3 candidates had each a considerable surplus, the largest being 4 quotas, and the smallest 1 quota, and that a considerable portion of this surplus should be transferable only to a few chosen candidates. No more than 3 contingent votes were allowed, and as to the rest, the papers were written pretty much at random. There were 19 vacancies and 26 candidates. The first quota was 100, and the last 63, and the candidate last returned was elected by 55 votes. The same election worked out by the method described in the current number of the *Melbourne Review* returned 2 candidates not returned by the above process, and these were returned on 13 votes each.

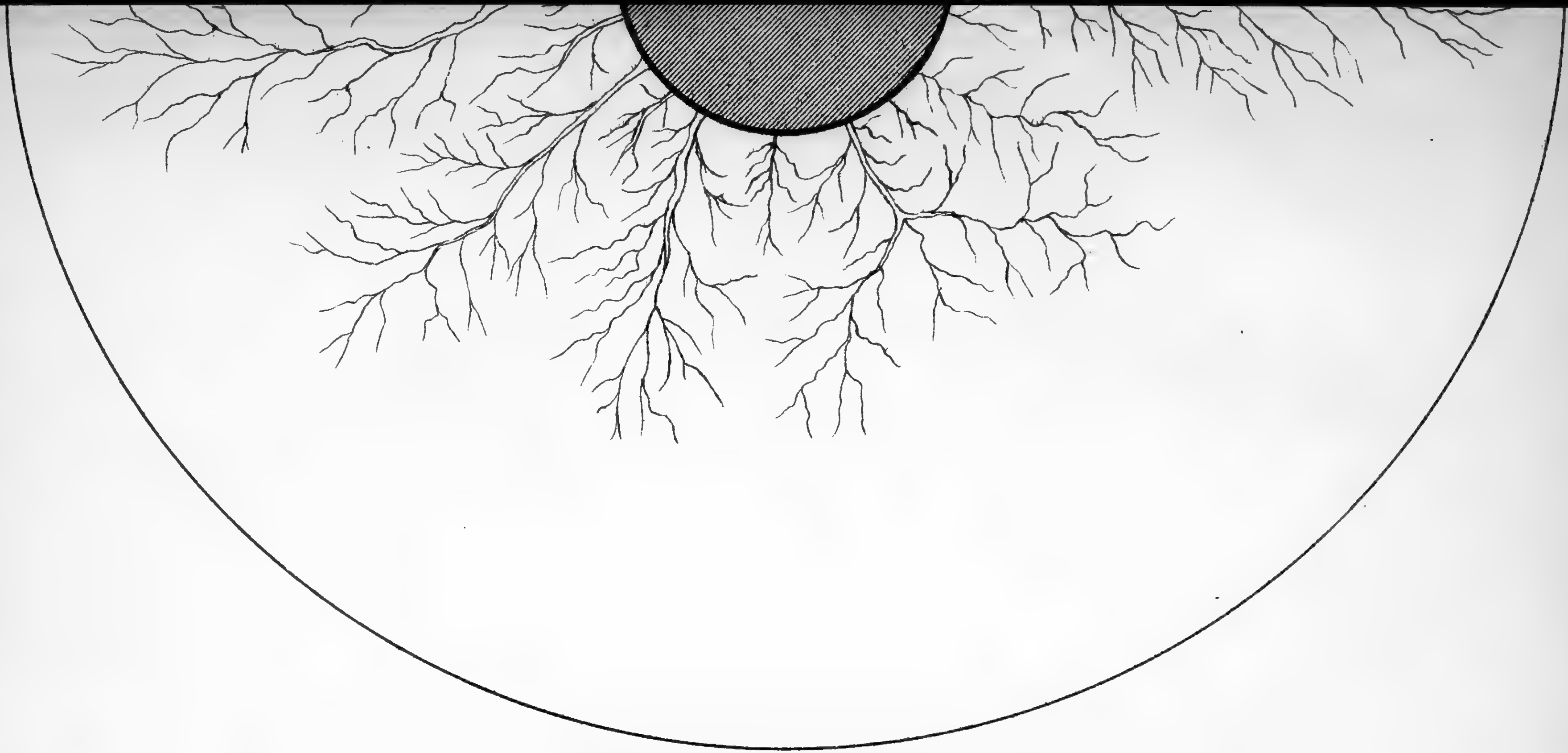
ART. VII.—*On Some Curious Effects of Lightning at Gabo Island.*

BY ARNOLD LILLY.

[Read August 10th, 1880.]

IN the early part of January last I had occasion to visit the lighthouse and meteorological station upon Gabo Island. Two days before my arrival, on the 7th of the month, there had been a very severe thunderstorm, which traversed all the eastern districts of the colony and apparently came to a climax in the neighbourhood of Cape Howe and Gabo Island; here it raged for about three hours, accompanied by a full gale of wind and a very heavy sea. From what Mr. Fanning, the lighthouse-keeper, experienced in the lantern, and from what was seen by others outside, there is no doubt that the lighthouse was, in common parlance, struck by lightning. The lighthouse, I should explain, is built of granite, with a central iron column supporting the iron frame of the lantern which contains the light. There is a wire conductor connected with the lower part of the lantern, carried outside the lighthouse down to its base, and over the rocks into the sea, but there was apparently no pointed terminal upon the roof. In this case the lightning appears to have travelled down the iron column instead of down the wire conductor, and to have met with bad earth contact where it passed into the granite and concrete of the base, for Mr. Fanning states that the whole lighthouse seemed to rock from its foundations, and in the morning the pattern shown in the accompanying diagram was found traced in the sand, which was lying about a quarter of an inch thick on the basement floor of concrete; this sand was left undisturbed until my visit, and





Plan of Basement Floor of Lighthouse.

I made a sketch of the pattern traced in it; the radial lines branching out from the foot of the iron column, were about a quarter of an inch thick where they emerged from the column, and extended from four to five feet, diminishing to the finest points, and having ramifications and offshoots like the roots or branches of a tree. They appeared to be analogous to the marks sometimes found on the bodies of persons struck by lightning, and roughly described as resembling trees. These traces were not *ridges*, such as might have been produced by the seismic effects of a shock, but *furrows* cleanly cut in the sand, and leaving bare the basement floor below; had the floor not been sanded there would, of course, have been no record left. I noticed that the traces or furrows were much longer and more marked on one side than on the other, owing, perhaps, to non-homogeneity in the transmitting column.

ART. VIII.—*On Recent Improvements in Electric Lighting.*

BY R. E. JOSEPH.

[Read September 9th, 1880.]

I PROPOSE this evening to bring under the notice of the Royal Society a brief description of some of the recent improvements that have taken place during the last few years in the employment of electricity as a means of illumination, and, in doing so, I may state that the description of the various machines, and some of the results obtained with them, have been acquired by reference to *Engineer*, *Engineering*, the *Telegraph*, and other journals, together with a few notes I have received from home, and a little experience in the way of experiments occasionally conducted here. I have divided my paper into three parts; the first treating of the generators of the current, the second of the apparatus or lamps used in connection with the same, and the third describing some of the several systems in use.

The first introduction of the electric light is, of course, to be dated back to seventy-two years ago, or in 1808, when Sir H. Davy first exhibited the light by means of his powerful battery of two thousand pairs of plates. This light was improved in 1810, and from that date to the present time but little improvement may be said to have taken place in the use of the voltaic current as a practical generator of electricity for illuminating purposes. I think any one who has had experience in fitting up and attending to a battery of the requisite size for such a purpose will agree that, to say nothing of the expense of working and maintaining, the trouble of keeping it in order would preclude its becoming available for any other than temporary purposes, such as lectures, &c., or where, perhaps, a small light for photographic use might be required, for which a battery of eight Bichromate cells of an improved construction, in which the solution is kept agitated by a current of air, has recently been introduced, it is said, in a perfectly practical form. Whilst we are not able, therefore, to recognise the ordinary battery as an efficient or practical generator of the current, I may mention that a thermo-electric battery has been introduced by M. Clamond, formed of iron as the positive and antimony and zinc as the negative elements, and that it has been used for lighting a workshop with great success. The size given is about 8 feet high by 3 feet 3 inches diameter; the electro-motive force is given as being equal to 120 Bunsen cells, and giving a light of about 1000 candles; the internal resistance of the battery is stated to be 0·31 Ohms, and it consumes about 22 lbs. of coke per hour. I am unable to give any more information on this matter; but from what we already know relative to thermo-electric batteries, they do not possess the requisite stability for lighting purposes. We may, therefore, pass on at once to the principles by which the necessary amount of current for our purpose can be produced efficiently and economically.

In 1831 Faraday made known the fact that if a helix, or coil of insulated wire, was moved or rotated in front of a permanent magnet, a current of electricity was induced in the coils, and that by suitable arrangements it could be used in the place of an ordinary battery.

Very many magneto machines, as they are called, were constructed of different forms; the ordinary kind used for medical purposes at the present time is but a modification of Faraday's discovery. In 1854 Siemens introduced an improved armature, which gave a considerable increase in the power to the machines which were then constructed. Then came Holmes, Gramme, and many others; and whilst it is true that in 1857 Holmes's machines were used in one or two lighthouses, they did not come up to the necessary standard required for electric lighting.

In 1863 Wilde introduced his machine, which was a considerable advance on all former; in the place of permanent he used electro magnets, which were excited either by a battery or small magneto machine. At this time, also, Ladd and many others made machines of a similar description. In 1866-7 discoveries were announced by Wheatstone, Siemens, and Varley simultaneously that a separate exciter for the electro-magnets was unnecessary, and that it was sufficient to pass the current induced in the armature through the coils of wire surrounding the electro-magnets, which, provided they were made of hard iron, retained a certain amount of magnetism. Each revolution of the armature served to increase this magnetism, until a maximum effect was obtained. Dating from this period, an immense number of machines based on this principle have been constructed, notably the Gramme, Siemens, Brush, Wallace-Farmer, Maxim, Weston, and a host of others, all differing only in minor details, or different methods of constructing the armatures or connections with the commutators. These machines, however, appear to have vastly different degrees of efficiency, the Siemens, Brush, and Gramme being accepted, I think, as giving the best results.

According to experiments formerly made, the maximum effect was obtained by making the resistance of the wires of the machine equal to the resistance of the outside circuit, following the same law as the voltaic battery.

Now, this rule has usually been carried out, but with this disadvantage—if the resistance of the outside circuit happens to fall lower (such as the carbons of the lamp remaining in contact, &c.) the driving engine running at a higher speed a larger amount of current was developed in the coils of the electro-magnets, heating them, and thus tending to destroy their insulation; it was therefore advisable for safety to work with a larger outside resistance, but with its attendant disadvantage of reducing the amount of current the machine was capable of producing.

In a paper recently read by Dr. Siemens before the Royal Society he stated that he had found it better to increase the size of the wire on the armature and to place a considerably greater resistance than usual on the coils, not by the use of finer wire, but by a greater number of turns, and then only allowing a shunted portion of the current from the armature to pass through them. By this means he increased the efficiency of the machine to a considerable extent, that all danger of its becoming heated was avoided, and that any irregularity in the driving engine did not affect the new machine nearly as much as the old. The necessity of keeping the machine cool whilst working has been recognised by all makers as an absolute requirement. Apart from the fact of the liability to injury by this heating, it has been estimated that hitherto half the current developed in any machine was only available for lighting purposes, the other half being wasted in heating the machine and conducting wires. Various mechanical devices have been used to this purpose. In the earlier forms of Dynamo machines a stream of water was kept flowing through the armature axis; in the Brush machine the iron of the armature has grooves cut nearly through it in various places, so as to have an insulating medium of air in various parts; and, later on, in the Weston machine the iron part of the armature is built up of thin plates so as to leave hollow spaces; the axis is also hollow. This permits the air to rush through and pass between the coils of wire, and so tends to keep them from heating.

I have up to this point treated of machines giving a continuous current—that is, of the same polarity.

Whilst continuous currents appear to be the most efficient, they, of course, consume carbon points unequally, the carbon that is connected with the positive pole of the machine being consumed at nearly double the rate of that of the negative. (Latterly Dr. Siemens has stated that the negative carbon only wastes away from the constant heat, and suggests other substances that might be kept cool for the negative pole.)

For burning carbon candles, and for some systems where more than one light is required to be maintained in one circuit, alternate current machines are required. Many forms have lately been introduced, and apparently with great success; the best appear to be the new Gramme, the Lontin, and the Siemens. All these alternate current machines require an exciter for the electro-magnets, consisting usually of a small

Dynamo machine of the ordinary type; and where a number of machines are required at the same spot, one exciter serves for the whole number. Still further improvements have been made by dividing the commutator into different branches, so that by increasing the number of collecting brushes the current may be drawn off in various circuits, each one being quite distinct and capable of maintaining from one to ten lights on each circuit.

We have now to examine the various forms of lamps that have been designed from time to time for use with the generators of the current.

Probably the earliest form may be considered as a stand into which two pencils of carbon or graphite could be fitted and remain insulated from each other.

As the carbons were consumed they were adjusted by hand; very soon mechanical contrivances were introduced to effect this automatically, but it is not too much to say that although very many beautiful pieces of apparatus are in use for this purpose, and considerable ingenuity has been displayed in designing the various forms, much still remains to be done in this direction. For instance, Mr. Preece, on being examined before the Select Committee of the House of Commons, stated, in reply to a question as to the application of the electric light for the use of the General Post Office, "that at that time (1st July, 1879) he had not been able to determine on a suitable form of lamp for their requirements, which were of a special character. For his purpose he required each light equal to 1000-candle power; it must be absolutely steady, so as not to fatigue the eyes of the operators in the Telegraph Department; and that it must remain steady and uniform for at least nineteen hours without requiring any attention whatever. Not any of the lamps he had examined fulfilled all these conditions, but some had especial qualifications. The Serrin gave the requisite amount of light, the Werderman was perfectly steady, and the Wallace-Farmer sufficiently durable. It is, however, over eighteen months since this report was made, and much progress has been made lately in improving and introducing new forms of lamps. It will be unnecessary to take up much of your time by describing or attempting to describe the immense variety of lamps that have been brought forward. It will suffice to mention those that have apparently met with the greatest success for direct lights—that is, a single light supplied by a continuous current machine. The Serrin lamp, which is almost exclusively used with the Gramme machine; the Siemens, in several forms; the Brush, Wallace-Farmer, and Crompton—all these lamps are not only arranged to bring the carbons together as they are consumed, but are so constructed as to maintain them always at the same distance apart. Where such lamps are used with alternate current machines, and where more than one lamp is in the same circuit, a shunt of very high resistance has been lately introduced in the outside circuit between the carbons, so arranged with either an electro-magnet or other contrivance as to bring the carbons closer together when the resistance of the electric arc is increased beyond that point for which the shunt has been arranged to work. In this way the length of the arc is maintained much more uniform and steady than by simply trusting to the strength of the current.

A number of lamps have also been introduced in which a light is maintained by incandescence only, notably the Wederman, Reynir, Andrée, &c., the action of all being of a similar nature, namely, that of a very slender pencil of carbon, the point of which is always in direct contact with a carbon or copper button. Of Edison's platinum wire, and carbon lamps, very little may be said. I do not think that any one who had any experience in electric lighting placed much confidence in his proposed plans; and we now see that Edison has only done the same as others who had experimented in the same direction many years previously—given it up as being impracticable.

The Jablochkoff candles, about which we read so much, appear to have been considerably improved during the last few months. The removal of the insulating medium from between the carbon pencils, and the arrangement of the lamps, enabling the new carbons to be placed automatically in circuit as the old ones are consumed, has caused this system of lighting to be introduced in many places with considerable success. Wilde's lamp is now similar in principle to the Jablochkoff, with the advantage of extra simplicity; and the latest form of this description of lamp is the Jamin. This, according to the inventor, M. Jamin, gives a greater amount of light than any other of similar form; and on its introduction before a number of leading men in Paris lately was spoken of most favourably.

Now, as to the application oı the various systems. Where large open spaces, halls, &c., have to be illuminated, the employment of single lights, fed by separate machines, appears to have been accepted as being the best and most reliable method; for smaller places, or where the lights have to be extended to a considerable distance, the alternate current machines, with either specially contrived lamps or a candle system, have been more successful. It is, however, certain that up to the present time a subdivided light is not nearly as economical as a direct one.

Taking the whole subject into consideration, in what way can we be said to have improved in electric lighting? I think in very many ways. Firstly, we have gained an amount of experience in practical requirements; we are finding out the especial merits of the several systems, and are thus enabled to apply them advantageously and successfully. The generators and the lamps have undoubtedly been lately improved; the carbons also; and the importance of having the last-named of good quality simply means the success or failure of any otherwise good system of lighting. There is very little reason to doubt that in the earlier days many failures occurred through the imperfections in the carbons. No matter how good or efficient the Dynamo machine or the lamp may be, with bad carbons they must naturally work irregularly; and irregularity in any part of the system, from the driving engine downwards, means unsteadiness of the light. The demand for carbons soon led to their improved make, and I believe they are now to be obtained in a nearly as perfect condition as possible.

Another point that cannot be overlooked, and in which considerable improvements have recently been introduced, is in the motors, or engines, with governors of a sensitive form for driving the Dynamo machines with the same regularity under varying conditions of force.

It is a recognised fact that the motor that drives the machine must do so with perfect steadiness, otherwise a flickering light may be obtained. Many failures have occurred in several systems by inattention to this point.

On board two steamers that have lately been in this port two systems of electric lighting were in use. On the "Potosi" Siemens' alternate current machine, with six differential lamps, was used, the Dynamo machine being driven by a Tangye's four and a-half horse-power engine, fitted with large fly-wheel and sensitive governor; the system was described as being perfectly satisfactory.

The "Chimborazo" had one of the direct Gramme machines supplying a number of Andrée incandescent lamps. On inquiry we found that, although the lights were intense they were unsteady, but that when the whole current was directed into a large Crompton lamp it was all that could be desired. The Gramme machine was driven by a Wheelan engine of five horse-power, with a very small fly-wheel and a governor that did not work. We were informed that the engine ran so steadily that this latter circumstance did not interfere with it; but assuming that the Andrée system has been perfect in other places, it would not be difficult to account for any irregularity in the present instance, for with several incandescent lamps in circuit, each giving only a comparatively small light, I can imagine that the slightest variation in the driving power would make itself very apparent in such lamps, although when the current was utilised in a single arc light of large size its fluctuations were not, perhaps, discernible.

Professor Tyndall recently stated that "he did not believe any fresh discovery needed to make the electric light of general application for all large places;" while Sir William Thompson stated that "he believed before long it would be used in every case where a fixed light was required; that there was immense progress in the actual work carried out by the practical men of the day." Sir William Armstrong has an electric lamp in his library, the Dynamo machine being some mile and a-half distant, and driven by a turbine wheel from a large fall of water.

The British Museum is lighted on Siemens' principle by means of four lights of 5000-candle power each, produced by continuous current, and seven lamps of 400-candle power each, supplied by an alternate current machine; another Dynamo machine serves to excite all the electro-magnets. The four single lamps are on the pendulum principle; the other seven are differential, and the lights are maintained for six hours without touching the lamps. The machines are driven by two eight horse-power steam engines, about 200 yards away from the reading-room. Last winter, about ten in the morning, a dense fog arose, and the many visitors in the museum prepared to take their departure, not being able to read longer, when, the authorities being equal to the occasion, the electric light was turned on, and kept so during the whole day, to the great satisfaction of the readers. The lamps in the library are fitted with gilt reflectors, and they are stated to be an improvement on the silvered.

At Blackpool, a small watering-place of the north, the corporation decided on lighting up the promenade and piers for a certain number of weeks each season. The system adopted is Siemens'. There are eight lights of 6000-candle power, all direct lights. Six of these lamps are suspended from poles 60 feet from the ground; the other two lamps are on the Prince of Wales Theatre, midway between the two piers. The eight Dynamo machines are driven by two Robey engines of sixteen horse-power each; the total length lighted is 1800 yards, and it is spoken of as being perfectly successful.

At the Victoria Station of the Metropolitan District Railway the Jablochkoff system is in use. The space illuminated is 300 feet x 50 feet, and 40 feet high; there are two platforms, with spaces 20 feet between. Ten lights are used—five on the down, dividing the space equally; four on the up, in alternate spaces; and one central, over the bridge. The lights are enclosed in 16-inch opal globes. The Gramme machine is 2373 yards distant, and forms part of a circuit of the same machine that supplies ten lights on Waterloo Bridge. The steam engine that maintains it is now driving several machines, supplying altogether eighty lights. At Ludgate Hill a large establishment has just been lighted by thirteen Jablochkoff's candles, supplied by a Gramme machine, driven by a twelve horse-power gas engine.

The Brush machine supplies from one to sixteen lamps in one circuit. At a cotton factory on Rhode Island machines have been in use some time, supplying eighty lamps; and on the introduction of this system of lighting in London lately it appears to have met with marked success. According, however, to trials made with various machines, the Brush did not give as great an efficiency per horse-power as the Gramme; on the other hand, the continuous current Gramme will only supply one light.

At the Hippodrome, Paris, the electric light apparatus is of the most perfect kind; the Gramme system is used, both continuous and alternate current machines, the lamps being the Serrin and Jablochkoff. The motor power consists of two engines of one hundred and twenty horse-power each.

The different systems enumerated possess certain advantages for each purpose; the knowledge acquired as to the best system for any particular purpose must, I think, be considered an important advancement in electric lighting.

Where large open spaces or rooms require lighting, the direct system, as before stated, appears to be the best, and

Siemens' machines have given the greatest amount of efficiency. For subdividing the light, the Jablochkoff system, certainly, has had the greatest success; but the new Siemens machine should be capable of doing quite as much work. At present the Siemens and the Gramme appear to be ahead of any other system, and have, therefore, been adopted most extensively.

I have not in this paper attempted to enter into any details with respect to the economy of any system, or its relative value as compared with ordinary means of illumination.

The results of experiments I shall shortly be engaged in will, I hope, enable me to lay before you some information on this part of the subject.

ART. IX.—*An Improved Ombrograph, or Self-registering Rain-Gauge.*

By R. L. J. ELLERY, F.R.S., F.R.A.S.

[Read September 9th, 1880.]

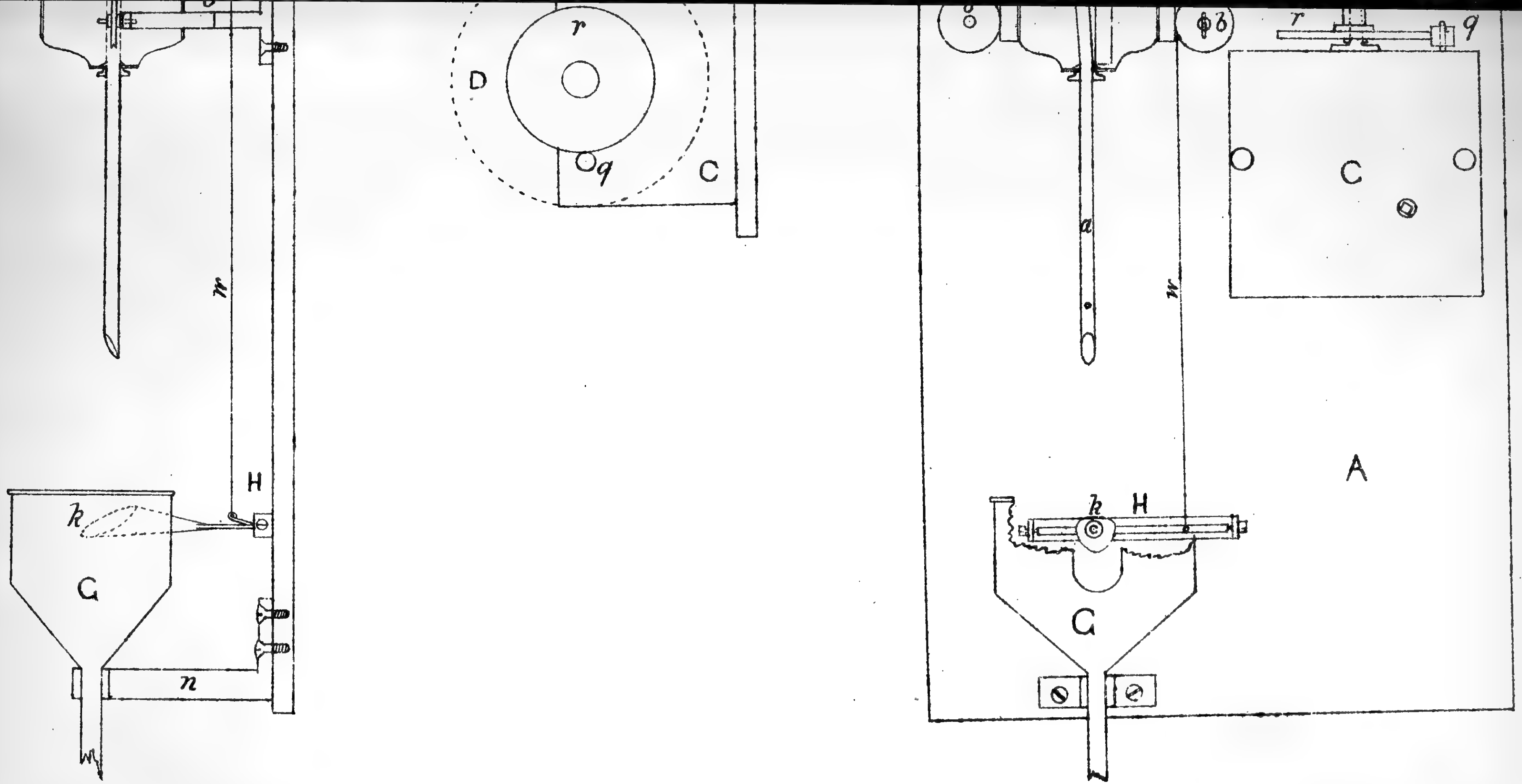
ON the 16th May, 1878, I gave a description of a new self-registering rain-gauge that I had devised, which appears at page 2 of Vol. XV. of our *Transactions,* accompanied by a rough diagram of the arrangement. This apparatus has been in use at the Observatory ever since, and, with the exception of an occasional failure of the intermittent syphon by which it empties itself immediately a quarter of an inch of rain has fallen, it has always worked very satisfactorily. It, however, became apparent to me that it was open to considerable improvement in one or two particulars, which I think I have now succeeded in accomplishing. It will be remembered that the instrument referred to consisted of a receiving vase suspended by two well-made steel spiral springs about five inches long and three-quarters of an inch in diameter. Into this vase the rain as collected in the rain-gauge flowed, the springs stretching as the vase descended with the increasing weight of the collected water until a quarter of an inch of rain had fallen, when an intermittent syphon within the vase overflowed with the last drop or two of the arranged amount, emptying the vase in a few seconds, which gradually rose to its zero position. In descending, the vase raised a light pen frame, carried between vertical guide wires; a glass pen, charged with aniline and glycerine ink, being suspended like a pendulum in the frame, marked on paper stretched on a cylinder revolving on a vertical axis once in 24 hours every movement of the vase, thus furnishing a graphic record of the time, intensity, and duration of rainfall in a very reliable and satisfactory manner.

One point which appeared open to improvement was the mode of communicating to the pen the movements of the vase, which was done by a fine platinum wire passing upwards from the top of the vase over two delicate pulleys downwards to the pen frame; both pulleys and wire guides produced sufficient friction to interfere somewhat with the ultimate accuracy of the quantity register. The other direction in which improvement was required was indicated by the fact that the syphon took a very sensible interval to empty the vase—say from fifteen to twenty seconds—and that in this interval in heavy rains an appreciable amount of rain might flow into the vase which would overflow with the rest without giving any indication on the register that more than a quarter of an inch had fallen. This defect, of course, would not be very appreciable except in heavy rains; still it is in heavy rains that the most accurate measures of intensity of fall are required, and, therefore, a practical method of meeting this difficulty was wanted.

The new instrument—*ombrograph,* as it may be styled—is on the table at work, and you can see the action, and also how the defects I have referred to have been met. In the first place, the pen is suspended from a little gallows on the vase itself, any movement of which is recorded directly on the cylinder without intervention of pulleys; to prevent the swinging to which a weight hung by spiral springs is very liable to, the vase has two vertical ribs of thin metal, which run loosely in two grooved guide wheels, running on fine steel axles, by which contrivance a steady vertical movement downwards and upwards of the vase, and therefore of the pen, is secured.

In the second place, a simple little intermediate tubular receiver has been added, into which the water from the rain-gauge collector flows on its way to the vase. In this receiver is a valve, which is ordinarily kept open by a small counterpoised lever on the top of the tube, allowing the rain to trickle unobstructed into the vase; immediately, however, the syphon commences to act, and it delivers the first drop at the longer leg, the falling water depresses a small bucket on the end of a lever, which pulls down the valve lever, to which it is connected by a very light wire, and the valve at once closes the tubular reservoir, allowing no more than exactly the quarter of an inch to enter the vase until it is quite empty, for as the last drop flows out the counterpoised lever lifts both bucket and valve, and the small amount accumulated while the syphon was acting is delivered into the vase just as it comes back to zero. This syphon empties the vase in nine seconds, and it must be evident with this arrangement that the register will be as accurate as can well be desired, and, I think, quite as accurate as necessary.

There are two parts of this instrument I should like to say a few words upon—the *spiral springs* and the *hanging pen.* I find that Dr. Draper, of the New York Meteorological Observatory, speaks most highly of the performance of carefully made spiral springs of steel wire, for many purposes of measurement in meteorology, and my own experience entirely coincides with his. Spiral springs made of piano wire, carefully wound on a turned and hollow iron mandril, evenly hardened, and tempered at the temperature of burning oil *before removing from the mandril,* appear to be perfectly resilient, and some I have had in use for nearly three years give the same results in weighing as when first made. For delicate measures, of course, the spirals must be long; the longer they are the more difficult it is to harden and temper them properly, and it becomes necessary to heat them for both processes inside of an iron tube, which can be evenly heated throughout. I am about to attempt making such spirals 18 inches long. The other matter I wish to draw your attention to is the form of pen. It is simply a piece of small glass tube, drawn down at one end to a point with a fine capillary bore, and is very easily made. This pen is fixed in a little wire holder, which hangs on the gallows or frame like a small pendulum, with the pen as its bob, and free to move backwards and forwards in a vertical plane passing nearly through the axis of the barrel. Its point is so adjusted that it rests against the paper with a minimum of pressure and, therefore, with the smallest amount



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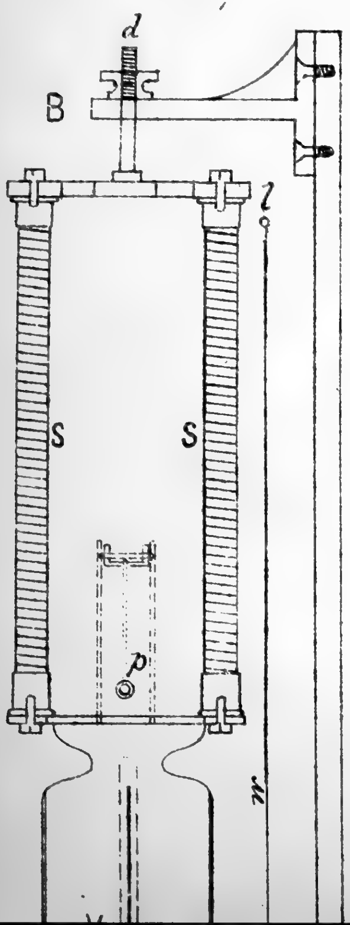
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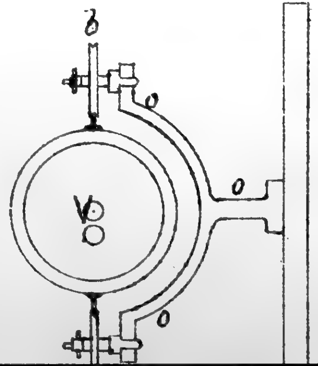
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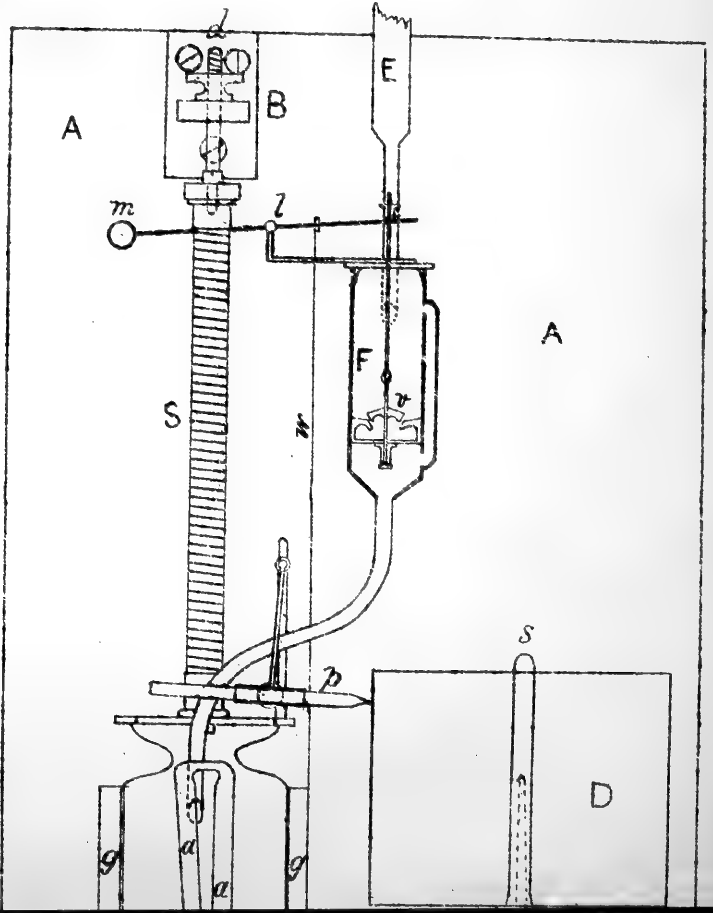
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of friction possible, while the fluidity of the ink by the use of glycerine is such that, however lightly the pen rests on the paper, or however dry the weather may be, the trace made is always clear and unbroken. One of these pens charged with about 50 drops of aniline and glycerine ink has traced on our self-registering rain-gauge for two months without a break. The ink used was a mixture of five parts of Cochrane's blue ink with one or one and a-half of glycerine. This ink requires filtering before using, except when newly mixed.

Reference to Diagrams, showing Side View, Plan, Section, and Sectional Front View.

A A—Board of well-seasoned wood, to which all parts of the apparatus are attached. B—A metal bracket carrying the weighing system. C—The clock for rotating record cylinder D. S S—The spiral springs. V—The vase or receiver. G—Discharge funnel. H—Lower lever for closing valve *v*. E—Delivery tube from rain-gauge outside building. F—Valve chamber. *a a*—The syphon. *b b*—Guide wheels. *g g*—Guide wings. *m* and *l*—Counterpoise and lever for valve. *w w*—Wire connecting lower lever with upper lever. *p*—The pendulum pen. *d*—Nut and screw for raising or lowering the system so as to adjust pen to zero on record cylinder. *r* and *q*—Pinion and wheel conveying motion of clock to cylinder, which is removable from spindle *s* to facilitate changing register-papers. *k*—The lever bucket which by the first drops of discharge from vase pulls on *w w*, depressing lever *l*, and allowing valve *v* to close. *o o o*—Bracket carrying guide wheels.

ART. X.—*Additions to the Lichen Flora of Queensland.*

BY JAMES STIRTON, M.D., F.L.S., &C.

[Contributed by the REV. J. E. TENISON-WOODS, F.G.S., Sept. 9th, 1880.]

I AM mainly indebted to Mr. F. M. Bailey, of the Queensland Museum, Brisbane, for the materials of this paper. A small proportion has been contributed by Mr. Hugh Paton, of Glasgow, while on a tour through Southern Australia. Mr. Bailey's collections are chiefly from the neighbourhood of Brisbane, although on several occasions he extended his excursions many miles into the interior and along the coast. Considerable difficulty has been experienced in the discrimination of species, and this has arisen, for the most part, from two causes—first, from the close affinities of the species to those of different and distant localities, whose extremes may be stated to be South Africa on the one side, and the Eastern Archipelago on the other. In several instances, indeed, I have been obliged to leave the determination in abeyance until a more extended series of specimens shall have enabled me to settle the question of specific distinction, or to merge them into others known and determined; second, from defect or excess (so to speak) of development. While this difficulty has to be encountered more or less in all tropical and sub-tropical lichens, it is enhanced in a much greater degree than usual in those from Queensland. The causes at work likely to produce this condition of things have strongly excited my curiosity. In the absence, however, of the knowledge of well-ascertained atmospheric conditions I have endeavoured, by a sort of reflex process, to construct atmospheric peculiarities likely to give rise to the curious interruptions to the vegetative processes of lichens from Brisbane.

The first and main presumption is, that the rainy season (if there is such properly so called) is frequently interrupted by clear, bright, dry days. Now such interruptions, however favourable to plants rooting in the soil, are adverse to a continuous development of lichens whose growth is nearly entirely dependent on atmospheric moisture and heat.

Again, the few specimens found growing on earth rarely show fructification, or, if so, the spores are seldom fully developed; and the inference from this is, that the soil is porous or sandy, and has a very meagre, or, it may be, discontinuous substratum of clay.

3rd. The dry season or seasons are very dry, and with few or short interruptions of rain, such, indeed, as can scarcely perceptibly advance the development of lichens, whose growth at the quickest is much slower than that of any other section of botany.

4th. A considerable portion of the lichens show, at first sight, fully developed conditions; but a microscopic examination reveals the fact that, in many, the vegetative processes are all past, and the spores gone, although the apothecia look fresh and plump. This phenomenon also goes towards confirming my previous assertions of the atmospheric conditions, inasmuch as the exceptional dryness is favourable to the preservation of old lichens; while in moister, colder countries, maceration and consequent disintegration of dead vegetable tissues soon serve to dissipate the whole.

There are other minor considerations that tend to the same conclusions. On the whole, then, it cannot be said that the atmospheric conditions of the neighbourhood of Brisbane are favourable to the growth and development, as well as spread, of lichens.

SIROSIPHON PULVINATUS, *sp. nov.*

Thallus niger vel fusco-niger, effusus, minute coralloideo-compactus, pulvinulos plus minus confertos (latit. usque ad 3 mm.) formans, et filamenta, irregularia, ramosula (latit. ·02—·03 mm.), tomentoso-intricata sistens, filamentis extus omnino hyalinis (non cellulosis) et gonimia majuscula sordide violacea vel etiam sordida, 1—4 transverse sita continentibus.

Supra thallum et apothecia *Lecideæ foliatæ* parasiticus.

The violaceous colour of the gonimia is changed by K to a greenish-yellow.

This plant, which has close affinities to Sirosiphon, has puzzled me much, and, in the absence of fructification, has been placed here only provisionally.

OBRYZUM SCABROSUM, *sp. nov.*

Parasiticum supra thallum cujusdam collematis apothecia minuta immersa extus prominula rugosula, perithecio dimidiatim nigro; sporæ 8 næ incolores, obtuse fusiformes, (1—3)—nucleatæ, rarius simplices, ·012—·018 x ·0055 mm.; paraphyses irregulares. Iodo gel. hym. non colorata nisi flavescens thecæ pallide fulvescentes.

Ipswich (No. 99, coll. Bailey).

USNEA ELEGANS, *sp. nov.*

Thallus (K—C—) pallide flavescens, teres firmus, erectus (altit. 1—2—pollicaris), parcissime divisus, interdum simplex et tunc rigidus, undique densissime fibrillosus; axis medullaris tenellus fere filiformis (K—C—); apothecia concoloria vel pallidiora, terminalia, plana (latit. 6—13 mm.), receptaculo fibrilloso præsertim margine; sporæ 8 næ incolores, ellipsoideæ vel late ellipsoideæ, simplices, ·0085—·011 x ·006—·008 mm. Iodo gel. hym. intense cærulescens dein obscurata.

Corticola in Gowrie Mountain, Darling Downs (coll. Bailey, No. 13).

RAMALINA PERPUSILLA, *sp. nov.*

Thallus pallescens vel pallide cervinus rigescens furcatim divisus parvus (altit. ·5—1—pollicaris), compressus, sæpe lacunose impressus et hinc inde (præsertim infra) foraminibus oblongis terebratus, subfastigiatus; apothecia concoloria vel pallidiora mediocria (latit. ·8—1·5 mm.), marginalia receptaculo demum subpedicellato; sporæ 8 næ incolores oblongæ, rectæ vel leviter curvulæ, 1—septatæ, ·012—·015 x ·004—·005 mm.

Corticola prope Brisbane River (coll. Bailey, 113).

RAMALINA EXIGUELLA, *sp. nov.*

Thallus pallidus vel pallide stramineus minor (altit. circ. semi-pollicaris), erectus, rigescens, fruticulosus, anguloso-compressus et longitudinaliter sulcatus (præsertim basi), supra teretiusculus, parce divisus vel ramosus ramulis pallidis setiformibus; apothecia pallida (latit. ·5—1·5 mm.), terminalia vel subterminalia receptaculo lævigato, apice ramuli deflexi et vix unquam nigricantis appendiculato; sporæ 8 næ incolores, ellipsoideæ interdum gibbosæ, 1—septatæ, ·01—·013 x ·006—·007 mm.

Affinis R. melanotrichi (Laur).

Corticola prope Brisbane (coll. Bailey, 91).

STICTINA RUTILANS, *sp. nov.*

Thallus expansus (latit. 4—7—pollicaris), lævigatus, crassiusculus, rotundato-lobatus lobis rotundato-lobulatis, rufescens vel pallide cinnamomeo-rufescens, subtus cinnamomeus vel cupreus, nigro-tomentosus, cyphellis sat magnis (latit. usque 1·5 mm.), thelotremoideis cinnamomeis vel rufescentibus; apothecia sparsa rufo-fusca (latit. 1—2 mm.), receptaculo thallino extus rugosulo præsertim juniore et pallido-ciliato et margine demum fere integro cincta; sporæ 8 næ incolores vel (vetustæ) pallide fuscescentes, 1—septatæ, fusiformes, ·027—·033 x ·007—·009 mm. Gonimia glomerulosa latit. circ. ·005 mm.

Corticola (?) prope Brisbane.

PARMOSTICTA RUBRINA, *sp. nov.*

Thallus coriaceus, sordide luridus vel sordide rufescens, lobatus mediocris (latit. circ. 2—pollicaris), nudus, læviusculus intus citrinus, subtus flavescenti-pallidus vel sordide flavescens, tomento rhizinarum pallido brevi, pseudo-cyphellis prominulis parvis planis citrinis; apothecia fusco-nigra mediocria (latit. 2—4 mm.), receptaculo thallino, rugoso aut papilloso; sporæ (6—8) næ incolores aciculares vel nonnihil bacillares, septatæ vel interdum vix septatæ (septulis 3—7), ·06—·1 x ·003—·004 mm.; paraphyses mediocres discretæ. Iodo gel. hym. leviter cærulescens dein fulvescens.

Corticola (?) prope Brisbane (coll. Bailey, 11).

Gonidia flavescentia latit. ·006—·011 mm.

This may be the fully developed state of *Sticta rubella* (Hook and Tayl.), but as the apothecia in the Tasmanian specimens, from which Nylander gives his description, are without spores, there is a doubt; besides, there are other differences.

PARMELIA AMPLEXULA, *sp. nov.*

Similis P. austro-africanæ (Strn. Trans Glasgow Field Nat., 1877) sed minor et arcte adpressa.

Thallus flavescens, vel obscure virescenti-flavescens, laciniatulus et sæpe isidiosus (K—C erythrinosus) subtus nigricans (quantum video); sporæ 8 incolores, ellipsoideæ, simplices, ·008—·01 x ·005—·006 mm.; paraphyses crassæ breves et quasi interruptæ.

Saxicola (coll. Bailey, 262), Fassifern.

PARMELIA BRISBANENSIS, *sp. nov.*

Thallus adpressulus pallide cinereo-glaucescens laciniatus, hinc inde isidiosulus (supra K flavens), subtus niger rugosulus nudus, hinc inde parce et brevissime rhizinosus, ambitu spadiceus; medulla citrina vel virescenti-citrina (K—C—): sterilis.

Corticola prope Brisbane (coll. Bailey, 228).

Affinis P. sulphuratæ (Flot.).

PHYSCIA SUBLURIDA, *sp. nov.*

Thallus parvus pallidus vel virescenti-pallidus adpressus laciniatulus (laciniis imbricatis multifidis), subtus pallidus et rhizinis pallidis munitus; medulla rufescens (præsertim supra), K—C—; apothecia parva cæsia pruinosa, margine pallido incurvo fere integro cincta; sporæ 8 næ in ascis saccatis, ellipsoideæ, fuscæ 1—septatæ, ·014—·018 x ·0065—·008 mm.; hypothecium incolor.

Ad ramulos prope Brisbane (coll. Bailey, No. 241).

PYXINE OBSCURIOR, *sp. nov.*

Thallus pallidus vel glaucescenti-pallidus adpressus ambitu effiguratus vel laciniatulus; apothecia nigra sessilia plana marginata mediocria; sporæ 8 næ fuscæ, distincte 1—septatæ, ·015—·02 x ·007—·009 mm.; hypothecium crassum fusco-nigrum, K rufo-ferrugineum sed epithecium eodem reagente non mutatum. Medulla alba tenuis K flavens dein intense rubens.

Corticola prope Brisbane (coll. Bailey, No. 236).

LECANORA PULVERATA, *sp. nov.*

Thallus pallidus vel pallide glaucescens tenuis, minute rimuloso-areolatus, hinc inde minute granulosus (K—C—); apothecia sessilia (latit. ·8—1·6 mm.), pallida vel pallide lutescentia, grosse albo-pruinosa concaviuscula dein plana, margine prominulo undulato cincta; epithecium C—; sporæ 8 næ incolores ellipsoideæ simplices, ·009—·012 x ·006—·0075 mm.; paraphyses gracilis apicibus parce citrino-inspersis; hypothecium incolor. Iodo gel. hym. cærulescens dein sordida.

Corticola, Brisbane (coll. Bailey, No. 86).

The paraphyses are rendered distinct and separate by K when they show as very fine threads. This lichen seems to play between L. albella and L. galactina.

ASCIDIUM PROFUNDUM, *sp. nov.*

Thallus albus vel albidus (K—C—), lævis rugulosus tenuis; apothecia profude immersa in substrata (cortice), peridio nigro integro vel fere integro, ellipsoideo, collo longo angusto instructo, ostiolo supra vel extus pallido firmo rotundo aperto (diam. circ. ·15 mm.), columella nigra; thecæ monosporæ, sporæ incolores vel pallide lutescentes, fusiformes aut cylindraceo-fusiformes, sæpe haloniatæ, muralidivisæ, ·27—·44 x ·032—·045 mm., iodo cæruleo-infuscatæ; paraphyses gracilimæ, confertæ.

Corticola (coll. Bailey, No. 131).

The paraphyses are rendered distinct and filiform by K.

This may only be a sub-species, or even a variety of *A. depressum* (Mnt.) with larger spores, &c.

LECIDEA FOLIATA, *sp. nov.*

Thallus flavescenti-pallidus vel lurido-flavescens, microphyllinus, e squamulis convexulis crenato-incisis vel digitato-incisis, imbricatis constans, hypothallo non distincto; apothecia spadiceo-rufescentia vel testaceo-rufa, conferta, pallidius marginata, hinc inde congesta (latit. ·6—1·4 mm.), planiuscula dein convexa et immarginata; sporæ 8 næ cylindraceæ vel fusiformi-cylindraceæ, simplicis, incolores, ·012—·016 x ·0025—·003 mm.), longit. interdum usque ad ·02 mm.; paraphyses crassiusculæ (crassit. usque ad ·003 mm.) non discretæ, conglutinatæ apicibus incoloribus non clavatis; hypothecium electrinum crassiusculum. Iodo gel. hym. cærulescens dein fulvescens.

Corticola prope Brisbane (coll. Bailey, 156, &c.).

Affinis L. longiusculæ (Nyl.) sed differt hypothecio constanter electrino, &c.

LECIDEA ABERRATA, *sp. nov.*

Thallus albus vel albidus, tenuis pulverulentus vel leproso-granulatus (K pallide flavescens); apothecia fusco-rufa, mediocria (latit. ·6—1·3 mm.), sessilia, plana et tunc quasi thallino-marginata demum convexa et immarginata; sporæ 8 næ incolores simplices, ·0085—·011 x ·005—·0065 mm.; paraphyses graciles non bene discretæ apicibus flavescentibus inspersis (K—); hypothecium incolor. Iodo gel. hym. intense cærulescens dein sordida.

Ad corticem *Eucalypti crebræ* Brisbane (coll. Bailey, No. 190).

This lichen appears to be allied to L. vernalis.

LECIDEA SUBNUBILA, *sp. nov.*

Thallus pallidus vel (detritus) pallide cinere-virescens, lævigatus minute rimuloso-areolatus (K vix coloratus); medullo alba (K flavens, I cærulescens); apothecia nigra innato-sessilia, concaviuscula vel plana prominule marginata (latit. circ. 1 mm.), epithecio grosse albido-pruinoso; sporæ 8 næ incolores, simplices, ellipsoideæ vel fusiformi-ellipsoideæ, ·014—·02 x ·007—·009 mm.; paraphyses confertæ distinctæ filiformes apicibus fuscis conglutinatis; hypothecium fuscum vel in lamina crassa fusco-nigrum. Iodo gel. hym. intense cærulescens.

Saxicola (coll. Bailey, 261), Fassifern.

LECIDEA DEMUTANS, *sp. nov.*

Thallus (Kfl. Cfl.) pallidus vel pallide albidus, rugulosus vel granulosus, hinc inde diffractus, fusco-limitatus vel effusus; apothecia nigra, innata vel innato-sessilia, mediocria, plana acute marginata; sporæ (4—8) næ olivaceæ fusiformi-oblongæ bi-loculares vel sæpe breviter polari-bi-loculares, ·022—·03 x ·01—·013 mm.; paraphyses distinctæ crassiusculæ, granulis et sparsius guttulis oleosis inspersæ apicibus conglutinatis clavatis; hypothecium fuscum tenue. Iodo gel. hym. cærulescens dein fulvescens vel etiam vinose rubens præsertim thecæ.

Corticola (coll. Bailey, 82).

The perithecium is entire, but thin.

LECIDEA INALBESCENS, *sp. nov.*

Thallus firmus albidus vel pallidus verrucoso-rugulosus crassiusculus, valde inæqualis (K—C—); apothecia nigra sessilia mediocria (latit. circ. 1 mm.), plana, crasse marginata, hinc inde conglomerata, epithecio sæpe virescenti-pruinoso præsertim juniore; sporæ (4—8) næ incolores fusiformes vel sæpius obtuse fusiformes, plerumque curvulæ, (6—10)—loculares (loculis parvis subquadratis), ·03—·045 x ·0055—·007 mm.; paraphyses distinctæ filiformes crassiusculæ apicibus rufescentibus contextis; hypothecium crassum fusco-nigrum vel nigrum. Iodo gel. hym. vinose rubescens vel etiam vinose rubens (præcedente cærulescentia nulla).

Ad lignum decorticatum prope Rosewood Scrub (coll. Bailey, 258).

Affinis L. coniochloræ (Mnt.).

GRAPHIS (MEDUSULA) PERTENELLA, *sp. nov.*

Thallus albus vel pallido-albidus rugulosus firmus nonnihil cerebriformis, bene evolutus (K—C—); apothecia depresso-innata flexuosa, tortuosa vel irregularia interdum ramosula, epithecio fuscescente vel pallidiore planiusculo (latit. ·05—·1 mm.); sporæ 8 næ incolores ellipsoideæ vel oblongo-ellipsoideæ, 4—loculares, ·011—·016 x ·0055—·007 mm.; paraphyses distinctæ graciles; hypothecium incolor. Iodo gel. hym. non tincta protoplasma thecarum fulvescens vel fere incolor.

Corticola, Brisbane (coll. Bailey, 79).

Allied (perhaps too nearly) to Gr. æquabilis (Nyl.).

GRAPHIS ELUDENS, *sp. nov.*

Thallus cinereus vel rufescenti-pallidus crassiusculus (crassit. ·2—·3 mm.) lævigatus, minute rimuloso-areolatus (K—C—); apothecia innata fusca, oblonga vel oblongo-linearia vel irregularia, parce ramosula obtusa, epithecio concaviusculo vel planiusculo (latit. circiter ·06 mm.), interdum margine thallino discisso cincto; sporæ 8 næ fuscæ 3—septatæ rarius (1—2) septatæ, oblongæ vel oblongo-ellipsoideæ, ·011—·016 x ·004—·0055 mm.; paraphyses distinctæ crassiusculæ apicibus fuscescentibus conglutinatis; hypothecium incolor. Iodo gel. hym. non tincta nec sporæ. Gonidia majuscula flavescentia.

Saxicola (coll. Bailey, 287).

A thin lateral fuscous perithecium is seen on making a cross section.

This lichen is closely allied to Gr. hypoglauca (Krph.), but the spores are much smaller than those of the latter, &c.

GRAPHIS REPLETA, *sp. nov.*

Thallus pallidus fere continuus, tenuis, bene evolutus (K e flavente rubens); apothecia fusca innata, ovata vel oblonga aut nonnihil irregularia interdum aggregata, thallino-marginata vel fere nuda, epithecio concaviusculo vel planiusculo (latit. ·2—·3 mm.); sporæ (4—8) næ incolores fusiformes, vel oblongo-fusiformes (10—17)—loculares, ·054—·075 x ·009—·012 mm.; paraphyses gracillimæ in gelatina firma involutæ, apice fuscescente granuloso inspersæ; hypothecium incolor. Iodo gel. hym. obsolete cærulescens, sporæ cæruleo-infuscatæ.

Corticola, Brisbane (coll. Bailey, 226 ex parte).

The paraphyses appear as very fine threads imbedded in a stiff jelly such as are seen in one or two of the Glyphides when treated with K.

GRAPHIS CIRCUMFUSA, *sp. nov.*

Thallus pallide vel sordide cervinus sæpe ad rufuscentem mergens, minute areolatus vel continuus, hinc inde nonnihil farinaceus (K flavens dein intense rubens); apothecia oblonga vel irregularia interdum ramulosa, innata, pallida vel albida, margine thallino prominulo irregulari cincta, intus tota incoloria, epithecio concaviusculo (latit. circiter ·2 mm.); sporæ 2 næ rarissime 3 næ, incolores oblongo-fusiformes (sæpius uno apice obtusæ, altero acuminatæ), (11—21)—loculares, ·07—·1 x ·009—·012 mm.; paraphyses distinctæ, apice inspersæ; hypothecium incolor vel leviter lutescens. Iodo gel. hym. non tincta vel obsolete cærulescens, sporæ cæruleo-infuscatæ.

Corticola, Brisbane (coll. Bailey, 201).

OPEGRAPHA INTRUSA, *sp. nov.*

Parasitica supra thallum et apothecia *Verrucarriæ circumrubentis;* apothecia nigra prominula parva oblonga (longit. ·4—·8 mm.), epithecio-rimiformi hinc inde expansulo; sporæ 4 næ rarius 2 næ fuscæ, 1—septatæ, medio constrictæ, oblongæ, ·016—·018 x ·007—·009 mm.; paraphyses parcæ graciles irregulares, apicibus nigris vel cæruleo-nigris (K cæruleis); hypothecium incolor. Iodo gel. hym. leviter vinose rubescens vel fere incolor. Brisbane (coll. Bailey, 125 ex parte).

ENDOCARPON BAILEYI, *sp. nov.*

Thallus pallidus vel glaucescenti-pallidus, firmus crassiusculus (crassit. usque ad ·5 mm.), late expansus (latit. 1—2—pollicaris), corniculato-convolutus et bullatus, fere cerebriformis, ambitu nonnihil lobato-divisus, chrysogonidicus, subtus pallide fuscescens; perithecia innata pallida sed supra annulo nigro munita; sporæ 8 næ fere uniseriatæ fuscæ vel fusco-nigræ, variabiles, ellipsoideæ, oblongæ et interdum fere sphæricæ, irregulariter loculosæ, fere mura-lidivisæ, ·014—·023 x ·0085—·014 mm.; paraphyses graciles longæ, in gelatina firma involutæ; hypothecium incolor. Iodo gel. hym. non tincta.

Corticola, Brisbane (coll. Bailey, 249).

This lichen presents several peculiarities, but meanwhile it is preferable to rank it under the genus *Endocarpon.*

VERRUCARIA OBOVATA, *sp. nov.*

Thallus macula albida vel pallida indicatus; apothecia nigra prominula hemisphærica (latit. ·3—·4 mm.), perithecio demidiatim nigro crassiusculo; sporsæ (6—8) næ in thecis saccatis incolores dein fuscæ vel fusco-nigri-cantes, oviformes (i.e., uno apice acutiores), 1—septatæ (septo apici acutiori viciniore), ·022—·032 x ·009—·012 mm.; paraphyses graciles confertæ, molliusculæ. Iodo gel. hym. non tincta.

Ad cortices (præsertim juniores) prope Brisbane (coll. Bailey, 125). Arcte affinis *V. conothelenæ* (Nyl.) sed differt colore thalli, magnitudine sporarum, &c.

VERRUCARIA FLAVENTIOR, *sp. nov.*

Thallus bene flavens (K aurantiaco-rubens), nitidus crassus, nodulosus vel noduloso-rugosus, diffractus; apothecia nigra, plerumque tota immersa, solum ostiolis pallidis denudatis, demum partim emersa, perithecio integre nigro; sporæ 8 næ fuscæ, oblongæ vel ellipsoideo-oblongæ, 4—loculares, ·018—·025 x ·008—·011 mm.; paraphyses inspersæ. Spermogonia nigra parva (partim immersa); spermatia recta, cylindraceo-aciculares, ·015—·023 x circ. ·0006 mm.

Corticola prope Brisbane (No. 244).

The spores are, for the most part, old and shrivelled, and the dimensions given above may not indicate the fully developed size.

VERRUCARIA CIRCUMRUBENS (Nyl.) RUBROTECTA (Strn.).

Thallus macula pallida vel pallide lutescente, nitida indicatus; apothecia nigra prominula (basi latit. ·6—·9 mm.), fere omnino erythrinose obtecta, perithecio integre nigro sed supra crasso, infra tenuiore; sporæ (4—8) næ, incolores demum olivaceæ, ellipsoideæ, 4—loculares (loculis sæpissime sexangularibus, rarissime semel divisis); paraphyses graciles, granulis et guttulis oleosis inspersæ. Iodo gel. hym. non tincta.

Corticola, Brisbane (coll. Bailey, 124).

The red colour is rendered intense—purpureo-violaceous by K.

STRIGULA ELATIOR, *sp. nov.*

Thallus adnatus, pallidus vel pallide virescens, nitidus, maculiformis, rotundatus, effiguratus vel ambitu nonnihil lobulatus, statu juvenili pilis longiusculis pallidis adspersus; apothecia nigra minuta innata, perithecio dimidiatim nigro; sporæ 8 næ in thecis oblongis inæqualiter fusiformes (*i.e.* una parte latiores obtusiores altera tenuiores acutiores), 1—septatæ, ·018—·023 x ·005—·0065 mm.; paraphyses parcæ distinctæ breviusculæ filiformes granuloso-inspersæ. Iodo gel. hym. non tincta, protoplasma thecarum vinose fulvescens vel fulvescens.

Ad folia viva prope Herbert River (coll. Bailey, No. 96).

PLAGIOTHELIUM AUSTRALIENSE, *gen. nov.*

Thallus pallescens vel pallide lutescens, rugulosus vel nodulosus; apothecia nigra tota immersa, in prominentiis thallinis sita, solum ostiolis nigris umbilicatis emersis, perithecio integro crasso et supra oblique et longe ampullaceo, interdum 2—3 peritheciis appositis; sporæ 2 næ incolores dein fuscæ vel fusco-nigræ, muralidivisæ, ·14—·2 x ·035—·045 mm.; paraphyses longæ confertæ graciles distinctæ sed molliusculæ. Iodo gel. hym. dilute vinose rubescens.

Corticola (coll. Bailey, No. 58).

In every instance the peridium is obliquely set, and has a longish oblique neck, ending in a minute ostiolum, but here and there 2, or even 3, of these peridia are clustered and apparently enclosed in the same black stroma. Accordingly, this curious lichen has affinities to Trypethelum, but may well constitute the type of a new genus under the name given above.

Lichens contributed by MR. HUGH PATON, *of Glasgow.*

LEPTOGIUM PATONI, *sp. nov.*

Thallus expansus, olivaceus vel obscure olivaceus, membranaceus, læviusculus vel hinc inde tenuissime rugulosus, lobatus, lobis rotundatis et dentato-crenatis, subtus nudus et pallidior; apothecia carnea vel interdum dilute carneol rufa, plerumque elevata, mediocria, margine thallino lævigato tenui cincta; sporæ 8 næ incolores, fusiformes, apice acuminatæ, 5—septatæ, interdum (4—6) næ, ·038—·045 x ·005—·007 mm.; paraphyses dictinctæ filiformes. Iodo gel. hym. intensive cærulescens.

Spermatia recta apicibus incrassatula, ·004—·005 x ·001 mm. Gonimia moniliformi-disposita oblonga, ·009 x ·005 mm.

Corticola, Ohœwai, Bay of Islands, N.Z.

STICTA PERISSA, *sp. nov.*

Thallus pallidus, lurido-pallidus vel pallide rufescens firmus, lævigatus, late expansus, fere totus lineari-laciniatus, laciniis subpinnatifidis, apice plerumque retusis, subtus nigricans vel niger, ambitum versus cervinus, tomento concolore denso brevi indutus; cyphellæ sat magnæ, fundo pulverulentæ albæ; apothecia marginalia (latit. 2—3 mm.), fusca, receptaculo granulato-ruguloso, juniore sordide ve, albide ciliato, margine crenulato; sporæ 8 næ fuscæ 1—septatæ, rarius 3—septatæ, ·024—·036 x ·008—·011 mm.

Ohœwai, N.Z.

This lichen plays between *St. laciniata* and *St. dissimulata*, but the cyphellæ are truly thelotremoid—*i.e.*, with distinct cups, having sharp elevated margins, while they are covered with white powder. The small undeveloped cyphellæ appear almost as pseudo-cyphellæ.

PSOROMA DISPERSUM, *sp. nov.*

Thallus pallidus vel pallide cervinus, squamulosus, squamulis dispersis, contiguis et interdum imbricatulis, margine crenatis et hypothallo nigro insitis; apothecia fusca vel fusco-nigra, plana, margine thallino crenato inflexo cincta; sporæ 8 næ, incolores, simplicis ellipsoideæ vel sæpius fusiformi-ellipsoideæ, ·018—·025 x ·009—·011 mm.; hypothecium rufum. Iodo gel. hym. leviter cærulescens dein vinose rubens.

Corticola, Gippsland, Australia.

LECANORA MUNDULA, *sp. nov.*

Thallus albidus vix ullus visibilis; apothecia rosea vel interdum cocinea biatorina, plana vel convexiuscula obtuse vel vix marginata (latit. ·6 mm.); sporæ 8 næ incolores, fusiformi-ellipsoideæ, simplices, ·008—·01 x ·003—·004 mm.; paraphyses graciles conglutinatæ apicibus late rufis conglutinatis, K purpureo-violaceis; hypothecium incolor. Iodo gel. hym. cærulescens.

Corticola, Gippsland, Australia.

LECIDEA SUBHYALINA, *sp. nov.*

Thallus albus tenius nonnihil squamulosulus; apothecia electrina pellucida primum planiuscula et vix marginata dein convexa et fere globosa; sporæ (2—8 ?) næ, incolores, simplicis, ellipsoideæ, ·015—·02 x ·0065—·009 mm.; paraphyses nullæ (proprie sicdictæ), epithecium incolor; hypothecium incolor. Iodo gel. hym. leviter cærulescens dein fulvescens.

Corticola, Gippsland in Australia.

The entire hymenium is gelatinous. The apothecia appear under a Codington lens as little particles of clear amber without any apparent structure. I have not been able to detect more than two spores in each theca, although a presumption is afforded on other grounds that the normal number is 8. There were very few thecæ or spores seen.

LECIDEA GROSSULINA, *sp. nov.*

Thallus albidus vel pallidus tenuissimus fere continuus; apothecia sessilia nigra mediocria (latit. circiter 1 mm.), plana et obtuse marginata dein convexa et immarginata; sporæ 8 næ in thecis oblongo-saccates, incolores, ellipsoideæ, 1—septatæ, ·022—·034 x ·013—·018 mm.; paraphyses graciles distinctæ confertæ apicibus conglutinatis cærulee nigris interdum fusco-nigris; hypothecium incolor vel fere incolor. Iodo gel. hym. cærulescens dein vinose rubens.

Corticola, Fern-tree Gully in Australia.

GRAPHIS GYRIDIA, *sp. nov.*

Thallus albidus tenuis hinc inde visibilis; apothecia tota pallida vel pallide lutescentia, segregata, prominula, pulverulenta (latit. ·2—·3 mm.), ramosa et plerumque stellatim divisa, epithecio rimiformi; sporæ 8 næ incolores obtuse fusiformes, (6—9)—loculares loculis mediis interdum semel divisis, ·018—·025 x ·006—·0075 mm.; paraphyses distinctæ, crassiusculæ; hypothecium incolor vel pallide lutescens. Iodo gel. hym. leviter vel obsolete cærulescens.

Corticola, Gippsland.

In one of Mr. Paton's parcels there were detected traces of a Parmelia, presenting characters so closely resembling those of one sent by Mrs. Roy, of Royston Park, Owen Sound, Ontario, Canada, that I am inclined to identify them.

The following is a description of the Canadian lichen:—

PARMELIA ROYI, *sp. nov.*

Thallus cinereo—vel cervino-fuscescens, cinereo-rufescens vel interdum obscure olivaceus (K nonnihil flavescens), substellatus, laciniatus, laciniis interdum imbricatis (et tunc latioribus, planis), incisis et lineari-multifidis, convexiusculis, hinc inde transversim diffractis (latit. 1—3 mm.), subtus dense fuligineo-pannosis vel spongiosis; medulla albida K—C—; apothecia rufo-fusca vel fusco-nigra, plana (latit. 1—4 mm.), receptaculo extus furfuraceo sed non rugoso et margine tenui nonnihil inflexo; sporæ numerosæ (100 et ultra), incolores, simplices, lineares sed arcuatæ vel crescenticæ, ·009—·013 x ·0025—·003 mm. Iodo gel. hym. vix tincta, thecæ cærulescentes.

Corticola, Owen Sound in Canada (Mrs. Roy).

Affinis *P. tæniatæ* (Nyl.) sed distincta.

The receptacle of the apothecia is externally yellowish, and finely tomentoso-furfuraceous, as in that of several *Peltigeræ.*

ART. XI.—*Suggestions for a New and Economical Method for the Scientific Production of some Acids.*

BY EDWARD LLOYD MARKS, LECTURER ON CHEMISTRY, &c., SCHOOL OF MINES, SANDHURST.

[Contributed October 14th, 1880.]

REFLECTING upon the important *rôles* played by Silica in the formation of numerous natural and artificial bodies, also upon its application in the manufacture of technical products of great utility in scientific and industrial pursuits, it has occurred to me that advantage might be taken of its chemistry in a way that might be useful in the production of some acids, and possibly on a large scale, where circumstances are favourable.

It will be remembered that, at varying temperatures, opposite effects may be produced with the same materials—affinities stable at a low may be reversed by a high heat, and conversely: numerous facts might be cited to verify the statement. The stability of the alkaline Silicates is readily overcome by a moderate heat, whilst in consequence of the non-volatility of Silica, even at the highest temperatures, salts of volatile acids are readily decomposed by *it,* their acidulous radicals being liberated; consequently, open for collection.

Silicates may have several formulæ. Those to which I am about to refer are the meta-silicates, whose types are $\overset{\prime}{\mathrm{M}}_2\,\overline{\mathrm{Si\ O_3}}''$ and $\overset{\prime\prime}{\mathrm{M}}\,\overline{\mathrm{Si\ O_3}}''$; $\overset{\prime}{\mathrm{M}}$ and $\overset{\prime\prime}{\mathrm{M}}$ respectively, indicating univalent and bivalent basylous radicals, one atom of the latter, or two of the former, being saturated by the diabasic silicic radical.

To illustrate the process for the production of acids, I will take, firstly, the reactions going on during the glazing of pottery with salt. It is well known that although salt may be volatilized unchanged, a white heat failing to dissociate its elements, yet, in the presence of moisture and Silica, it is readily decomposed, thus :—

$$\overset{\prime\mathrm{v}}{\mathrm{Si}}\ \mathrm{O}''_2 + \mathrm{H}'_2\,\mathrm{O}'' + 2\ \mathrm{Na}'\ \mathrm{Cl}' = \mathrm{Na}'_2\,\overline{\mathrm{Si\ O_3}}'' + 2\ \mathrm{H}'\ \mathrm{Cl}',$$

metasilicate of sodium and hydrochloric acid being the results, the latter through its volatility escaping, and hence condensable.

If then, as suggested by that formula, we substitute, say, nitrate of sodium or of potassium, we shall equally obtain nitric acid, thus :—

$$\overset{\prime\mathrm{v}}{\mathrm{Si}}\ \mathrm{O}''_2 + \mathrm{H}'_2\,\mathrm{O}'' + 2\,\mathrm{K}'\ \overline{\mathrm{NO_3}}' = \mathrm{K}'_2\,\overline{\mathrm{Si\ O_3}}'' + 2\ \mathrm{H}'\ \overline{\mathrm{NO_3}}';$$

or using ferrous sulphate—at times a waste product, always a cheap article—we get sulphuric acid.

$$\overset{\prime}{\mathrm{Si}}\ \overset{\mathrm{v}}{\mathrm{O}}''_2 + \mathrm{H}'_2\,\mathrm{O}'' + \mathrm{Fe}''\ \overline{\mathrm{SO_4}}'' = \mathrm{Fe}''\ \overline{\mathrm{Si\ O_3}}'' + \mathrm{H}'_2\ \overline{\mathrm{SO_4}}''.$$

In addition to the primary object, there remains as a by-product, a meta-silicate available for use in soap-making, paint manufacture, or for rendering matters incombustible, &c., &c.

It may be said that in the cases of the nitric and sulphuric acids the formation of anhydrides would result, but as these bodies, in the presence of moisture, would re-form acids, I think that point is answered.

Suppose again that acetic acid be required, framing an equation upon the same formula we get

$$\overset{\prime\mathrm{v}}{\mathrm{Si}}\ \mathrm{O}''_2 + \mathrm{H}'_2\,\mathrm{O}'' + 2\ (\mathrm{Na}'\ \overline{\mathrm{C_2H_3O_2}}') = \mathrm{Na}'_2\,\overline{\mathrm{Si\ O_3}}'' + 2\ (\mathrm{H}'\ \overline{\mathrm{C_2H_3O_2}}'),$$

and so on, varying the quantities of the substance to be decomposed according as the acidulous radical is univalent, bivalent, &c.; or mono- or poly-basic in saturating power.

Art. XII.—*On Some New Marine Mollusca.*

By the Rev. J. E. Tenison-Woods, F.G.S., F.L.S., &c.,
Corresp. Mem. Roy. Soc., Vict.,
Pres. Linn. Soc., N.S.W.

[Communicated October 21st, 1880.]

Two of the following shells were sent to me by Mr. J. F. Bailey, of Swanston-street, Melbourne, who, by his interest in the marine fauna of Victoria, has been able to add much valuable knowledge on the subject. The shells are remarkably different from any hitherto known. One is a small *Purpura,* which I have named after its discoverer. The South Australian coast is not rich in purpuroid forms, and the present species is distinguished for the thickness and almost tropical aspect of the shell, as well as its approximation, in the form of the lips, to some of the Mazatlan *Purpuræ.* There is also a *Fossarus,* which is different from a Tasmanian species, though of a similar character.

PURPURA BAILEYANA, *n.s., T., acuminate ovata, sordide et pallide oliva, crassa; anfract. 5, conspicue, crebre carinatis et creberrime longitudinaliter undulosé lamellatis, lineis incrementi sub-variciformibus, irregularibus et conspicuis; spira brevi, conica; ultim. anfr. reliq. valde superante: apertura alba, nitente; labio lato, concavo; labro solido, margine crenato, acuto, intus late sulcato; canali elongato, haud recurvo.*

Shell acuminately ovate, of a dirty pale olive colour, thick; whorls 5, conspicuously but closely carinate, and very finely undulately lamellose lengthwise; lines of growth thick, irregular, and almost like varices; spire short, conical, the last very much exceeding the others in size; aperture white and shining; lip broad, and concave on the columella; labrum solid, with a crenated margin and broadly sulcate within; canal a deep groove, rather long and not recurved. Long. 30, Lat. 19, long. spire 8 mil.

This shell belongs to an Australian family of *Purpuræ,* of which *P. Flindersi* of Adams may be considered the type. I described two more species of the same general habit in the "Proceedings of the Tasmanian Royal Society"

—see vol. for 1875, p. 135, and vol. for 1876, p. 135. These species, which I named *P. littorinoides* and *P. propinqua*, differ from the one now described in being smaller, of less solid habit, and having a purple aperture, which is also the case with the shell described by Adams.

GIBBULA TESSERULA, *n.s. Pl., figs.* 3, 4, 5. *T. parva, nitente, oblique depressa, profunde umbilicata, tenui, atra, ad peripheriam conspicue tesselata; anfr.* 3½, *convexis, regulariter distanterque spiraliter striatis, transversim lineis tenuibus crebre decussatis; labro tenui, crenato, labio reflexo, curvato; a labro vix sejuncto; apertura sub-quadrata, intus tesselata, iridescente; basi lævi, polita, convexa.* Alt. *vix.* 4 mil.

Shell small, shining, obliquely depressed, deeply umbilicate, thin, blackish, with a kind of purple iridescence, conspicuously marked with a line of large square black and white spots at the periphery; whorls 3½ to 4, convex, regularly and distantly spirally striate, decussate transversely with close fine lines. Outer lip thin, crenulate, inner lip reflexed and curved, scarcely separated from the labrum; aperture subquadrate, tesselate inside, with a fine iridescent film; base smooth, polished, and convex.

The depressed form of this shell and its conspicuous tesselations distinguish the species from the many forms of *Gibbula* we have in the Australian seas. *Gibbula depressa*, described by me in the Trans. Roy. Soc. Tas., 1875, p. 154, is a dark tesselated form, but it is widely sulcate.

FOSSARINA FUNICULATA, *Pl., figs.* 6, 7, 8. *F. t. oblique depresso-globosa, quasi auriformi, obtecte umbilicata, solida, opaca, albida, maculis et lineis angularibus atratis ornata; spira plano-convexa, vix elevata; anfr.* 3½, *carinatis, carinis rotundatis magnis et parvis alternantibus; ultimo anfr. valde expanso; apertura rotundata; labro simplici, vel crenato, columella subreflexa, umbilico sulciformi; basi funiculata.* Diam. 5, *mil. circiter.*

Shell obliquely depressedly globose, almost ear-shaped, subumbilicate, solid, opaque, whitish with dark zigzag lines and spots; spire plano-convex, hardly exsert; whorls 3½, keeled, keels rounded, alternating large and small; last whorl much expanded, aperture rounded, labrum simple or crenulate, columella subreflexed, umbilicus represented by a groove, base corded.

This shell closely resembles *F. Simsoni*, nobis, which is identical with *F. Petterdiana*, Crosse, a prior name. The difference between the present species and the Tasmanian shell is that the latter is simply striate, while this is corded.

CHITON INORNATUS, *C. t., figs.* 8, 9. *C. t. ovalis, tenui, depressa, badia saturata, concolor, ubique minutissime punctata; valvis æqualibus, carinatis, vix rostratis; areis lateralibus parum elevatis, striis radiantibus obsoletis; areis centralibus, lineis tenuibus concentricis striatis; valvis terminalibus haud magnis, obscure costatis, costulatis, rotundatis, margine membranacea pilosa. Punctis in valvis confertissimis, depressis.* Long. 40, Lat. 25, Alt. 5 mil. N. Tasmania.

Shell oval, thin, depressed, of a uniform deep brown, very finely dotted all over with minute depressions like the top of a thimble, valves of a uniform width, keeled, slightly beaked; lateral areas very little elevated with obsolete radiate striations; central areas finely marked with concentric striæ; terminal valves not large, obscurely ribbed with broad rounded ribs; margin membranaceous, covered with scattered short silvery hairs.

The distinction of this species is its very uniform ornamentation. In most of the Chitons there is some marked difference between the lateral and central areas of the valves, but here all seems uniform in the colour as well as in the ornament. The lateral areas have concentric lines like those of growth. The minute dots with which the surface is pitted is a feature which this species shares with many others in Australia, but the marks are finer and more shallow than usual. The species is very rare.

AUSTRIELLA, *nov. gen. Testa æquivalvis, inæquilateralis postice parum producta, periostraca induta, concentrice lamellosa, ligamentum externum, dente cardinalis uno, arcuato, inconspicuo; intus haud iridescenti, impressione pallii sinu nullo, duobus impressionibus muscularibus, lateralibus. In locis paludosis sub-salinis vel dulcis prope Bowen, Portis Denisoni ubi olim ab indigenis barbaris ut alimentum abundanter conquisita et nunc extant innumeris testarum fragmentis in cumulis arenacis prope mare. A Spatha genus Unionidæ testa non iridescente sed lamellosa sat distincta. Nomen duxi ab Australia cui adhuc numquam a naturalistis genus conchiliorum sit dedicatum.*

It is with considerable hesitation that I erect this new genus in a science which has already been so heavily burdened with useless and confusing genera; but I cannot find any of the existing divisions which will in any way meet the

Fig. 2

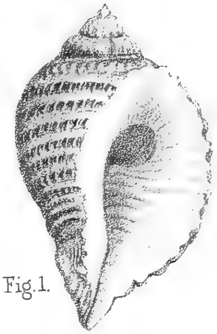

Fig. 1.

Purpura Bayleana

Fig. 3

Gibbula tesserula

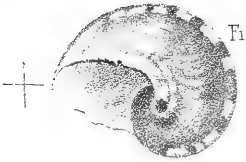

Fig. 4

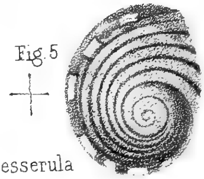

Fig. 5

Gibbula tesserula

Fig. 6

Fossarina funiculata

Fig. 7

Fossarina funiculata

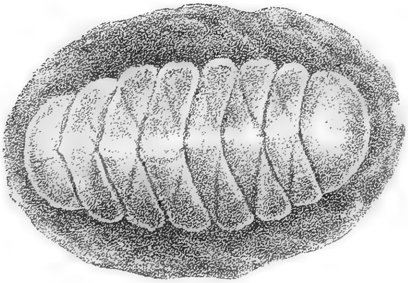

Fig. 8

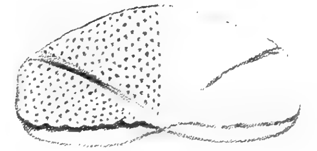

Fig. 9

Chiton inornatus

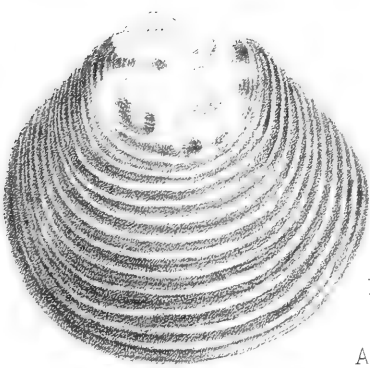

Fig. 10

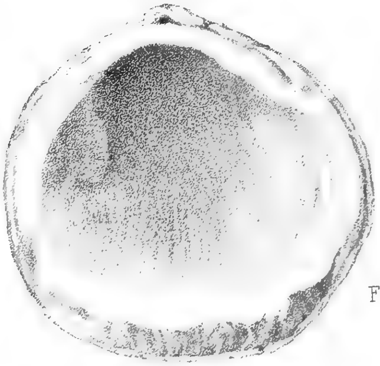

Fig 11

Austriella sordida

S.T. Leigh & Co. lith. Sydney

J.E. Tenison-Woods. del.

characteristics of this shell. In the family of Unionidæ the genus *Spatha*, of Lea, is the only one that comes at all near it. The latter includes rounded thick shells covered with a persistent reddish-brown periostraca and a smooth arcuate hinge margin. Three species of *Spatha* are noted by Messrs. Adams, which are from Senegal and the River Nile. The species I now describe is not nacreous, and the valves are covered with concentric lamellæ.

A. SORDIDA, *Pl., figs.* 10, 11, *n.s. T. sub-orbiculari, tenui, tumida, sordida, periostraca luteo-olivacea, sordida, valde erosa, postice parum angulata; lamellis concentricis inæqualibus conspicuis; intus alba, costis obsoletis, radiantibus munita periostraca late marginata; cardine dente inconspicuo arcuato, ligamento crasso.* Diam. 30 *ad* 5, Mil. Alt., 2-valv., *conjunctis* 15 *ad* 30.

Shell sub-orbicular, thin tumid, sordid, periostraca yellowish olive, much eroded at the umbones, slightly angular posteriorly, with unequal concentric lamellæ, white inside, with radiating obsolete ribs broadly margined at the edge with periostraca, ligament thick, with an inconspicuous arcuate smooth tooth.

This shell is found in the fresh-water or brackish-water swamps about Bowen, at Port Denison. It is largely eaten by the natives, who have left it in heaps in the sand-hills at their former camps close to the sea-shore.

EXPLANATION OF PLATE.

Fig. 1. *Purpura Baileyana*—Front view. 2. Back view, natural size.

Fig. 3. *Gibbula tesserula*—Shell, much enlarged. 4. Base. 5. Spire.

Fig. 6. *Fossarina funiculata*—Spire. 7. Base; both magnified 8 diam.

Fig. 8. *Chiton inornatus*—Natural size. 9. Single valve, enlarged to show the absence of ribs and the dotted ornamentation.

Fig. 10. *Austriella sordida*—Upper surface, natural size. 11. Interior of valve.

ART. XIII.—*On Some New Species of Catenicella and Dictyopora; and on Urceolipora, a New Genus of Polyzoa.*

BY P. H. MACGILLIVRAY, M.A., M.R.C.S.

[Read November 18th, 1880.]

IN the present paper are described two species of Catenicella, two of Dictyopora, and a new genus for which I propose the name of Urceolipora. The new genus resembles Calwellia in its individual cells, but, unlike all the Gemellariidæ, these are not arranged in pairs, but alternately. I do not at present, however, propose a new family for its reception. The two species of Dictyopora, for which, with many other additions to the marine fauna of Victoria, we are indebted to my able and enthusiastic friend, Mr. J. Bracebridge Wilson, will be fully illustrated in Professor M'Coy's *Decades,* as well as the previously known *D. grisea.* I retain Dictyopora provisionally in the Escharidæ, although I think it will be advisable to constitute a new family, Adeonidæ, for the reception of this genus and Adeona proper. In this connection I may mention that in consequence of our rapidly increasing knowledge of the Victorian species and the many new forms, especially in the Escharine group, I have thought it advisable to adhere in the description of the Polyzoa appearing in the *Decades,* as far as possible, to Busk's classification. When the descriptions and illustrations are completed, a systematic arrangement of the families and genera can be more satisfactorily given than could be done at present.

Family, CATENICELLIDÆ.

Genus, CATENICELLA.

C. concinna.

Cells elliptical, or including the wide lateral processes, vase-shaped. Mouth arched above, with a deep rounded sinus in the nearly straight lower lip. A close series of about 12 (5 or 6 on each side) rounded foramina, arranged along the margin of the cell. The lateral processes are very wide, extending the whole length of the cell; they are divided into two portions by a partition extending outwards and downwards from the top of the cell, the upper part triangular, with the point directed upwards and outwards. In the outer edge, immediately below the partition, is a small avicularian cup. Back of cell minutely sulcate.

Port Phillip Heads, Mr. J. B. Wilson.*

C. Wilsoni.

Cells large, squared at both ends. Mouth deeply arched above, the lower lip straight and entire. A space down the centre of the cell, of the same width as the mouth, occupied by a double row of (usually) 7 large, closely set, shallow fenestræ. The sides slope backwards, from the margin of the fenestrate area, leaving on each side a smooth, slightly hollowed space, nearly as wide as the central division, with an avicularian chamber at the upper angle. Back of cell with a prominent central band extending the whole length, and at about a third of the distance from the top, giving off a similar transverse band on each side. Ovicell large, galeate, terminal, thickly fenestrate.

Port Phillip Heads, Mr. J. B. Wilson.

Family, ———————— ?

Genus, URCEOLIPORA.

Polyzoary continuous, dichotomously-branched; cells urceolate, alternate, in a more or less regular double series, the front of the cells being directed outwards. Ovicell galeate, surmounting a cell and united to the base of the cell above.

U. nana.

This species forms small, dichotomously-branched, rigid tufts, about half an inch high, growing on Retepora and other Polyzoa. The cells are alternately arranged in a double row, the fronts facing outwards. They are urceolate, much elongated and narrowed downwards. The mouth is terminal, opening almost horizontally upwards, and at each side is a small projecting process. The ovicell is of moderate size, galeate, surmounting a cell opening and incorporated with the base of the cell above; surface minutely cribriform, or marked with radiating, beaded lines.

Family, ESCHARIDÆ.

Genus, DICTYOPORA.

D. Wilsoni.

Of this species I have only seen one specimen. It consists of a tuft of four separate plates, the stems arising from the

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* This species may prove to be identical with Maplestone's *C. pulchella*, the figure of which it much resembles, but the ornamentation in front of which is described as consisting of round bosses.

same basis. The polyzoary is thin, fan-shaped, somewhat contorted. The plates are about four inches high, and the broadest is about the same width. The separate flexible stems are up to an inch long, and from an eighth to a quarter of an inch wide. To one of the plates there is a secondary plate attached, at an acute angle, and in another there are several plates so arranged as to form two compartments, one very small, the other two inches deep, half an inch wide in one diameter, and one and a-quarter in the other at the orifice. In all, slightly raised ridges extend, dividing from the stem to a variable distance up the plate. The fenestræ are of a considerable size, 1½ to 3 mm. wide, the intervening spaces about 4 mm.

The cells are arranged in oblique lines. They are trapezoid, broad, and more or less rounded above, much attenuated below. The mouth is circular, or nearly so. Below the mouth and about the middle of the cell there is frequently an avicularium, with a small triangular mandible directed obliquely upwards, with a deep pit at its base. In many cells there is only a large round pore, without any mandible. The surface of the cell is somewhat raised on each side of the avicularian pit (frequently more so on one side), and towards the sides of the mouth. It is obscurely pitted. The margin of the foramina is nearly plain, and not divided into distinct, abortive cells or nodules, as in *D. grisea* and *cellulosa*.

The structure of the cells in Kirchenpauer's *Adeona arborescens* seems to resemble that of the present species. They are, however, sufficiently distinguished by the prolongations of the stem in the frond, which, in the former, are very thick and prominent, and extend for a long distance on the polyzoary, while in *D. Wilsoni* they are short and very slightly elevated.

Port Phillip Heads, Mr. J. B. Wilson.

D. albida var *avicularis.*

I have examined two imperfect specimens of a species seemingly identical with *Adeona albida* (Kirchenp.), but having a number of large avicularia round the borders of the fenestræ, which could scarcely have been overlooked by Dr. Kirchenpauer. I propose to name it *D. albida* var *avicularis.* One specimen is four inches by two, the other rather narrower. Both are broken, and want the stem. The polyzoary is twisted and cellular, like that of *D. cellulosa.*

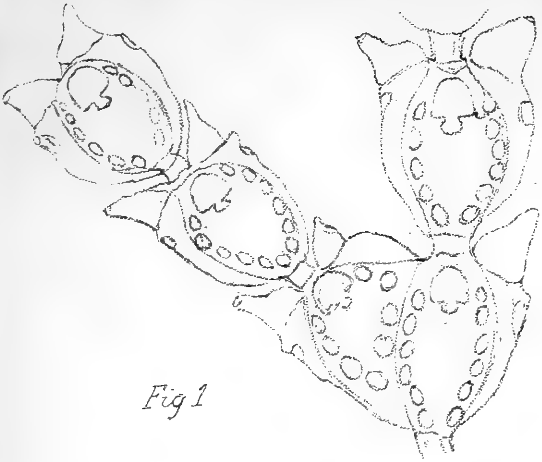
Fig 1

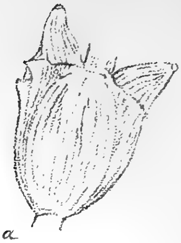
Fig. 1.a

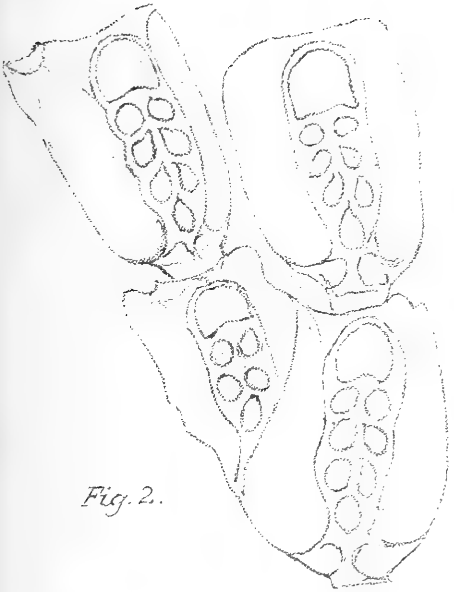
Fig. 2.

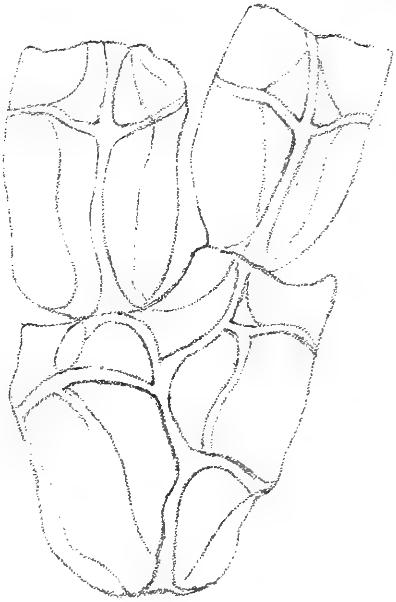
Fig. 2.a


Fig. 3.a


Fig. 2.b


Fig. 3.

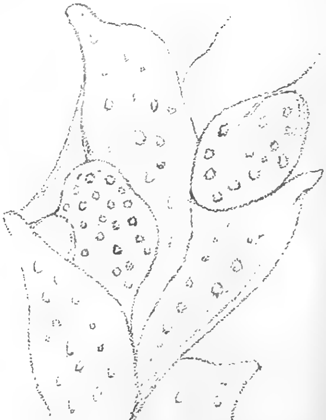
Fig. 3.c

P. H. Mac Gillivray, del.

It is of an ash-grey colour. The fenestræ are small, 1 to 2 mm. in diameter, the intervening spaces 3 to 4 mm. wide.

The cells are expanded and arched above, narrowed below, surface pitted, the pits forming a regular row just inside the margin. Surface raised round the mouth. Mouth nearly circular. A round pore a short distance below, to the side of which is frequently attached a minute triangular avicularium, with the mandible pointed obliquely upwards. The surface immediately round the fenestræ is not divided, but forms a narrow, continuous, punctate rim. Around this rim are usually four or five large avicularia, replacing cells. In these the mandible is very wide at the base, rapidly narrowing to a long, slender point.

Port Phillip Heads, Mr. J. B. Wilson.

The species of this genus now known to occur in Victoria are *D. cellulosa, D. grisea, D. Wilsoni,* and *D. albida* var *avicularis.* They are all readily distinguished from each other. *D. cellulosa* has been figured and described in the *Decades. D. grisea,* of which a beautiful specimen was dredged by Mr. Wilson off Port Phillip Heads, is closely allied to it, but may be distinguished by the polyzoary being simple and fan-shaped, or only slightly proliferous, and by the mandible of the avicularium being shorter, broader, and directed obliquely across the front of the cell, not, as in *D. cellulosa,* extending up the side of the cell to opposite the middle of the mouth. In *D. grisea,* also, there is a wart-like elevation, situated on the side opposite to that to which the avicularium points. *D. cellulosa* and *grisea,* in addition to having much larger avicularia, differ from the other two in the structure of the margin of the fenestræ. In the two former it is divided into prominent nodules, like abortive cells, while in the latter it is thin, and not so divided. When the ectoderm covering the cells is removed by incineration in a spirit lamp, the calcareous pattern is seen to be distinct. It is difficult to describe the differences in words, but, as the appearances will be of value in determining any fossil species, they will be carefully figured in the *Decades.*

Explanation of Plate.

Fig. 1. *Catenicella concinna,* front. Fig. 1a. Back of cell x 60.

Fig. 2. *C. Wilsoni,* front. Fig. 2a. Back view. Fig. 2b. Ovicell x 60.

Fig. 3. *Urceolipora nana* x 25. Fig. 3a. Front view of a cell and ovicell. Fig. 3b. Lateral view of a portion of a branch x 60.

ART. XIV.—*Notes on Professor Bell's Photophone.*

BY W. C. KERNOT, M.A., C.E.

[Read November 18th, 1880.]

ART. XV.—*The Lowan, or Mallee Hen.*

BY MR. ROBERT MORRICE.

[Communicated December 16th, 1880.]

ART. XVI.—*A Sunshine Recorder.*

BY R. L. J. ELLERY, F.R.S., F.R.A.S.

[Read December 16th, 1880.]

Obituary.

REDMOND BARRY, K.C.M.G., M.A., LL.D.,T.C.D.

Sir Redmond Barry was a native of Glanworth, in the county of Cork, Ireland, and was born in 1813. He emigrated to Australia in 1839, immediately after being called to the Irish bar. He went first to Sydney, but did not remain there, and came to Melbourne when Mr. Latrobe was then Superintendent; Victoria being at that time only a province of New South Wales.

In 1842 he was appointed commissioner of the newly-formed Court of Requests, an office he held for several years. In 1850 he became Solicitor-General, and a member of the Legislative and Executive Councils. In 1851 he was appointed a judge of the Supreme Court, a position he continued to hold up to the time of his death. At various periods he acted as Chief Justice, and on two occasions he administered the government of the colony. In 1860 he was knighted, and in 1876 he received the distinction of K.C.M.G.

His name will always be illustrious in the history of Victoria, from his association with the University and the Public Library, of both of which institutions he may be said to have been the founder. He was the Chancellor of the former and chairman of the trustees of the latter. The extraordinary progress of these institutions is, in large measure, due to his strong interest in them; and during the two visits he paid to Europe and America, he never lost an opportunity of making known their claims to attention.

He was the first President of the Victorian Institute, which was commenced in 1854, and which afterwards, uniting with the Philosophical Society, helped to form the Philosophical Institute, now the Royal Society of Victoria. He was, at various periods, a member of the council of this body, and at all times exhibited a sincere regard for its welfare.

In all matters relating to the higher education, and to the fine arts and their influence upon society, Sir Redmond Barry stood foremost in this colony. He was himself a man of advanced literary culture; and to his influence, his example, and his unwearied efforts, much of the social progress of this colony is due.

He died at East Melbourne on the 23rd of November, 1880, aged sixty-seven.

ALEXANDER KENNEDY SMITH, C.E., M.L.A.

Mr. Smith was born in Cauldmill, Roxburghshire, Scotland, in 1824, and was trained as an engineer. He was actively employed in his profession, both in Scotland and England, up to the time of his leaving for this colony in 1854, whither he came with the appointment of engineer to the Melbourne Gas Company, then only recently formed. His first occupation in Victoria, therefore, was to superintend the building of the works of that Company. Shortly after his arrival, he competed successfully for the prize offered by the City Council for the best plan for disposing of the refuse of the city. In the same year he joined earnestly in the volunteer movement, and maintained his connection with the volunteer force up to the time of his decease. He was a Fellow of the Royal Scottish Society of Arts, and he joined the Philosophical Institute of Victoria soon after its formation.

After ceasing his connection with the Melbourne Gas Company, he was extensively and actively engaged in the construction of many other public works throughout both this and the neighbouring colonies. He was sixteen years a member of the Melbourne City Council, and he filled the office of mayor in 1875-6. From 1877 to his death he represented East Melbourne in the Legislative Assembly. Mr. Smith took a consistent interest in all sanitary questions, and all matters generally relating thereto, and he contributed to this society, and to the periodicals of this colony, many papers of high practical value, both on this and on other subjects connected with his profession. He occupied an official position in the Royal Society for many years, having been variously its treasurer, vice-president, and member of council, from the year 1859.

He died at his residence, Studley Park, on the 16th of January, aged fifty-six.

HENRY SAMUEL PATCHING.

Mr. Patching was the son of Captain H. Patching, the highly respected master of a well-known steamer trading between Australian ports. He was born at Launceston, Tasmania, in October, 1854, but came to this colony at an early age, and was educated at St. Paul's School, in this city. His scientific leanings showed themselves when a boy, and he took up ardently the subject of chemistry, to which he applied himself with much enthusiasm, and eventually adopted as his occupation that of a manufacturing chemist. His connection with the Royal Society brought him into much congenial companionship, and when, two years ago, it was desired to revive Section A, this reorganisation of the departmental proceedings of the Society evoked from him such a marked expression of interest that he was appointed honorary secretary. The earnest manner in which he subsequently performed the duties of this office made it certain that if he had lived, he would have done much to aid in developing the usefulness of this section.

He died at Emerald Hill on the 7th February, 1881, aged twenty-six.

MR. THOMAS HIGINBOTHAM, M.I.C.E.

Mr. Higinbotham was a native of Dublin. He learned the rudiments of his profession in the Royal Dublin Society House, and, about the year 1838-39, he went to London and entered the office of Sir William Cubitt. In 1853 his brother, now Mr. Justice Higinbotham, came out to this colony, and he followed him in 1857.

In January, 1858, he was appointed by Captain Clarke, C.E., Inspector-General of Roads for the colony.

All our lines of railways from 1860 to 1878 were made under Mr. Higinbotham's supervision, the value of whose ability became more and more apparent as time rolled away. Under his *régime* the cost of constructing railways was reduced to less than £5000 per mile. He played a part in the inquiry with regard to the efficiency of the Malmsbury Reservoir, and it will be remembered that this terminated in the dismissal of the other engineers employed.

He always opposed any effort to alter the gauge of our railways. He carried his point, and afterwards he received the thanks of all persons concerned. In 1874 he left the colony to inspect the British, Continental, and American railways, and on returning, after two years, he presented a valuable report on the construction of cheap lines. On the 8th of February he was dismissed, with other victims of Black Wednesday. He was, however, restored to his position of Engineer-in-Chief on the occasion of the Service

Ministry coming into power. His re-instatement gave great satisfaction, which it was believed no future government would attempt to disturb. His death was sudden, and he expired in the night, at the age of 60 years, at the residence of his brother, Mr. Justice Higinbotham, at Brighton, 5th September, 1880. He was much esteemed by his friends, and was conspicuous for his invincible good temper and courtesy.

Mr. Higinbotham was a member of the Society for many years, and always showed a large interest in its welfare.

1880.

PROCEEDINGS

ROYAL SOCIETY OF VICTORIA.

ANNUAL MEETING.

March 10th, 1881.

THE President in the chair, 18 members and associates present.

The Annual Report and Balance-sheet for 1880 were read and adopted, as follow :—

"*Report of the Council of the Royal Society of Victoria, for the Year 1880.*

"Your Council has the honour to submit the following report for the year 1880.

"During the past session nine ordinary meetings were held, at which the following papers were read :—

"On the 15th April Dr. MacGillivray read a paper on 'Two New Genera of Polyzoa,' and Mr. Norman Taylor read a paper by the Rev. J. E. Tenison-Woods, F.G.S., on 'The Hodgkinson Goldfield, Northern Queensland.'

"On the 13th May Mr. W. C. Kernot, M.A., read a paper on 'The Best Form for a Balance Beam,' and Mr. Blackett read a paper by Mr. Birkmire on his 'Process for Purifying the Yan Yean Water.'

"On the 10th June Mr. Birkmire's 'Process for Purifying the Yan Yean' was discussed, the discussion occupying the whole evening.

"On the 8th July Mr. Kernot, M.A., read a paper on 'The Tay Bridge,' and Professor Nanson, M.A., read a paper on 'Proportional Representation.'

"On the 10th August a discussion took place on the papers read at the previous meeting by Mr. Kernot on 'The Tay Bridge,' and by Professor Nanson on 'Proportional Representation ;' Mr. Lilly read 'Notes on Some Curious Effects of Lightning at Gabo Island.'

"On the 9th September Mr. Joseph read a paper on 'Recent Improvements in Electric Lighting ;' Mr. Ellery, F.R.S., exhibited an Ombrograph, and read a paper descriptive of the instrument; a paper by Dr. Stirton, F.L.S., on 'Additions to the Lichen Flora of Queensland,' was contributed to the Society by the Rev. J. E. Tenison-Woods.

"On the 21st October Mr. T. Harrison described the various forms of Automatic Railway Brakes now in use; the President read a paper by Mr. E. L. Marks on 'A New and Economic Method for the Scientific Production of some Acids;' the Hon. Secretary read a paper by the Rev. J. E. Tenison-Woods, F.G.S., on 'New Marine Mollusca.' Mr. Sutherland, M.A., read some notes on the Bôrô Boudour of the Island of Java, described in a publication recently presented to the Society by the Government of the Netherlands.

"On the 18th November Dr. MacGillivray read a paper on 'Some New Species of Catenicella and Dictyopora,' and on 'Urceleopora: a New Species of Polyzoa;' and Mr. Kernot, M.A., read 'Notes on Professor Bell's Photophone.'

"On the 16th December Mr. Ellery, F.R.S., read a paper by Mr. Robert Morrice on 'The Lowan, or Mallee Hen.' Mr. Ellery also exhibited a 'Sunshine Recorder,' and explained the method by which the duration of sunshine is recorded by that instrument.

"Volume XVI. of the transactions of the Society was issued on the 30th April, and forwarded to the members and to the societies entitled to receive it. Vol. XVII. is now in the press, and will be ready for delivery in the course of next month.

"During the past year 15 members, 2 corresponding members, and 14 associates have been elected.

"Since the last annual meeting the number of books in the library has been increased by the addition of 78 volumes and 269 parts, presented principally by learned societies in various parts of the world—viz., from Europe, 31 volumes and 119 parts, of which 29 are British; from Asia, 2 volumes and 11 parts; and from America, 20 volumes and 91 parts; the remainder having been received from New Zealand and the several colonies of Australia.

"Sections A and B C and D have held meetings during the session, reports of which will be duly read at the annual meeting.

"In compliance with request from the Commissioners of the Exhibition, the use of the Society's rooms has been placed at their service for holding meetings of the juries.

"In the Estimates for the year 1881 your Council was surprised to note the omission of the customary annual Government grant of £200; but on bringing it under the notice of the Hon. the Chief Secretary, and making representations of the circumstances under which it was originally made, he courteously agreed to place the amount upon the Additional Estimates for 1881.

"During the year your Council was glad to avail itself of a favourable opportunity for cementing the exterior of the building, which for a long time had presented an unfinished and somewhat unsightly appearance.

"Your Council has with regret to record the loss of four of its members—viz., Mr. Thomas Higinbotham, M.I.C.E., Sir Redmond Barry, M.A., Mr. A. K. Smith, M.L.A., and Mr. H. S. Patching."

BALANCE-SHEET.

The Hon. Treasurer in Account with the Royal Society of Victoria.

Dr.

To Balance from last Balance-Sheet				£345	11	0
" Interest on Fixed Deposit				5	0	0
" Rents Received				43	7	10
" Sale of Transactions				0	5	0
" One Life Member				21	0	0
" Fourteen Entrance Fees				29	8	0
" Subscriptions—						
62 Members	£130	4	0			
3 do. (Half-years) ...	3	3	0			
12 do. (Country)	12	12	0			
24 Associates	25	4	0			
1 do. (Half-year) ...	0	10	6			
Arrears	25	4	0			
Exchange	0	2	0			
				196	19	6
				£641	11	4
" Balance due to Bank				26	13	11
				£668	5	3

Cr.

By Printing and Stationery	£81	13	6
" On Account of Alterations to Hall...	334	8	1
" Pavement Victoria and Latrobe Streets	49	7	8
" Books	2	2	0
" Freight and Charges of Books and "Transactions"	3	6	0
" Conversazione and Teas	22	6	4
" Rates	4	13	4
" Gas and Fuel	5	9	8
" Furniture	77	8	11
" Repairs	6	8	5
" Clerical Assistant	26	0	0
" Hall-keeper	6	0	0
" Collector	19	18	0
" Postage	21	9	9
" Petty Cash	6	10	3
" Sundries	1	3	4
	£668	5	3

Compared with the Vouchers, Bank Pass-book, and Cash Book, and found correct.

2nd March, 1881.

HENRY MOORS
JAMES E. GILBERT } AUDITORS.

P. DE JERSEY GRUT, HON. TREASURER.

STATEMENT OF LIABILITIES AND ASSETS.

Dr. LIABILITIES.	£	s.	d.	ASSETS. Cr.	£	s.	d.
To Publishing Fund	£216	11	2	By Estimated Value of Outstanding Subscriptions ...	£20	0	0
,, Three Debentures outstanding	15	0	0	,, do. do. Rents due	20	0	0
,, Interest unclaimed	12	12	0	,, Hall, Library, Furniture	3000	0	0
,, Due to Contractor for Plastering	178	15	0				
,, Due to Bank	26	13	11				
	£449	12	1				
,, Balance	2590	7	11				
	£3040	0	0		£3040	0	0

PUBLISHING FUND.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance	£216	11	2	By Royal Society of Victoria	£216	11	2

Ordinary Meetings.

11*th March*, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 16 members and associates.

Mr. J. S. Jenkins, Mr. J. B. Wilson, M.A., and Mr. B. Loughrey were elected members of the Society.

Mr. F. A. Dunn and Mr. J. J. Fenton were elected associates of the Society.

(Signed) Robt. L. J. Ellery.

15*th April*, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 27 members and associates.

Mr. W. Graham, Field, C.E., Mr. H. B. De La Poer, Wall, M.A., and Mr. W. Davidson were elected as members, and Mr. B. Baker and Mr. E. W. Parry were elected associates of the Society.

Dr. MacGillivray read a paper on "Two new Genera of Polyzoa," and exhibited specimens under the microscope.

Mr. Norman Taylor read a paper by Rev. J. E. Tenison-Woods, F.G.S., on "The Hodgkinson Goldfield, Northern Queensland."

(Signed) Robt. L. J. Ellery.

13*th May*, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 25 members and associates.

Mr. David Whitley was elected a member of the Society. Mr. John Young and Mr. Herbert Quarry were elected as associates of the Society.

Mr. Kernot, M.A., read a paper on "The best Form for a Balance Beam."

Mr. Blackett read a paper on the "Purification of the Yan Yean Water, by a process invented by Mr. Birkmire." A discussion took place, in which Mr. Foord, Dr. Gillbee, Mr. Newbery, Mr. White, and Dr. Jamieson took part.

(Signed) Robt. L. J. Ellery.

10*th June*, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 36 members and associates.

Mr. Frederic Dunn was elected as a member, and Mr. W. J.

Brownscombe, Mr. C. F. Bailey, and Mr. A. Millington Atkin, were elected associates of the Society.

The discussion of Mr. Birkmire's process for purifying the Yan Yean was resumed by Mr. Blackett, the following gentlemen also taking part in the discussion—viz., Dr. Gillbee, Mr. Kernot, Mr. Newbery, Mr. Hopwood, Mr. Ellery, Dr. Jamieson, Mr. Patching, Mr. Clarke, and Mr. White, which closed the discussion on the subject.

(Signed) Robt. L. J. Ellery.

8th July, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 35 members and associates.

Mr. W. Emerson M'Ivor was elected a member, and Mr. H. W. Taylor was elected as an associate of the Society.

Mr. H. Moors was elected to fill the vacancy in the Council caused by the resignation of Mr. G. Foord, F.C.S.

Mr. W. C. Kernot, M.A., read a paper on "The Tay Bridge."

Professor Nanson, M.A., read a paper on "Proportional Representation."

(Signed) Robt. L. J. Ellery.

10th August, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 34 members and associates.

Mr. Harry B. Gibbs and Mr. C. E. Wallen were elected associates.

Discussion took place on the papers previously read by Mr. Kernot, M.A., and Professor Nanson, M.A.

Mr. Lilly read "Notes on some curious Effects of Lightning at Gabo Island."

(Signed) Robt. L. J. Ellery.

9th September, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 22 members and associates.

Dr. Robert Talbot was elected a member, and Mr. F. M. Bailey, of Brisbane, and Dr. James Stirton, F.L.S., of Glasgow, were elected corresponding members.

Mr. Joseph read a paper on "Recent Improvements in Electric Lighting."

Mr. Ellery, F.R.S., read a paper on the "Ombrograph," and exhibited the instrument.

Rev. J. E. Tenison-Woods contributed a paper by Dr. Stirton, F.L.S., on "Additions to the Lichen Flora of Queensland."

(Signed) Robt. L. J. Ellery.

21st October, 1880.

R. L. J. Ellery, F.R.S., Esq., President, in the Chair—Present, 16 members and associates.

Mr. A. C. Macdonald was elected a member of the Society, and Mr. John Clark Jones and Mr. C. F. Crouch were elected associates.

Mr. Thomas Harrison read a paper describing the various forms of automatic railway brakes that are now in use. A discussion followed, in which Mr. Kernot, Mr. Ellery, Mr. Blackett, Mr. Halley, and Mr. Goldstein took part.

Mr. Ellery, F.R.S., read a paper by Mr. E. L. Marks on a "New and Economic Method for the Scientific Production of some Acids."

A paper by the Rev. J. E. Tenison-Woods, F.G.S., was read on "New Marine Mollusca."

Mr. Sutherland, M.A., read a paper giving a short account of the Bôrô Boudour in the Island of Java; a valuable work on the subject having recently been presented to the Society by the Government of the Netherlands.

(Signed) Robt. L. J. Ellery.

18th November, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 22 members and associates.

Mr. Gustav Beckx and Mr. E. L. Marks were elected as members of the Society.

Dr. MacGillivray read a paper on "Some New Species of Catenicella and Dictyopora; and Urceolipora, a New Species of Polyzoa."

A discussion ensued, in which Mr. Kernot, Mr. J. B. Wilson, Mr. Goldstein, and other members took part.

Mr. Kernot, M.A., read a paper, "Notes on Professor Bell's Photophone."

A discussion followed, in which several members took part; and Mr. W. L. Carpenter gave a brief history of the steps by which Professor Bell arrived at the discovery of the telephone.

(Signed) Robt. L. J. Ellery.

16th December, 1880.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 20 members and associates.

The Hon. John Woods, M.L.A., and Mr. S. Jermyn Masters were elected members of the Society.

Mr. Ellery, F.R.S., read a paper by Mr. Robert Morrice on "The Lowan, or Mallee Hen."

Mr. Ellery also exhibited a "Sunshine Recorder," and explained the method by which the instrument records the duration of sunshine.

REPORT OF SECTION A.

Gentlemen,

I have the honour to present the usual Annual Report of Proceedings of Section A of the Royal Society of Victoria.

During the year 1880 nine meetings of the Section were held, the dates and subjects discussed being as follow :—

January 28th.—"Factors of Safety," introduced by Mr. Kernot. "Edison's loud-speaking Telephone," by Mr. Kirkland.

February 25th.—General discussion on the subject of conveying motive power to a distance by compressed air, electricity, and other means. A Tisby's compound pendulum was exhibited in action by Mr. Chambers.

March 31st.—Adjourned discussion on "Factors of Safety." Mr. Kernot submitted to the Section certain calculations as to the strength of the Tay Bridge.

April 28th.—Mr. T. W. Fowler introduced the subject of "Continuous Girders," and Mr. Kernot offered some suggestions as to re-building the Tay Bridge.

May 26.—Adjourned discussion on "Continuous Girders." Mr. Kernot exhibited portion of a steam boiler showing a peculiar case of corrosion.

June 80th.—Professor Nanson submitted a paper on "Methods of Electing Representatives," and advocated a modification of Hare's system.

July 28th.—Meeting lapsed, there being no quorum.

August 25th.—Mr. Kernot read notes on the dynamical condition of railway trains, and Mr. Patching exhibited some experiments on the behaviour of fluids at high pressures and temperatures.

September 29th.—Mr. Kernot submitted the results of some experiments to determine the efficiency of a small turbine known as Bailey's Thirlmere Motor.

October 27th.—Mr. Ellery read notes on "Anemometers," and directed the attention of the Section to the desirability of devising improved appliances for determining the velocity and pressure of the wind.

Mr. Patching then read notes on methods of determining the viscosity of liquids, and exhibited a viscosimeter of his own construction.

Though the attendance at the meetings has been but small, I am happy to say that the debates have been well maintained, and considerable interest shown by the members in the questions submitted.

It is with feelings of deep regret that I have to inform the Council of the death of Mr. Henry S. Patching, who has filled the office of Secretary to the Section since its reorganisation in July, 1879. In him the Section loses a most assiduous officer, and the Society a laborious and enthusiastic member.

I have the honour to be,
Your obedient servant,
W. C. KERNOT, M.A.,
Chairman of Section A.

Royal Society's Hall, 2nd March, 1881.

REPORT ON SECTION B C D.

Early in the year 1880 it was decided to form Sections B C D, as provided by the Rules of the Royal Society. Nineteen names were received, but owing to the limited number of members for each Section, and as the work of each Section was closely allied, it was considered advisable to amalgamate them, and hold the meetings as for one section.

Mr. Goldstein was appointed by the Council to act as Secretary, and he summoned a meeting for the 21st of April, 1880, at which the following members were present:—Messrs. Blackett, Duerdin, Goldstein, Challen, Fenton, Fowler, and Patching.

Mr. C. R. Blackett was appointed to act as chairman, and Mr. Patching as secretary of Section B C D.

The next meeting of the Section was held 26th April, 1880, at which Mr. Blackett read a paper on Mr. Birkmire's method of water purification. Mr. Blackett illustrated his paper with experiments. An interesting discussion followed, in which Mr. Patching, Mr. Goldstein, and others had part.

The next meeting of the Section took place 21st May, 1880, at which Mr. C. R. Blackett submitted some analysis of the Yan Yean water, and the residues thrown down by tersulphate of alumina, which were subsequently brought before the Society's ordinary meeting, and gave rise to a long and useful debate.

Mr. Ellery described a process for reproducing impressions on glass by means of some metallic sulphides.

Meetings were called for June, July, and September, but lapsed for want of a quorum.

The death of the estimable Secretary (Mr. Patching) has for the present suspended the business of the Section.

C. R. BLACKETT, *Chairman.*

LAWS.

I. The Society shall be called "The Royal Society of Victoria." Name.

II. The Royal Society of Victoria is founded for the advancement of science, literature, and art, with especial reference to the development of the resources of the country. Objects.

III. The Royal Society of Victoria shall consist of Members and Honorary Members, Corresponding Members, and Associates, all of whom shall be elected by ballot. Members and Honorary Members.

IV. His Excellency the Governor of Victoria, for the time being, shall be requested to be the Patron of the Society. Patron.

V. There shall be a President, and two Vice-Presidents, who, with twelve other Members, and the following Honorary Officers, viz., Treasurer, Librarian, and two Secretaries of the Society, shall constitute the Council. Officers.

VI. The Council shall have the management of the affairs of the Society. Management.

VII. The Ordinary Meetings of the Society shall be held once in every month during the Session, from March to December inclusive, on days fixed by and subject to alteration by the Council with due notice. Ordinary Meetings.

VIII. In the second week in March there shall be a General Meeting, to receive the report of the Council and elect the Officers of the Society for the ensuing year. Annual General Meetings.

IX. All Office-bearers and Members of Council, except the six junior or last elected ordinary Members, shall retire from office annually at the General Meeting in March. The names of such Retiring Officers are to be announced at the Ordinary Meetings in November and December. The Officers and Members of Council so retiring shall be eligible for the same or any other office then vacant. Retirement of Officers.

Election of Officers.

X. The President, Vice-Presidents, Treasurer, Secretaries, and Librarian shall be separately elected by ballot (should such be demanded), in the above-named order, and the six vacancies in the Council shall then be filled up together by ballot at the General Meeting in March. Those members only shall be eligible for any office who have been proposed and seconded at the Ordinary Meeting in December, or by letter addressed to one of the Secretaries, and received by him before the 1st March, to be laid before the Council Meeting next before the Annual Meeting in March. The nomination to any one office shall be held a nomination to any office the election to which is to be subsequently held. No ballot shall take place at any meeting unless ten members be present.

Members in arrear.

XI. No Member whose subscription is in arrear shall take part in the election of Officers or other business of the meeting.

Inaugural address by the President.

XII. An Address shall be delivered by the President of the Society at either a Dinner, Conversazione, or extra meeting of the Society, as the Council for the time being may determine, not later than the Ordinary Meeting in June in each year.

Vacancies.

XIII. If any vacancy occur among the Officers, notice thereof shall be inserted in the summons for the next meeting of the Society, and the vacancy shall be then filled up by ballot.

Duties of President.

XIV. The President shall take the chair at all meetings of the Society and of the Council, and shall regulate and keep order in all their proceedings; he shall state questions and propositions to the meeting, and report the result of ballots, and carry into effect the regulations of the Society. In the absence of the President the chair shall be taken by one of the Vice-Presidents, Treasurer, or ordinary Member of Council, in order of seniority.

Duties of Treasurer.

XV. The Treasurer may, immediately after his election, appoint a Collector (to act during pleasure), subject to the approval of the Council at its next meeting. The duty of the Collector shall be to issue the Treasurer's notices and collect subscriptions. The

Treasurer shall receive all moneys paid to the Society, and shall deposit the same before the end of each month in the bank approved by the Council, to the credit of an account opened in the name of the Royal Society of Victoria. The Treasurer shall make all payments ordered by the Council on receiving a written authority from the chairman of the meeting. All cheques shall be signed by himself, and countersigned by one of the Secretaries. No payments shall be made except by cheque, and on the authority of the Council. He shall keep a detailed account of all receipts and expenditure, present a report of the same at each Council Meeting, and prepare a balance-sheet to be laid before the Council, and included in its Annual Report. He shall also produce his books whenever called on by the Council.

Duties of Secretaries.

XVI. The Secretaries shall share their duties as they may find most convenient. One or other of them shall conduct the correspondence of the Society and of the Council, attend all meetings of the Society and of the Council, take minutes of their proceedings, and enter them in the proper books. He shall inscribe the names and addresses of all Members in a book to be kept for that purpose, from which no name shall be erased except by order of the Council. He shall issue notices of all meetings of the Society and of the Council, and shall have the custody of all papers of the Society, and, under the direction of the Council, superintend the printing of the Transactions of the Society.

Meetings of Council.

Quorum.

XVII. The Council shall meet on any day within one week before every Ordinary Meeting of the Society. Notice of such meeting shall be sent to every Member at least two days previously. No business shall be transacted at any meeting of the Council unless five Members be present. Any Member of Council absenting himself from three consecutive meetings of Council, without satisfactory explanation in writing, shall be considered to have vacated his office, and the election of a Member to fill his place shall be proceeded with at the next Ordinary Meeting of Members, in accordance with Law XIII.

Special Meetings of Council.

XVIII. One of the Secretaries shall call a Special Meeting of Council on the authority of the President or of three Members of the Council. The notice of such meeting shall specify the object for which it is called, and no other business shall be entertained.

Special General Meetings.

XIX. The Council shall call a Special Meeting of the Society, on receiving a requisition in writing signed by twenty-four Members of the Society specifying the purpose for which the meeting is required, or upon a resolution of its own. No other business shall be entertained at such meeting. Notice of such meeting, and the purpose for which it is summoned, shall be sent to every Member at least ten days before the meeting.

Annual Report.

XX. The Council shall annually prepare a Report of the Proceedings of the Society during the past year, embodying the balance-sheet, duly audited by two Auditors, to be appointed for the year, at the Ordinary Meeting in December, exhibiting a statement of the present position of the Society. This Report shall be laid before the Society at the Annual Meeting in March. No paper shall be read at that meeting.

Expulsion of Members.

XXI. If it shall come to the knowledge of the Council that the conduct of an Officer or a Member is injurious to the interest of the Society, and if two-thirds of the Council present shall be satisfied, after opportunity of defence has been afforded to him, that such is the case, it may call upon him to resign, and shall have the power to expel him from the Society, or remove him from any office therein at its discretion. In every case all proceedings shall be entered upon the minutes.

Election of Members and Associates.

XXII. Every candidate for election as Member or as Associate shall be proposed and seconded by Members of the Society. The name, the address, and the occupation of every candidate, with the names of his proposer and of his seconder, shall be communicated in writing to one of the Secretaries, and shall be read at a meeting of Council, and also at the following meeting of the Society, and the ballot shall take place at the next following ordinary meeting of the Society.

The assent of at least five-sixths of the number voting shall be requisite for the admission of a candidate.

Members shall sign Laws.

XXIII. Every new Member or Associate shall receive due notice of his election, and be supplied with a copy of the obligation,* together with a copy of the Laws of the Society. He shall not be entitled to enjoy any privilege of the Society, nor shall his name be printed in the List of Members, until he shall have paid his admission fee and first annual subscription, and have returned to the Secretaries the obligation signed by himself. He shall at the first meeting of the Society at which he is present sign a duplicate of the obligation in the Statute Book of the Society, after which he shall be introduced to the Society by the Chairman. No Member or Associate shall be at liberty to withdraw from the Society without previously giving notice in writing to one of the Secretaries of his intention to withdraw, and returning all books or other property of the Society in his possession. Members and Associates will be considered liable for the payment of all subscriptions due from them up to the date at which they give written notice of their intention to withdraw from the Society.

Conditions of Resignation.

Honorary Members.

XXIV. Gentlemen not resident in Victoria, who are distinguished for their attainments in science, literature, or art, may be proposed for election as Honorary Members, on the recommendation of an absolute majority of the Council. The election shall be conducted in the same manner as that of ordinary Members, but nine-tenths of the votes must be in favour of the candidate.

Subscriptions.

XXV. Members of the Society, resident in Melbourne, or within ten miles thereof, shall pay two guineas annually, Members residing beyond that dis-

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* The obligation referred to is as follows :—

Royal Society of Victoria.

I, the undersigned, do hereby engage that I will endeavour to promote the interests and welfare of the Royal Society of Victoria, and to observe its laws, as long as I shall remain a Member or Associate thereof.

(Signed)

Address

Date

tance and Associates shall pay one guinea annually. The subscriptions shall be due on the 1st of January in every year. At the commencement of each year there shall be hung up in the Hall of the Society a list of Members and Associates, upon which the payments of their subscriptions as made by Members and Associates shall be entered. During July notice shall be sent to Members and Associates still in arrears. At the end of each year a list of those who have not paid their subscriptions shall be prepared, to be considered and dealt with by the Council.

Entrance fees, &c.

XXVI. Newly-elected Members shall pay an entrance fee of two guineas, in addition to the subscription for the current year. Newly-elected Associates shall not be required to pay any entrance fee. Those elected after the 1st of July shall pay only half of the subscription for the current year. If the entrance fee and subscription be not paid within one month of the notification of election, a second notice shall be sent, and if payment be not made within one month from the second notice, the election shall be void. Members, resident in Melbourne, or within ten miles thereof, may compound for all Annual Subscriptions of the current and future years by paying £21; and Members residing beyond that distance may compound in like manner by paying £10 10s. Associates on seeking election as Members shall have to comply with all the forms requisite for the election of Members, and shall pay an entrance fee of two guineas.

Life Membership.

Durations of Meetings.

XXVII. At the ordinary meetings of the Society the chair shall be taken punctually at eight o'clock, and no new business shall be taken after ten o'clock.

Order and mode of conducting the business.

XXVIII. At the Ordinary Meetings business shall be transacted in the following order, unless it be specially decided otherwise by the Chairman:—

Minutes of the preceding meeting to be read, amended if incorrect, and confirmed.
New Members to enroll their names, and be introduced.
Ballot for the election of new Members.
Vacancies among officers, if any, to be filled up.
Business arising out of the minutes.
Communications from the Council.

Presents to be laid on the table, and acknowledged.
Motions, of which notice has been given, to be considered.
Notices of motion for the next meeting to be given in and read by one of the Secretaries.
Papers to be read.

XXIX. No stranger shall speak at a meeting of the Society unless specially invited to do so by the Chairman. Strangers.

XXX. At no meeting shall a paper be read, or business entertained, which has not been previously notified to the Council. What business may be transacted.

XXXI. The Council may call additional meetings whenever it may be deemed necessary. Additional Meetings.

XXXII. Every Member may introduce two visitors to the meetings of the Society by orders signed by himself. Visitors.

XXXIII. Members and Associates shall have the privilege of reading before the Society accounts of experiments, observations, and researches conducted by themselves, or original papers, on subjects within the scope of the Society, or descriptions of recent discoveries, or inventions of general scientific interest. No vote of thanks to any Member or Associate for his paper shall be proposed. Members may read papers.

XXXIV. If a Member or Associate be unable to attend for the purpose of reading his paper, he may delegate to any Member of the Society the reading thereof, and his right of reply. Or depute other Members.

XXXV. Any Member or Associate desirous of reading a paper shall give in writing to one of the Secretaries, ten days before the meeting at which he desires it to be read, its title and the time its reading will occupy. Members must give notice of their papers.

XXXVI. The Council may permit a paper such as described in Law XXXIII., not written by a Member of the Society, to be read, if for any special reason it shall be deemed desirable. Papers by strangers.

XXXVII. Every paper read before the Society shall be the property thereof, and immediately after it has Papers belong to the Society.

been read shall be delivered to one of the Secretaries, and shall remain in his custody.

Papers must be original.

XXXVIII. No paper shall be read before the Society or published in the Transactions unless approved by the Council, and unless it consist mainly of original matter as regards the facts or the theories enunciated.

Council may refer papers to Members.

XXXIX. Should the Council feel a difficulty in deciding on the publication of a paper, the Council may refer it to any Member or Members of the Society, who shall report upon it.

Rejected papers to be returned.

XL. Should the Council decide not to publish a paper, it shall be at once returned to the author.

Members may have copies of their papers.

XLI. The author of any paper which the Council has decided to publish in the Transactions may have any number of copies of his paper on giving notice of his wish in writing to one of the Secretaries, and on paying the extra cost of such copies.

Members to have copies of Transactions.

XLII. Every Member and Associate whose subscription is not in arrear, and every Honorary Member, is entitled to receive one copy of the Transactions of the Society as published. Newly-elected Members shall, on payment of their entrance-fee and subscription, receive a copy of the volume of the Transactions last published.

Property.

XLIII. Every book, pamphlet, model, plan, drawing, specimen, preparation, or collection presented to or purchased by the Society, shall be kept in the house of the Society.

Library.

XLIV. The Library shall be open to Members and Associates of the Society and the public at such times and under such regulations as the Council may deem fit.

Legal ownership of property.

XLV. The legal ownership of the property of the Society is vested in the President, the Vice-Presidents, and the Treasurer for the time being, in trust for the use of the Society; but the Council shall have full control over the expenditure of the funds and management of the property of the Society.

Committees elect Chairman.

XLVI. Every Committee appointed by the Society shall at its first meeting elect a Chairman, who shall subsequently convene the Committee and bring up its report. He shall also obtain from the Treasurer such grants as may have been voted for the purposes of the Committee.

XLVII. All Committees and individuals to whom any work has been assigned by the Society shall present to the Council, not later than the 1st November in each year, a report of the progress which has been made; and, in cases where grants of money for scientific purposes have been entrusted to them, a statement of the sums which have been expended, and the balance of each grant which remains unexpended. Every Committee shall cease to exist on the 1st November, unless re-appointed. Report before November 1st.

XLVIII. Grants of pecuniary aid for scientific purposes from the funds of the Society shall expire on the 1st November next following, unless it shall appear by a report that the recommendations on which they were granted have been acted on, or a continuation of them be ordered by the Council. Grants expire.

XLIX. In grants of money to Committees and individuals, the Society shall not pay any personal expenses which may be incurred by the Members. Personal expenses not to be paid.

L. No new law, or alteration or repeal of an existing law, shall be made except at the General Meeting in March, or at a Special General Meeting summoned for the purpose, as provided in Law XIX., and in pursuance of notice given at the preceding Ordinary Meeting of the Society. Alteration of laws.

LI. Should any circumstance arise not provided for in these laws, the Council is empowered to act as may seem to be best for the interests of the Society. Cases not provided for.

LII. In order that the Members and Associates of the Society prosecuting particular departments of science may have opportunities of meeting and working together with fewer formal restraints than are necessary at the Ordinary Meetings of the Society, Sections may be established. Sections.

LIII. Sections may be established for the following departments, viz.:— Names and number of Sections.

Section A. Physical, Astronomical, and Mechanical Science, including Engineering.

Section B. Chemistry, Mineralogy, and Metallurgy.
Section C. Natural History and Geology.
Section D. The Microscope and its applications.
Section E. Geography and Ethnology.
Section F. Social Science and Statistics.
Section G. Literature and the Fine Arts, including Architecture.
Section H. Medical Science, including Physiology and Pathology.

Meetings of Sections.

LIV. The meetings of the Sections shall be for scientific objects only.

Members of Sections.

LV. There shall be no membership of the Sections as distinguished from the membership of the Society.

Officers of Sections.

LVI. There shall be for each Section a Chairman to preside at the meetings, and Secretary to keep minutes of the proceedings, who shall jointly prepare and forward to one of the Secretaries of the Society, prior to the 1st of November in each year, a report of the Proceedings of the Section during that year, and such report shall be submitted to the Council.

Mode of appointment of Officers of Section.

LVII. The Chairman and the Secretary of each Section shall be appointed at the first meeting of the Council after its election in March, in the first instance from Members of the Society who shall have signified to one of the Secretaries of the Society their willingness to undertake these offices, and subsequently from such as are recommended by the Section as fit and willing.

Times of meetings of Sections.

LVIII. The first meeting of each Section in the year shall be fixed by the Council; subsequently the Section shall arrange its own days and hours of meeting, provided these be at fixed intervals.

Corresponding Members.

LIX. The Council shall have power to propose gentlemen not resident in Victoria, for election in the same manner as ordinary Members, as Corresponding Members of the Society. The Corresponding Members shall contribute to the Society papers which may be received as those of ordinary Members, and shall in return be entitled to receive copies of the Society's publications.

LX. Associates shall have the privileges of Members in respect to the Society's publications, in joining the Sections, and at the Ordinary Meetings, with the exception that they shall not have the power of voting; they shall also not be eligible as Officers of the Society. Privileges of Associates.

MEMBERS

OF

The Royal Society of Victoria.

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Allan, Alexander C., Esq., Yorick Club
Anderson, Major J. A., Melbourne Club
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Dunn, Frederick, Esq., Technological Museum

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Mason, Firth & M'Cutcheon, Printers, 51 & 53 Flinders Lane West, Melbourne.

Royal Society of Victoria.

TRANSACTIONS

AND

PROCEEDINGS

OF THE

Royal Society of Victoria.

VOL. XVIII.

Edited under the Authority of the Council of the Society.

ISSUED 1st JUNE, 1882.

MELBOURNE:
MASON, FIRTH & M'CUTCHEON, PRINTERS,
FLINDERS LANE WEST.

AGENTS TO THE SOCIETY.
WILLIAMS & NORGATE, 14 HENRIETTA STREET, COVENT GARDEN, LONDON
To whom all communications for transmission to the Royal Society of Victoria
from all parts of Europe should be sent.

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1881.

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Royal Society of Victoria.

ANNIVERSARY ADDRESS

OF

The President,

MR. R. L. J. ELLERY, F.R.S., F.R.A.S., Government Astronomer.

(Delivered to the Members of the Royal Society of Victoria, at their Annual Conversazione, held September 27th, 1881.)

GENTLEMEN OF THE ROYAL SOCIETY,

We meet to-night to commemorate the entrance of our Society on its twenty-fourth year of existence, and, according to our now time-honoured custom, it is incumbent on me as your President to deliver a brief address on the affairs of the Society and cognate matters; but first permit me to tender you my thanks for the great honour you have done me by again re-electing me your President.

Only once or twice, out of the many times I have had to address you on similar occasions to this, has the painful duty devolved upon me of referring to losses from death in our ranks. Still, in the natural course of events, we must expect, as time rolls on, that occasional gaps will occur. But on the present occasion I regret exceedingly that I have to call your attention to the loss by death since we met here last year of no less than five of our members—namely, Sir Redmond Barry, Mr. Alexander Kennedy Smith, Mr. Thomas Higinbotham, Mr. Samuel Patching, and Mr. Frederic Joy Pirani, leaving blanks in our midst it will be difficult to fill up.

Each session the Society passes through has of late years added substantially to its position and vitality. The number of our members has increased, our sessions have been busy, and there has been increased interest both among our members and the public generally in our proceedings. The financial position, aided each year by the annual grant from Parliament to assist in the publication of our Transactions, is satisfactory. The small debt we had to incur in renovating our house is nearly all paid off. I think, therefore, I am justified in congratulating you on a year's sound progress, and upon the present good prospects of the Society.

The large increase to our library, and the necessity, in consequence, of increased accommodation for the books, has occupied the attention of the Council, and will have to be dealt with without further delay.

The system of printing our Transactions directly after the meetings in pamphlet form for immediate circulation is found to work well; and not only is it convenient to the members, but it induces scientific men throughout Australia, in order to get prompt publication of their discoveries or investigations, to contribute the results of their researches to our Society.

I have usually on these occasions given a brief account of the year's progress and work of our several colonial science and art institutions; and although there is nothing of unusual importance to lay before you on this occasion, it may still be of some interest to know what has been doing in them.

First, then, I will refer to our Observatory, at which the usual routine investigations in astronomy, meteorology, terrestrial magnetism, and allied branches of physics have been carried on uninterruptedly.

The results of the last ten years' work in meridian astronomy are now being prepared for publication, forming the second *Ten Year Catalogue* of stars; and the results of the astronomical work generally for the years 1876, 1877, 1878, and 1880 will soon be in the press.

The great telescope continues to do well, and amongst other work done with it during the past year a very fine series of photographs (in negative) of the moon have been obtained, duplicates of which have been sent to the Royal Astronomical Society in London for publication in England. The members of this Society will be glad to learn that there is every prospect of our Observatory being soon furnished with a new transit circle of the most modern form of construction, and of dimensions and power sufficient to cope with the increasing requirements of astronomical science.

The astronomical event of the year in Australia was the apparition in the Southern Hemisphere of a large comet in May last, which afterwards becoming visible in the Northern Hemisphere, afforded an opportunity for obtaining an extended series of observations for important investigations as to the constitution of these strange bodies. The comet was first seen by Mr. Tebbutt (the well-known amateur astronomer, of Windsor, N.S.W.), on the evening of 22nd May, who reported it to our Observatory. We first observed it on 22nd May, and subsequently obtained a good series of measures of its positions. Its northerly motion carried it beyond our reach on the morning of 15th June, and it was not seen again until 22nd June, when it became visible in the Northern Hemisphere. As there is generally some interest attaching to the question of "Who first saw the comet?" I may state that, so far as can be ascertained, it was seen in Australia on 22nd May, and in the Argentine Territory, South America, on 26th May, so that Australia may claim the first sight of the interesting stranger. Whether this comet was new to us telluric mortals, or an old friend returned, cannot be stated with certainty; some astronomers incline to the belief that it is identical with the one of 1807, there being great similarity in the elements of its orbit. If it be a return of this comet, it has come

1500 years before its time. It has been suggested by Dr. Gould, of South America, in a letter I have lately received from him, that more than one comet may occupy the same orbit. Such an hypothesis is certainly, in some measure, supported by the experience of the last few years, and fits into the fact that some comets and meteor swarms occupy the same orbit.

We shall soon have to prepare for the transit of Venus in 1882; an opportunity will be furnished to observers for gaining fresh experience in the characteristics of such a phenomenon by the transit of Mercury across the sun's disc, which will take place on the 8th of November next. The transit of Venus will take place on 7th December, 1882, but the principal part of the phenomenon will be over before the sun rises in Australia, and the last phases only will be visible here immediately after sunrise. For the observation of the transit of 1882, therefore, Australia is not in so favourable a position as it was for the transit of 1874.

Two or three years ago the astronomers and meteorologists of several of the colonies met together in conference at Sydney, during the time of the Exhibition there, with the view of bringing about more complete co-operation in the study of Australian meteorology, and the interchange of weather information for the benefit of the community generally, and the result was highly satisfactory. A second conference was held at our Observatory in April last, at which some very important conclusions were arrived at, among which was the desirability of adopting in Australia a system of weather telegraphy and forecast similar to that which has been found so valuable in the Northern Hemisphere, concerning which I have a few words to say presently.

The Government botanist, our talented fellow-member, Baron von Müeller, has been busy with his phytographical and allied work, and has during the year contributed important additions to our knowledge of the Australian flora, both recent and fossil, as well as of the uses of many of our vegetable productions. The eleventh volume of the *Fragmenta Phytographiæ Australiæ* has been completed. It is especially interesting, as it concludes with a list of nearly 3000 acotyledonous plants of Australia, comprising the algæ, mosses, lichens, and fungi, and including those collected by Gunn, Harvey, Bailey, Archer, Drummond, and Preiss. I have referred in a former address to a very important and valuable work upon which our Government botanist has been for some time engaged, namely—*Eucalyptography*—a treatise on the eucalypts of Australia. The plates of 90 different species are already lithographed, and it is expected the text will be through the press before the end of the year. You will be pleased also to hear that his book on *Select Plants for Industrial Purposes* has lately, by consent of our Government, been re-published in Calcutta, and also in Sydney; and its value is so fully recognised by other countries that it is also in course of translation into German by Dr. Goeze, of Grafswald, and into Portuguese by Viscount Villars, of Oporto. The second decade of the vegetable fossils of the auriferous drifts is nearly completed, and will contain an account of the *Spondylostrobus*, which formed vast pine forests in the pleiocene age in this part of Australia, and, according to our present knowledge, extended into Tasmania and to the south-west part of New South Wales, large stems of which, of enormous length and 3 feet in diameter, have been found in pleiocene drifts below the basalt near Ballarat. In this decade Baron von Müeller will trace out and explain the life history of this tree. There yet remain in the interior of Australia, and indeed in its coastal regions, vast fields comparatively unexplored by the botanist, and therefore there is much to be done in this branch of natural science before the hundreds of genera and thousands of species of plants already collected can be rigorously established or their geographical distribution thoroughly known. The increased traffic with Polynesia, and notably with New Guinea, Samoa, and the New Hebrides, has opened up new botanical treasures, and by the kind and zealous aid of missionaries and other friends, Baron von Müeller has been able to make known several highly interesting novelties from these islands. That the Baron is still unable to resume his phytochemical researches and inquiries into the utilitarian value of our native vegetable products, for want of means and appliances, is a matter we must all regret, more especially as the investigations he made some years ago in this direction promised to be of great value to the country.

The National Museum at the University is constantly adding to its stores, and some important additions have been made this year from the International Exhibition just closed. It now contains 45,250 specimens, labelled, arranged, and catalogued. The delay in the publication of the decades of the natural history of the colony seems now to have been overcome, for one decade of zoology and one of paleontology will now soon be out of the printer's hands. Each of these decades that issues facilitates the study of natural science by enabling observers to identify objects.

Our members have always taken an interest in the progress of the technological school and museum attached to the Public Library, and they will be pleased to hear that not only has the museum been greatly increased during the past twelve months—partly by purchase, but chiefly by donations —by collections valued at over £5000, but the technical classes show increased vitality. There have been 43 pupils in the chemical and 44 in the mechanical engineering classes. To meet an urgent requirement for the proper carrying out of the Pharmacy Act, a new series of class lectures on chemistry, pharmacy, and *materia medica* has been instituted at this school. Independent of the teaching, some good work is being done in the laboratory in technical research. Mr. Dunn's investigations in food adulteration have attracted public attention, and the Government has promised to introduce an Adulteration Act. Mr. Adams and Mr. Mansfield, in the metallurgical laboratory, have been engaged in working out processes for the more complete extraction of gold and other products of our mines.

The curator of the Botanical Gardens continues to combine with the ornamentation and tasteful disposal of the gounds under his charge scientific arrangement in a manner which, without in any way detracting from their beauty or picturesque harmony, adds considerably to the pleasure and information which can be obtained there. The classified groups, which have formed part of the general scheme of planting, have been largely increased, and now contain over 500 *genera* and nearly 2000 species. A very important improvement in the labelling of these groups is apparent. Each specimen has a label, on which is set forth the botanical and vernacular name, the natural order, the country to which the plant is indigenous, and the name of the botanist who first described it. Near the Victoria Regia house a a group of plants of known medicinal value has been commenced, among which can now be seen specimens of most of the better-known medicinal plants ; this will no doubt soon become of very great interest and value to medical students. If this course of making landscape gardening and pleasure-ground ornamentation go hand in hand with botanical grouping and classification continues to be carried out, our gardens will soon become an important and pleasant means of educating the people in a very useful branch of knowledge.

I stated just now I would refer again to the subject of Australian meteorology, and a few words on this subject may perhaps be of interest to some of our members. The meteorologists of Europe and America, during the last few years, by systematic co-operation, and aided by the telegraph, have greatly increased our knowledge of meteorology, and it has been advanced from its former unsatisfactory position almost to the condition of a science. I say almost, for it is only now that we are beginning to obtain clear ideas of the complex laws to which the movements and changing conditions of our atmosphere are subject. The result of the systematic work I refer to is the establishment of certain "laws" or generalisations of the conditions and movements of the atmosphere which appear to prevail at different parts of the earth's surface. These have been treated of by several recent writers on meteorology, but I believe most clearly and succinctly in a valuable little pamphlet by the Rev. Clement Ley, issued by the meteorological department of Great Britain. These may be stated as follows:—As regards pressure or normal height of barometer, our atmosphere may be divided into five great regions; a belt of moderately low pressure occupies the equatorial regions, north and south of this are two belts of high pressure, and north and south of these again we find areas of low pressure in the polar regions. These areas alter, however, with the seasons, being largely influenced by the solar heat, and we find this remarkable result—in the winter of either hemisphere the temperate zone belt of high pressure is continuous over land and sea. In the summer, however, the belt is broken up by all the continents becoming covered by areas of low pressure. Although Australia lies in the southern belt of high pressure, and is normally covered by an area of high pressure in winter, in summer, under the influence of increased solar heat, the equatorial region of low barometer extends southwards and embraces Australia, while on the ocean east and west of us the normal high pressure of the temperate belt prevails. The same occurs with Africa and South America, where similar areas of low pressure prevail during the summer months, while in the Northern Hemisphere high pressures prevail generally over land and sea in the temperate zones, and, in fact, extend almost to the polar regions north of the land in Asia and America. It has also been established that the movements of the atmosphere are subject to certain laws depending upon the rotation of the earth itself, and, therefore, upon position on the earth's surface, upon the distribution of land and water, and upon the seasons. It may perhaps be stated that, generally speaking, the normal direction of the wind over the earth is westerly, for we find in the Southern Hemisphere below 40 deg., where there is but little land to interfere with any normal current, it blows strongly and regularly from the west at all seasons of the year, except when temporarily disturbed by cyclonic movements. Our atmosphere may be likened to a great stream moving eastwards, meeting with islands, continents, and shoals, and affected largely by powerful thermal influences, which, as it sweeps along, gives rise to innumerable deflections, eddies, and whirlpools, and so divert the general movement as to produce currents in all directions. We can witness these in miniature in almost any steadily flowing river. The little whirlpools with their depressed centres represent the cyclonic movements of our atmosphere in some places, and the higher portions in their neighbourhood the anticyclonic areas which disturb the normal flow of the earth's atmosphere. The barometer always indicates the pressure to be less in the cyclonic than in anticyclonic areas, and the question of how these vertical movements arise, what governs their progression, their dimensions, duration, and the paths they follow, is now the most interesting problem in meteorology.

The climatic conditions of a continent as brought about or affected by these general laws of pressure and movement of our atmosphere may be perhaps illustrated by taking Australia in the summer season as an example. The Australian colonies are now all connected by telegraph, and from most of them telegrams, giving the state of the weather, temperature, height of barometer, direction and force of wind at nine a.m. every day are received in Melbourne; if, now, these are plotted upon a chart of Australia, we have presented a rough kind of contoured survey of the atmosphere lying over and about Australia, from which, with the assistance of the laws referred to, we can make deductions as to probable coming weather. Examining such a chart in summer time, we shall probably find that over Central Australia the barometer reads low, about 29·8; that it reads higher as the east, south, or west coast is approached, indicating a basin or depression in the atmosphere over the land. We find from the plotting of the wind directions that it has a tendency throughout to blow from the sea towards the area of low pressure, for, as a rule, winds always blow from a district of low towards a district of high pressure; therefore, in the north the winds range from N.W. to N.E., and in the south from S.W. to S.E. This is the normal state of affairs in summer, and all around our coast sea breezes prevail. But now if one of the constantly recurring whirls or cyclonic movements of the atmosphere, forming perhaps at the Cape of Good Hope, or on the ocean between here and there, should approach our western or south-western coast, a change of affairs very soon becomes apparent. In Western Australia, or perhaps first at Cape Borda or Cape Northumberland, the barometer begins to fall, the wind coming from N.E., then increasing from north; then the barometers at Portland, Cape Otway, George Town, Melbourne, Wilson's Promontory, fall in succession with a northerly wind, which increases in force as the pressure gets less; this wind, blowing from an area of higher to an area of lower pressure, although still from around the summer low pressure area of Central Australia, comes down to us heated by the tropical sun, and by travelling over regions of heated earth's surface, producing the hot wind of South Australia and Victoria. These hot winds are always in front of cyclonic movements, and are fully explained by them. As the cyclonic area approaches, moving eastwards, the barometer still continues to fall, while the temperature increases. The question now arises, Where is the centre of this area, and where will it pass?

The way the wind shifts tells us of this. So long as the wind is north, the centre is to the west of us; if it shifts from N. to N.W., as is most frequently the case here, the centre passes to the south of us; if it falls calm, with perhaps clear sky and very low barometer, the centre passes over us; but if the wind backs from N. to N.E. and E., it will pass to the north of us.

More or less rain generally accompanies such occurrences, but the quantity with us much depends on the magnitude and depth of the cyclone, the rate of translation, whether it is single or double, and also as regards our position with reference to the centre. Much rain often comes in front of a cyclone; yet some of our heaviest floods have occurred in the rear, and on the north or equatorial side of a large and slowly moving cyclonic area. The amount and extent of rainfall on our south coast also, I believe, depends a great deal upon the way the advancing isobars are resisted, so to speak, by the areas of higher pressure over the land; and heavy rains generally result if an area or part of an area of low pressure protrudes abruptly into a resisting area of higher pressure.

There is no doubt that the majority of our cyclonic whirls move from W. or S.W. easterly, many of them being deflected south down along our coast, and perhaps south of Tasmania. Some, however, pass inland to the north of Victoria, and occasionally they may be found coming down on us from a northerly direction, or from the south-east; these, however, are exceptional cases. New Zealand gets weather warnings from Australia, and a storm reported off Cape Borda arrives there in about three days. Dr. Hector tells me that nearly every depression we report reaches New Zealand, and can be foretold there two or three days beforehand.

One of the most important meteorological questions in these colonies is that of the rainfall; but although the approach and movement of storm centres along our coasts and over the land can be traced and foretold with a moderate degree of certainty, the question of how much rain, if any, they will bring is as yet an extremely difficult one to answer; nevertheless, with the knowledge already secured, when the general laws prevailing over the southern parts of Australia become fairly established, it is not at all improbable that, difficult and uncertain as it now appears, the conditions that determine precipitation of rain may be traced out.

The plan of publishing intercolonial weather telegram information in Melbourne will be limited at present to the issue of a weather chart soon after noon on each day, upon which will be shown the meteorological conditions prevailing over Australia, at nine a.m. of that day, and added to this forecasts of next day's probable weather will sometimes be given, more especially where cyclonic disturbances show themselves within the vicinity of our coast lines.

The great progress made in the practical application of electricity, which I referred to at our last year's meeting, continues with apparently increased activity. It has been demonstrated beyond doubt that streets and public places can be successfully and economically illuminated by the electric light; and in support of this I may point to the lighting by electricity of our chief city market by the newly formed Victorian Electric Company, accomplished under the great difficulties which usually beset new undertakings. The use of electricity, generated by mechanical means, for transmitting energy to a distance is now an accomplished fact. As regards electric lighting, it appears the important problem to be now solved is its economical adaptability to domestic use. Invention is busy in this direction, and already considerable and promising progress has been made by Swan and others, by the construction of lamps formed of glass-globes, exhausted and hermetically sealed, containing a loop of carbonised fibre or thread, which becoming incandescent when traversed by the electric current, gives a light well adapted for indoor illumination. It is intended that the electricity necessary to keep these lamps alight shall be supplied to each house in the same way that gas or water is now, but I fancy this part of the question is not so nearly solved in its economical as in its practical aspect. The advances made in all questions relating to electric lighting during the past year, however, leave but little doubt that what now appear as difficulties will soon be overcome.

A somewhat important and very interesting subject in electric science has lately attracted public attention—namely, the storage of electricity. It has long been known that certain arrangements of metal surfaces in fluids known as secondary batteries will act as accumulators of dynamic electricity, and M. Gaston Plantè, in 1859, constructed large ones of lead, which after long use would store the current of a galvanic battery passed into it for a considerable time. The new impulse given to the secondary battery as an accumulator of current electricity arose from the construction of a modified form of Plantè's cell by M. Camille Faure, in which, by the use of peroxide of lead on the surface of the metal, the cell at once becomes as effective as Plantè's was after long-continued use. One of these cells sent by M. Faure to Sir William Thomson, at Glasgow, retained a powerful charge during transit, and for some time after, and the latter gentleman, in a letter to the *Times*, gave a glowing account of the amount of energy thus transmitted to him from Paris, and of the possibilities arising out of the fact thus accomplished. Faure's cells have since been constructed and experimented upon everywhere, and some very interesting experiments with a battery of them were shown by one of our younger members at our last meeting. This new phase of the secondary battery has attracted attention to its value for many purposes, and more especially for the surgeon, as well as for the class-room and lecture-table; and it is, I think, likely to come into more general use in these directions; but, in its present form, it seems to me unlikely to fulfil the expectations that appear to have been entertained by many writers and some electricians. Nevertheless, if it is capable of holding as much energy as has been reported, it appears probable it may fill a very important office, especially in overcoming some of the difficulties in the way of the economic and regular distribution of electricity.

Early last year steps were taken by the Exhibition Commissioners to constitute a Social Science Congress in Melbourne. Such a congress, you are aware, was formed, and divided into various sections. The meetings were held in October and November, and addresses were given, papers read, and discussions taken on numerous subjects—some of the highest importance. Many of the papers contributed are now being printed, and will, I believe, soon be issued as the "Proceedings of the Melbourne Social Science Congress." The congress itself is virtually defunct, but the work it started upon so vigorously and so well should not be discontinued. The inquiry into and ventilation of the science of society is a matter of the highest importance, especially in large centres of population, and connects science itself with the application of its teachings towards the safety and welfare of the community. In the constitution of this Society the formation of a social science section was provided for, and should the congress not revive again, there are numerous and pressing questions our Society should grapple with, and especially matters relating to sanitary and economic science.

On a late occasion a talented member of this Society brought under our notice a certain published specification for making gas from metals, on which a patent has been granted, and on the faith of which it appeared the public were investing large sums of money. The specification had a certain glamour about it, calculated to entice unscientific people, but which to an expert appeared too absurd to waste a second thought upon. This specification was made the theme of a paper, the question fully discussed, and a resolution carried laying bare the facts. Now, this was a social science question clearly within the province of the Society, and one which it would have been almost culpable to have passed unnoticed. It is a matter for congratulation, therefore, that our members spoke plainly and clearly on the subject. Our Society was constituted on a wide basis, suited to the work before it in a new and rapidly growing community, and it is very desirable we should keep in view the functions it is obligatory upon the Society to fulfil. They extend beyond the records of the results of research and the discussion of abstract points of science, and its chief social function is to endeavour to protect the community from the effects of ignorance of natural laws, false science, and untruth, in whatsoever shape it may come, either as a levy upon its health, its pocket, its material progress or general well-being.

ART. I.—*A New Genus of Lichens.*

BY JAMES STIRTON, M.D., F.L.S., COR. MEM. ROYAL SOCIETY, VICTORIA.

[Contributed 28th April, 1881.]

TRICHOCLADIA BAILEYI (Strn.).

Thallus prostratus (latit. ·4—1—pollicaris et ultra), profunde laciniato—dissectus, laciniis divaricatis supra convexulis vel planiusculis (latit. 1·5—4 mm.), viridibus vel virescentibus demum pallide fuscescentibus, difformiter pinnatilobis, margine sinuato—crenatis et interdum incisis, subtus fuscescens vel fuscus, radiatim costatus, radiculosus (radiculis fuscis vel fusco-nigris, longiusculis, plerumque fasciculatim dispositis), insuper, dense pannoso—tomentellus, etiamque creberriter cyphellatus (cyphellis pallidis, rotundis vel oblongis, profunde urceolatis vel fere thelotremoideis); apothecia marginalia sessilia vel elevato-sessilia, pallide carnea demum pallide rufescentia, biatorina (juniora margine pallidiore), planiuscula (latit. ·5—1·5 mm.), intus pallide citrina; sporæ 8 næ, incolores simplices vel interdum spurie 1—septatæ, oblongæ vel fusiformi—oblongæ, hinc inde curvulæ, ·009—·012 × circ. ·003 mm.; paraphyses confertæ, graciles apice inspersæ (K—); hypothecium incolor. Iodo gelatina hymenialis intense cærulescens. Hyphæ medullares divaricato-ramosæ et anastomosantes, plerumque hirsutulæ (latit. ·006—·01 mm.). Thallus K vix coloratus; medulla K—C—.

Spermogonia nigra prominula verruciformia, marginalia; spermatia non visa.

Supra terram in pascuis prope Brisbane (Queensland). Coll. Bailey, No. 288.

This plant has evident affinities to the *Cladoniæ*, especially through such forms as those included under the term *Cladonia ephiphylla*, but the peculiarities of the under surface are such as to necessitate a generic distinction. The cyphellæ are deep and well formed, with, however, no distinct cupula as in the *Stictæ*, but the walls are composed, apparently, of the medullary fibres closely felted together, so as to give the appearance of distinct walls. Many of these cyphellæ are, besides, narrower at the aperture—*i.e.*, thelotremoid.

This lichen is due to Mr. F. M. Bailey, of the Queensland Museum, Brisbane, to whom I have taken the liberty of dedicating it. Mr. Bailey has recently furnished me with specimens of another curious lichen, also peculiar to Australia, and having corresponding affinities—viz., *Thysanothecium hyalinum* (Tayl.), formerly described by the late Dr. Taylor, in Hook, Journ. Bot., 1847, p. 187, under the name *Bœomyces hyalinus* (coll. Bailey, No. 312).

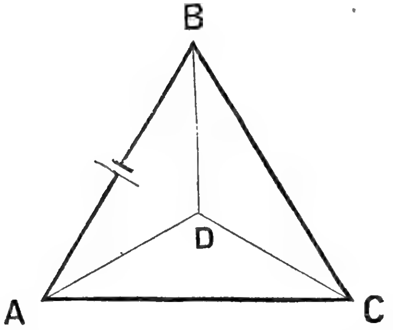
ART. II.—*On a Supposed New Species of Nipa.*

[Communicated by MR. F. M. BAILEY, F.L.S., of Queensland, 28th April, 1881.]

Art. III.—*On a Modification of Mance's Method of Measuring the Resistance of a Battery.*

By F. J. Pirani, M.A.

[Read 19th May, 1881.]



Mance's method of measuring the resistance of a battery is based on the following proposition:—

Let A, B, C, D be four points connected by six conductors, as in the figure, a battery being in the branch AB.

Then, if the resistance of AB is to that of BC as the resistance of AD is to that of DC, the current in AC will be independent of the resistance of BD; and, *vice versâ*, if the current in AC is independent of the resistance of BD, the above relation exists between the resistances of AB, BC, AD, DC.

If, then, we adjust the resistances of BC, AD, and DC until the current in AC is unaffected by varying the resistance of BD, and if we know the resistance of BC and the ratio of the resistance of AD to that of DC, the resistance of AB is found by a simple calculation.

In the method as originally proposed, a galvanometer is placed in AC, and a key in BD; and the resistances of BC, AD, and DC are adjusted until no alteration in the deflection of the galvanometer is produced by making and breaking contact by means of the key.

In this application of the principle the greatest sensitiveness is obtained when the resistance of AD is equal to that of DC, and the resistances of ADC and AC are equal, and as small as possible.

Dr. Lodge, in a very valuable and interesting paper, published in the *Philosophical Magazine* for June, 1877, has pointed out two defects in this method.

1. The balance of resistances being tested by the *variation* of the current in AC, which will be small compared with the current itself when the balance is nearly obtained, a sensitive galvanometer cannot be employed; and even the sensitiveness of the coarse galvanometer generally used has to be diminished by the intensification of the magnetic field in which its needle moves, caused by the external magnets used to bring the needle near its zero position.

2. Although, when the resistances are balanced, altering the resistance of BD does not directly change the current in AC, it does change the current in AB. Now the electromotive force of a battery does, to some extent, depend upon the strength of the current passing through it, so that if the resistance in BD is altered the change in the electromotive force of the battery thereby produced will alter the current in AC.

In some cases the resistance of AB will also vary with the strength of current passing through it. Dr. Lodge, in his paper, says that if the resistance of a conductor depends on the strength of the current passing through it, the resistance is not a definite magnitude, and cannot be measured. I would, however, point out that, while Ohm's law no doubt implies that the resistance of a conductor is a fixed quantity independent of the strength of current passing through it, yet changing the strength of the current may produce a change in the conductor itself (as in the temperature of a wire, the chemical composition of the parts of a voltaic battery, the size and temperature of an electric arc), whereby its resistance is altered. I imagine that it is in this indirect way that change of current strength affects electromotive force.

Dr. Lodge, in the paper above referred to, describes a modification of Mance's method, which consists in introducing a condenser in the branch AC, and employing a special form of key whereby contact in BD is made for but a very small portion of time.

In order to obtain the greatest sensitiveness, the resistances of AD and DC should be as great as possible, and the resistance of the galvanometer and capacity of the condenser also great.

Now, if we make the resistance of ADC large compared with that of AB, the current in AB will be small compared with the greatest current which the battery can produce. Hence Lodge's method, although very valuable for many purposes, seems unsuited for measuring the resistance of a battery when producing a current of magnitude comparable with that which passes through it when short-circuited.

The method which I submit to your notice this evening consists in replacing the galvanometer used in Mance's method by the primary wire of a small induction coil, with the secondary wire of which a telephone is connected. Contact in BD is alternately made and broken rapidly by a vibrating spring, kept in motion by an electro-magnetic arrangement worked by a separate battery, or by the current in BD itself, if none of the branches have sensible coefficients of self-induction, or the resistance of BD is slightly varied by introducing into it a microphone, on the stand of which a small clock is placed. By either of these methods we may produce periodic changes in the resistance of BD, and make these changes so small that the resistance and electro-motive force of AB will be practically constant. Although the changes in the strength of the current in AC will also be slight, yet the telephone will detect alterations which could not be rendered evident by galvanometric methods.

The modification of Mance's method which I propose seems to possess the two following advantages :—

1. It enables us to measure the resistance of AB when a powerful current is passing through it.

2. In its employment the strength of current in AB need be but slightly affected.

For these reasons it appears to me especially suited for measuring the resistance of an electric arc, the lamp being introduced in the branch AB, the joint resistance of the battery (or machine) and lamp measured, and the resistance of machine, lamp fittings, and carbons separately ascertained.

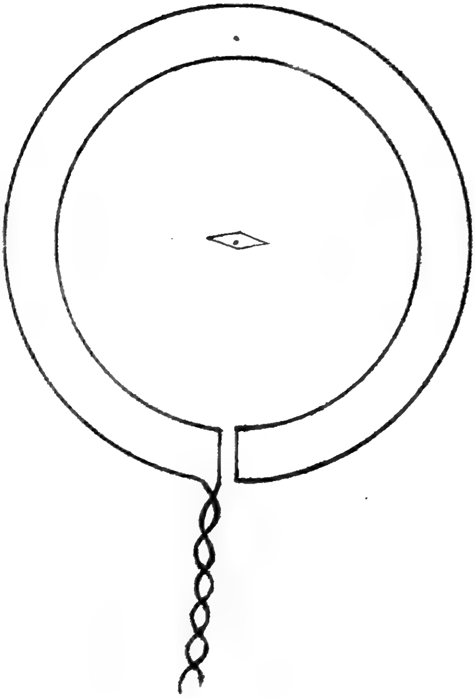
ART. IV.—*On a Form of Tangent Galvanometer suitable for Measuring Powerful Currents.*

BY F. J. PIRANI, M.A.

[Contributed 19th May, 1881.]

AN instrument for measuring the strength of such powerful currents as those employed in electric lighting, which shall combine portability, simplicity of construction, and accuracy, seems still to be a desideratum. The galvanometer, a rough model of which I exhibit this evening, combines these advantages better than any instrument of which I have seen a description. It consists of a band of copper, bent so as to form two concentric circles, which will be traversed by the current in opposite directions, as shown in the accompanying sketch. At the common centre of the circles is supported a magnetic needle, to which is attached an index moving over a graduated circle, or a mirror to reflect a beam of light on to a scale in the ordinary manner. The leading wires are twisted together to prevent their having any sensible influence on the needle.

(See Diagram.)



ART. V.—*Notes on the Diabase Rocks of the Buchan District.*

CONTRIBUTED BY A. W. HOWITT, F.G.S.

[Read 19th May, 1881.]

INTRODUCTION.

IN papers previously published in the Reports of Progress of the Geological Survey of Victoria,* on the Devonian rocks of North Gippsland, I gave some particulars as to those formations which collectively constitute, at Buchan, the Middle Devonian group, and whose geological age is determined by the characteristic marine fossils of the Buchan limestones.

In the last-published communication on this subject† I desired to describe and to bring into relation with each other the members of that group of rocks which I provisionally termed the Buchan Beds. I was led to make that more special examination by certain doubtful features which my previous more general examination had shown, and this again brought other appearances into view which required further elucidation. It even then remained uncertain whether certain dark-coloured basic igneous rocks at Back Creek and the Murendel River were intrusive into the Buchan Beds, or were older than some of them, and therefore contemporaneous members of the group.

I was not able at the time to completely satisfy myself on this point, but I inclined to regard them as being intrusive, and therefore younger than the whole of the Buchan Beds. Since then I have had an opportunity of examining this group of beds in detail over a wider area.

The following notes are the result of that examination, both as to the localities themselves in the field, and subsequently of the rock samples I then collected.

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* *Report of Progress of the Geological Survey of Victoria,* Parts III. and V.
† Same, Part V., p. 117.

Before entering upon details a few observations may be admissible upon the physical features of the district wherein the Diabase rocks occur.

PHYSICAL GEOGRAPHY OF THE DISTRICT.

That part of the district which is dealt with in this paper lies between the Buchan and Snowy Rivers, and immediately within the angle formed by their junction. The area may indeed be imagined as a rudely equilateral triangle, across the base of which extends the diagram section accompanying these notes, while the apex is approximately marked by the junction of the rivers. The country is mountainous, but it is lower in elevation than the tracts surrounding it. It is less rugged in outline, and it possesses a better soil and is more richly grassed than the felsitic areas amongst which it lies. This more favoured character is due to the preponderance in it of the Buchan limestones, and of the Diabase rocks which are the special subject of this paper.

The characters of the two rivers, the Snowy and the Buchan, which bound two sides of the area, differ considerably. The former rises on the great table land of Maneroo, and descends rapidly near the boundary line of the colony through a deep rocky valley, excavated into indurated Lower Silurian formations, and it thenceforward flows in a deep and, generally speaking, a barren valley towards the sea. The rocks in which this part of the valley has been excavated are mainly varieties of intrusive granites, or of kindred rocks of an acid character, such as felsites. More rarely there occur tracts of Silurian sediments in a greatly inclined and indurated condition. In that part of the valley which lies to the east of Buchan there are small areas of limestone which have been preserved by having been let down by extensive and often well-marked faults. Near the junction of the Buchan and Snowy Rivers there is a somewhat larger outlier than usual of these Buchan limestones, and associated with them is a still larger area of Diabase rocks. These latter are dealt with in these notes.

The settlement of Maneroo, the consolidation of the soil, and the grazing down of the thick coat of natural grasses by flocks and herds, the formation by stock of tracks and by man of roads, has, for the last twenty or thirty years, caused the rain falling on the great plateau to concentrate more and more rapidly in the main drainage channel. So long as the pitch of the river bed remains but slight, as on the table lands, no very great changes have followed; but where the river bed descends rapidly, as does that of the Snowy into the valley lying within this colony, the changes produced have been enormous.

Early settlers with whom I have conversed assure me that these changes in the Snowy River valley date from the year 1852. Its condition in the year 1848, about where the boundary line of this colony crosses it, has been described to me by one of the early settlers, as follows:—The river was then from 60 to 70 yards across, between banks about three feet in height, and with a rocky and shingly bottom. The flats were from 100 yards to a quarter of a mile wide, and were luxuriantly covered with oat-grass. Here and there a big rock stuck out of the soil.

The river began first to cut its banks in the year of the great Gundagai flood (1852), and almost the whole of the soil was then carried away. Each subsequent flood has added to the change, the great flood of 1873 having even removed the soil in many places from the hill-sides for some thirty feet above the river level.

The present state of the valley within flood-marks may be described as being washed out to the bed, and being either bare rock or banks of sand, gravel, or boulders. I have myself observed that throughout the whole course of the river, from the boundary line to the low lands near the coast, there are now no trees growing within flood-marks. In consequence of all these changes the drainage area of the river is undergoing more or less accelerated degredation, and the swamps and lagoons at the Snowy River mouth are in process of being filled up.

The Buchan River rises in Victoria, in the Great Dividing Range, near the mountain known as the Cobboras. Throughout its course to Buchan it flows in narrow and wooded valleys, which are almost uninhabited, and but little stocked. It has, therefore, remained far more in its original state than has the Snowy River valley. Still, changes somewhat analogous have occurred, though to a less degree.

However much this rapid stripping of the alluvial soil from the valleys is to be regretted, as possibly pointing to a future general denudation of the hill sides and sloping ground of the drainage area, the immediate result has been to disclose innumerable natural sections of the formations, of the very greatest interest and value to the field geologist.

It may be said that the floods which, during the past ten years, have swept out the streams, in many cases to the bed rock, in the North Gippsland mountains, have opened up a storehouse of facts bearing upon some of the most interesting as well as difficult problems of petrography.

DESCRIPTION OF THE ROCKS.

In the preceding paper on the Buchan Beds* I was led, from an examination of the much-altered olivine-bearing rocks at the Murendel River, to regard them as representing basalts, and I also regarded all the basic igneous rocks, both at the Murendel and Back Creek, as belonging to the same group. I now proceed to give the results obtained from a more complete and extended examination in the field, and a careful analytical examination of the samples I had collected.

The sketch section given here extends from Moore's Crossing, at the Snowy River, to a little west of the Murendel galena mine. The line of section and the Snowy and Buchan Rivers rudely represent an equilateral triangle, the junction of the rivers being at the apex. The length of the section is about three miles. In order to give as complete a view as possible of the various rock masses crossed, and also of their relations to each other, I have found it advisable to repeat some of the features given in a section at p. 131 in the previous paper.

The section commences on the eastern side of the Snowy River, at Moore's Crossing. At this place there is a somewhat larger outlier of the Buchan limestones than usual. On the western side, for some miles up and down the river, the principal rock is a dark-coloured (dark brown to nearly black) massive igneous rock. On the eastern side the limestones preponderate, and on the western side these igneous rocks. But on both sides there are numerous places where the contact of both rocks can be well observed. This dark-coloured igneous rock is evidently akin to that which, at the Back Creek, underlies the limestones, and also in that locality extends over much of the eastern side of the Buchan River. It decomposes into a moderately good soil, and it weathers into harsher and more rugged masses than is usual with the basalts and dolerites of Gippsland. This harsh character is

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* Progress Report Geological Survey of Victoria, Part V., p. 117.

everywhere the same where I have observed these rocks. They are often slightly porphyritic, with felspar prisms. The following notes on this rock and its varieties, as observed above and below Moore's Crossing, will illustrate its physical and microscopic characters, and its relations to other rock-masses.

At the eastern end of the section the Snowy River flows over these igneous rocks, which, on the eastern bank, are immediately overlaid by the representatives of the Buchan limestones. I have described in the previous papers already quoted the contact of the Devonian limestones of Buchan, through passage beds, with the uppermost members of a series of felsitic beds, for which I suggested the name of Lower Buchan Beds. Here, however, we find that the marine limestones do not, as elsewhere, rest conformably upon the felsitic beds, but upon massive igneous rocks of a basic character.

It may be well, however, before speaking further of the mode of occurrence of these rocks at the Snowy River, to consider the results of the microscopic and chemical analyses to which I subjected the collected samples. It will then be possible to make a first step in advance—namely, to determine the class to which these basic igneous rocks belong.

I prepared thin slices from samples collected from six different localities. I selected a sample for chemical analysis which appeared to me to be but little altered, and, at the same time, fairly to represent the average character of the rock masses.

MICROSCOPIC STRUCTURE OF THE ROCKS.

The structure of these rocks, as seen in thin slices under the microscope, is generally microporphyritic, and more rarely approaches porphyritic. The ground-mass usually contains, or is partly composed of, some almost colourless or slightly yellowish or brownish basis. I have found this to be in some cases microfelsitic.* The basis, where it is at all abundant, contains great numbers of minute dust-like particles. In places these particles coalesce so as to form long and narrow trichites, or often resemble a number of beads

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* Microfelsitic, *i.e.*, consisting of an aggregate of exceedingly minute crystalline particles. See *Zirkel. Mikroskopische Beschaffenheit der Mineralien und Gesteine*, p. 280; also *Rosenbusch Physiographie der Massigen Gesteine*, p. 65.

strung upon a thread. In places these trichites cross each other like a net-work. In a few cases I have observed that there are no trichites, but then these dust-like particles are diffused in numbers throughout the basis, which fills in the spaces in the crystalline ground-mass. The slices are in such cases very obscure. In rarer cases the basis contains very many rounded granules (sperulitic bodies) of a darker shade of brown than the basis. In such cases I have observed only a few thorn-like microliths, and none of the black dust so frequent in other examples.

Perhaps the most numerous components of the ground-mass are very minute prisms of felspar. In some cases these form a perfect net-work, separated by the basis, and enclosing the other constituents. In most, if not in all, instances these minute felspars seem to be twinned and to be triclinic.

The next most frequent component of the ground-mass is an ore of iron, either in irregular grains or in distinctly rectangular crystals. I believe these to be in almost if not all instances magnetite. At least such would be the case in the sample chosen for analysis, for in it I failed to obtain any titanic acid by special examinations. Still, titaniferous ores are not probably wholly absent, as I have occasionally observed hexagonal forms suggestive of them. Larger masses of black opaque iron ores fill in what probably represent the sites of former minerals, and there is often also a deposit in the ground-mass of ferric oxide (hæmatite), as well as ferric hydrate (brown iron ore). Finally, needles and prisms of apatite are very frequent in the ground-mass.

The porphyritic minerals are the following:—

Felspars.—All of these are triclinic. Their terminal planes are not, as a rule, well developed, and it is common to see them fractured, and the parts pushed aside. These felspars do not seem to have been the first constituents to crystallise, for they include small crystalline grains of augite, and have also been broken by crystals of the same. It is very common for these felspars to have their crystalline planes marked in the interior of the prisms by rows of rounded, oval, or ragged particles of what seems to have been glassy material.

The composition of these plagioclase felspars is, in almost all cases, by wide rather than narrow lamellæ. They are usually compounded according to the Albite law, sometimes according to the Carlsbad law, and in rare cases I have observed cross lamellæ which may be said to be interposed according to the Pericline law. It may be said that the larger the porphyritic crystals are the less perfect is their form; and this imperfection arises not from incomplete crystallisation, but from the fracture of the crystals, or also from their partial subsequent fusion.

The inclusions are confined to exceedingly numerous rounded or ragged portions of glass or slag, less numerous colourless microliths, and apatite in prisms or needles. This latter varies in amount in different samples examined, as is also shown by the two analyses given in this paper.

The alterations to which these felspars have been subjected are of three kinds:—

(a). To finely granular or scaly aggregates, which have but a slight effect upon polarised light, and which may be kaolin.

(b). Rather minute aggregates of calcite.

(c). Aggregates of plates and minute prisms of some almost colourless or greenish minerals.

It is frequently the case that the cleavages and flaws in the felspars are lined with translucent red flakes of ferric oxide (hæmatite).

In order to determine, if possible, the position of these felspars in the series, I made observations on all the thin slices, in order to determine the angle formed by the plane of vibration, and the twin plane (edge $OP — \infty \breve{P} \infty$). The measurements which I recorded were those which gave equal or very nearly equal angles on each side of the twin plane, such measurements being in the zone $OP — \infty \bar{P} \infty$. These sections would, therefore, represent planes perpendicular to the edge $OP — \infty \breve{P} \infty$, and having inclinations between two limits—namely, the base (OP) and the macropinacoid ($OP — \infty \bar{P} \infty$). The lowest observed angles should, therefore, represent more or less correctly the former, and the highest angles the latter. Besides these sections of crystals which were twinned, there were others which were simple, and which, as they did not show either physical or optical features referable to orthoclase, may reasonably be considered as representing the plane $\infty \breve{P} \infty$ of the same triclinic felspar.

I therefore obtained three groups of measurements, which may be thus tabulated from six sets of observations:—

OP (001).	$\infty \bar{P} \infty$ (100).	$\infty \breve{P} \infty$ (010).
3° 30′	21° 0′	13° 0′
5° 0′	28° 0′	10° 30′
5° 30′	28° 0′	9° 30′
5° 30′	22° 30′	7° 30′
6° 0′	26° 0′	10° 0′
7° 0′	25° 0′	12° 0′

The investigations of Des Cloizeaux, and more recently those of Schuster,* show that the angles formed by the plane of vibration with the edge OP— $\infty \breve{P} \infty$ depend upon the position of the optic axial plane as well as upon the position in that plane of the optic axes themselves. As the last-quoted authority well puts it—"the plane of vibration moves round the edge PM."

It seems evident that the differences of position of the optic axial plane in the triclinic felspars is connected with variations in chemical composition according as the felspars contain, for instance, Na_2O, K_2O, CaO, singly or together, in variable proportions.†

According to Schuster's late observations the optical angles in oligoclase, andesine, and labradorite are as follows:—

OP (001).	$\infty \bar{P} \infty$ (100).	$\infty \breve{P} \infty$ (010).
+ 2° to + 1°	+ 18°	+ 3° to + 2°
− 1° to − 2°	...	− 4° to − 6°
− 4° to − 5°	− 30°	− 17°

Taking, therefore, in the list of measurements which I have given from these plagioclase felspars, the lowest for OP and the highest for $\infty \bar{P} \infty$ and $\infty \breve{P} \infty$ respectively, we have the following:—

OP (001).	$\infty \bar{P} \infty$ (100).	$\infty \breve{P} \infty$ (010).
3° 30′	28°	13°

On comparing this series of measurements with those quoted from Schuster, it suggests that the felspars to which they refer stand between a normal andesine and labradorite. But at the same time it must be borne in mind that, owing to the difficulties in the way of obtaining perfectly accurate

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* *Über die optische Orientirung der Plagioklase*, *Sitzungsberichte der Wiener Akademie*, Vol. lxxx., p. 1, July, 1879; also, *Neues Jahrbuch der Mineralogie*, 1880, Vol. ii., pt. 1, p. 8.

† Also, Ba O and, perhaps, Sr O.

and satisfactory angular measurements, these results cannot be regarded as being more than approximate.

The porphyritic mineral, next in importance to the felspars, occurs in almost or quite colourless crystals, whose cross sections show the usual outlines of augite, with a more or less marked prismatic cleavage of nearly 90°. Sections parallel to the axis c show traces of this prismatic cleavage, as also of a second cross cleavage. The angle of extinction in one of these sections I found to be 48° 50′. The terminal planes are not well developed in any of the sections, but in those instances which I could observe at all, suggested the base only. There was not any dichroism. The only inclusions I have observed are a very few crystals or granules of magnetite. The alterations are wholly to calcite, being easily removed by cold dilute acids. Perhaps half of the crystals, and especially the larger ones, are thus more or less altered. This mineral can scarcely be other than a magnesia-lime augite —that is, diopsid. The augite seems to have been one of the earliest crystallised minerals of this rock, for I find it included in the plagioclase felspars, and also causing their fracture. Its own often ragged and even cavernous outlines—being surrounded by ground-mass, and this eroded appearance not being the result of alteration—strongly suggest to me the action of a molten mass upon pre-existing crystals.

Associated with the augite is another pyroxenic mineral. It occurs, namely, in prisms of less dimensions than those of the former, and they are distributed through the ground-mass singly or in groups; and also filling in spaces between other porphyritic crystals. The cross sections of the prism are nearly rectangular. In its freshest condition it is colourless and but faintly fibrous. Its sections are not then dichroic, and it becomes obscured when the prismatic sides are parallel to the plane of polarisation of either of the crossed nicols. Alterations can be traced by the appearance of a fibrous structure, especially connected with separations across the prism. Its colour then becomes yellowish, and it is dichroic. In two instances I found that the ray vibrating parallel to $\overset{|}{c}$ was faintly red in one case and yellowish brown in the other, while that vibrating perpendicular to $\overset{|}{c}$ was nearly colourless and green respectively. In one instance, in which the prism was unusually well developed, having terminal planes perpendicular to the sides, the unaltered portions were colourless or faintly brownish yellow; transverse separations were bordered by a bright green fibrous mineral, which extended irregularly into the colourless portions. This fibrous mineral was strongly dichroic: dark metallic green when the fibres were parallel to the polarising plane, and light green when they were perpendicular to it. This alteration I regard as some chloritic mineral. In further alterations the form of the prism remains; but when examined by polarised light it reacts faintly as an aggregate, and the flaws and separations are lined with brown iron ore.

The only inclusions which I have observed were small crystals and prisms of magnetite; but as these were invariably in the altered parts, and in connection with the chloritic mineral, I regard them as secondary products.

I think there cannot be any doubt that this orthorhombic mineral is enstatite, and that its alterations are, in the first place, to bastite, and finally to chlorite and to ores of iron.

Finally, the only remaining mineral to be noticed is apatite. Little, however, need be said concerning it. It occurs in its common prismatic form or as small needles. It is to be observed in the ground-mass, and especially in the larger plagioclase crystals. I have but rarely observed it in the pyroxenic minerals. It varies in amount in different samples of rock—being present in some cases in unusual abundance. The two analyses accompanying this paper illustrate this statement.

The secondary minerals to be noted are—First, calcite, which either forms pseudomorphs, generally after augite; less frequently replacing parts of the triclinic felspars; often filling space or diffused throughout the mass of the rock. It generally forms minute granular, but also crystalline, aggregates, in which the faint chromatic banded effects due to twinning, according to—½R, are often visible. Next to calcite are the alteration products after enstatite, of which I have spoken. Viridite, to apply a convenient term for otherwise undetermined chloritic minerals, is not so frequent in occurrence as might have been expected in rocks of the Diabase group of such great geological age. It occurs, however, more plentifully in some cases than in others; and I found it most commonly in slices, taken from places where the limestones rested upon the igneous rocks. Perhaps one of the secondary minerals which is most frequently met with in these rocks is agate, forming amygdules of from over an inch in diameter down to microscopic size. In thin slices the concentric and radial structure is beautifully displayed. It is very common to find these amygdules bordered by a bright green granular mineral, which, in its inner margin, often extends in filaments or acicular prisms into the agate. This mineral polarises as an aggregate, and is not, I think, dichroic. The acicular crystals bordering it suggest epidote to me. This mineral is not attacked by digestion with hot sulphuric acid. I suspect that it may be an aggregate of silica, coloured by some pigment. I am at present unable to further define it. Finally, ferric oxide, as translucent plates, and ferric hydrate (brown iron ore), are found as alteration products in all parts of the rock-mass. Some of the magnetite is, doubtless, also of secondary origin.

The microscopic analysis of this rock shows that its original constituents have been plagioclase felspars, augite, and magnetite, with apatite, and, in almost all cases, a second pyroxenic mineral enstatite.

The felspars evidently greatly predominate in amount over the pyroxenic minerals. The entire absence of olivin places such a rock, it being of pretertiary age, at once, and in accordance with the classification I here follow, in the great Diabase group.* The presence of plagioclase and augite as porphyritic crystals in a ground-mass, containing more or less basis, limits its range to the porphyritic forms of Diabase; and the occurrence of the rhombic pyroxene enstatite again restricts it to a particular section. The rock, therefore, belongs, according to the microscopic examination, to the enstatite-bearing section of the Diabase porphyrites.

Having thus arrived at a conclusion, based upon microscopic examination and optical data, it will be well to see how far these are confirmed or contradicted by a quantitative chemical analysis and a discussion of the results.

The sample which I took for analysis was selected from near Moore's Crossing. It was of a blueish-black colour, and did not show any of the red tinge which in these rocks indicates alteration. It had a finely crystalline structure, and showed some porphyritic, but still minute, white felspar crystals, as also rarely small crystalline grains of pyrite.

I prepared several thin slices of this sample, cut perpendicularly to each other. I found it to be typical of the porphyritic rocks of the group. It was, on the whole, re-

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* Rosenbusch.—*Physiographie der Massigen Gesteine*, 1877.

markably fresh and unaltered. The porphyritic felspars were of the description which I have already given, and very clear and fresh; the principal thing to be noted being the deposit of ferric oxide in translucent red patches in the fractures and cleavages. The augite was colourless in short, stout crystals. It also occurred as clusters of irregular crystals, and I also observed grains included in plagioclase felspars. This augite was more or less converted into calcite; enstatite was numerous, as previously described, and almost the whole of it was converted into bastite (serpentine). Iron ores were precisely as mentioned before. The ground-mass consisted as usual of very numerous microscopic prisms of apparently triclinic felspars, of magnetite grains, and some basis, together with minute trichites and brown spherulitic bodies. In addition to the above, there were in all the slices, but more in some than in others, cavities filled by agate.

The analysis was carried out mainly by the ammonium fluoride process, FeO was determined by the bichromate process, and the alkalis by Smith's method; SiO_2—$P_2 O_5$, CO_2, and $H_2 SO_4$ were specially determined. As neither TiO_2 nor MnO were met with in the course of analysis, I made special examinations confirming their absence. The specific gravity of the sample was taken by means of Walker's steelyard balance.

	Per cent.	Molecules.		Ratio.
SiO_2	53·39	177·98	Acids, less free SiO_2 =	3·822
$Al_2 O_3$	15·23	29·57	$R_2 O_3$ =	1·000
$Fe_2 O_3$	8·73	10·91		
FeO	3·61	10·03	RO =	1·503
CaO	8·46	30·20		
MgO	4·12	20·60		
$K_2 O$	1·84	3·92	$R_2 O$ =	·696
$Na_2 O$	3·60	11·61		
$H_2 O$	1·14	12·66		
CO_2	·22	1·00		
$P_2 O_5$	·16	·23		
	100·50		Proportion of Acids to Bases (Indicative Ratio).	1·194 to 1

Hygroscopic moisture	·60
Pyrite	·16
Specific gravity	2·814

It is interesting, where practicable, to ascertain by calculation the approximate proportions in which the various minerals exist in the rocks examined. This may often be done with considerable certainty when the chemical analysis is supplemented by a microscopic examination, and more especially when the rock is crystalline or crystalline-granular. Owing, however, to the porphyritic character of this Diabase porphyrite, it is not easy to satisfactorily calculate the percentages of all the rock-forming minerals. A difficulty arises at once in regard to the porphyritic felspars and to the microscopic felspars in the ground-mass. Another difficulty also arises as to the constitution of the basis, and also of some of the alteration products.

The basis being small in amount, and probably of the same general constitution as the whole rock, though, perhaps, more acid, I have necessarily disregarded. I have also left out of view the slight traces of chloritic material associated with the altered enstatite. If the rhombic pyroxene, as I conclude from the microscopic examination, has been almost entirely converted into bastite, then, for the latter, the formula for serpentine will probably be applicable. The other alterations—calcite, ferric hydrate, and agate—offer no difficulties. On this basis I have attempted the calculation of the analysis into the rock-forming minerals.

The microscopic examination has shown that the augite is probably a magnesia-lime augite—in other words, diopsid, and, therefore, having the empirical formula (RO, SiO_2) where RO may be (FeO, MnO, CaO, or MgO). The rhombic enstatite would be the same. Not being, therefore, aluminous pyroxenes, it is not necessary to allot any of the alkalis to them. There remain, then, only the felspars and the basis to which K_2O and Na_2O are to be assigned; and I have already stated that I leave the basis out of view. Disregarding this, and the traces of viridite, the whole of the alkalis may be taken to calculate the potassa and soda felspars. The amount of lime felspar is given by the remainder of Al_2O_3 after providing for the potassa and soda felspars. The H_2O would prohably be shared between the serpentinised enstatite and the ferric hydrate (limnite). The CO_2 and P_2O_5 give, of course, the amount of calcite and apatite respectively. The balance of CaO and the whole of $Mg.O$, with an equivalent number of molecules of SiO_2, indicate the augite; and there should be some SiO_2 over as representing the small agate amygdules discovered in the miscroscopic examination. Such a distribution of the rock-forming constituents—if the analysis be correct, and if I have correctly interpreted the microscopic data—should close without a remainder.

In making this calculation I have availed myself of a simple and effective method used by Professor Rosenbusch in his valuable work, "*Die Steiger Schiefer*," 1877. Not only is this method an extremely simple and effective one for calculating rock analyses, but it also affords an easy means of making a comparison of the ratios between the totals of acids and of bases which form the rock as a whole. To my mind it is preferable to the usual method of comparing the oxygen ratios. It affords what may be termed a mineralogical view of the composition of the rock instead of a merely chemical view. This is of great advantage when considering the probable proportions in which the various percentages are to be assigned to the constituent minerals. I have annexed this calculation to the analysis, and as it indicates a particular ratio for any one rock, and therefore a ratio within certain limits for a kindred group of rocks, I propose to speak of it shortly as the indicative ratio.

The method of calculation is based upon a comparative distribution of the constituent percentages calculated as molecules, between the minerals which are found to build up the rock, and the distribution is made in accordance with the most probable formula that can be assigned to the mineral.*

In calculating the molecular proportions of the percentages I have used the old atomic weights as giving simple numbers, and I have multiplied the results by 100, in order to bring them better under review.

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* I have made use of the formulæ given in Professor Groth's admirable "*Tabellarische übersicht der einfachen Mineralien*," Braunschweig, 1879.

Table A.—DIABASE-PORPHYRITE.

	Si. O_2.	Al_2. O_3.	Fe_2. O_3.	Fe. O.	Ca. O.	Mg. O.	K_2. O.	Na_2. O.	H_2. O.	C. O_2.	P_2.O_5.	Per cent.	Mole-cules.
	53·39	15·23	8·73	3·61	8·46	4·12	1·84	3·60	1·14	·22	·16	100·50	..
	177·98	29·57	10·91	10·03	30·20	20·60	3·92	11·61	12·67	1·00	·23	..	308·71
Calcite ..	..	..	..	..	1·00	..	..	..	..	1·00	..	·50	2·00
Apatite ..	..	..	..	..	·76	..	..	..	..	..	·23	·37	·99
Bastite ..	8·54	..	..	2·50	..	10·30	..	..	4·27	..	..	5·90	25·61
Limnite ..	..	..	2·80	..	..	..	..	..	8·40	..	..	3·00	11·20
Magnetite ..	..	..	7·53	7·53	..	..	..	..	..	..	..	8·73	15·06
Hæmatite ..	..	..	·58	..	..	..	..	..	..	..	..	·46	·58
Soda Felspar ..	69·66	11·61	..	..	..	..	..	11·61	..	..	..	30·45	92·88
Potassa Felspar .	23·52	3·92	..	..	..	..	3·92	..	..	..	..	10·92	31·36
Lime Felspar ..	28·08	14·04	..	..	14·04	..	..	..	..	..	..	19·58	56·16
Augite ..	24·70	..	..	..	14·40	10·30	..	..	..	..	..	13·50	49·40
Agate ..	23·48	..	..	..	..	..	..	..	..	..	..	7·04	23·48
Totals ..	177·98	29·57	10·91	10·03	30·20	20·60	3·92	11·61	12·67	1·00	·23	100·45	308·72

Assuming that the above calculation indicates the composition of this Diabase-porphyrite, a question remains as to the constitution of the felspars. This question, in fact, is—are the potassa, soda, and lime felspars associated together, or do they occur singly in this rock? Keeping in view Tschermak's theory of the felspars, there are, I think, three alternatives.

1. The potassa, soda, and lime felspars may be combined as a triclinic felspar, which occurs both as porphyritic and as microscopic crystals. This alternative is not, it seems to me, at all probable, for if the three are combined in a triclinic form, the potassa felspar would, I think, be most likely to be associated with the soda felspar as a potassa-bearing albite, which would then, in combining with the lime felspar, be in the proportion of albite 2·21 to anorthite 1·0—in other words, an oligoclase.

2. The potassa felspar may be in the ground-mass as orthoclase. The microscopic observations, that all the felspars in the ground-mass appear to be triclinic, negative this alternative.

3. The final alternative is that in the miscroscopic felspars, the potassa felspar and the soda felspar form together a potassa-bearing albite. For if the porphyritic plagioclase is taken in accordance with the microscopic data to be andesine, and of the normal constitution—namely, albite 1·0 to anorthite 1·0—then there remain for the microscopic felspars, soda felspar and potassa felspar in the proportions of 1·17 to 1·0. A felspar of such a composition is not improbable, although, judging from the analysis given by Rammelsberg, Dana, and other authorities, it might be expected to be monoclinic rather than triclinic. Yet the late researches of Fouqué[*] show that in the lavas of Santorin the porphyritic felspars are more basic than the microscopic prisms of felspar in the ground-mass, and that, moreover, the felspars have crystallised in the order of basisity. In the lavas of Georgios, where the porphyritic crystals were labradorite, or even anorthite, the numerous minute felspars in the ground-mass were albite, with perhaps a little oligoclase. It is noteworthy that in the analysis given of the albite, there is 1·33 per cent. of potassa evidently isomorphic in the compound with soda, while in the porphyritic crystals there is but ·08 per cent.

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[*] Fouqué.—*Santorin et ses Eruptions*, Paris, 1879.

Some additional support is afforded to the third alternative by observations which I have made as to the results of digestion of thin slices of the Diabase porphyrite in concentrated hydrochloric, and for periods varying from twenty-four hours to a week. The porphyritic felspars were only slightly affected, even after the longer period, being still tolerably clear and not having lost their characteristic polarisation. The microscopic felspars in the ground-mass seemed to be absolutely unaffected by this treatment. Although not much reliance can be placed upon such experiments, in so far as they may be supposed to indicate the variety of felspar present, yet in this case it is evident that a difference exists between the porphyritic and microscopic felspars. The latter being not all affected are doubtless nearer to albite than the former.

It seems to me, therefore, on these grounds, that the third alternative agrees best with the data before me, and that the porphyritic felspars may be regarded as andesine, and the microscopic felspars as albite, in which the potassa felspar in its triclinic form is isomorphuous with the soda felspar. The constitution of a nominal andesine is albite 1·0 to anorthite 1·0 ; but here the optical measurements suggest an andesine, say, of albite 1·0 to anorthite 1·2 or more. In this discrepancy I incline, considering the difficulties in the way of obtaining satisfactory optical measurements, to give most weight to considerations drawn from the chemical analysis.

Supported by the foregoing arguments the following may be taken as the composition of the Diabase porphyrite of the Snowy River. The secondary ores of iron are calculated as magnetite, and the bastite as enstatite.

		Per cent.		Molecules.
Felspars	...	60·95	...	180·40
Augite	...	13·50	...	75·00
Enstatite	...	6·80		
Magnetite	...	10·62	...	18·32
Apatite	...	·37	...	·99

or felspar, pyroxene, magnetite, in the proportion of nearly 10.-4.-1. This shows the great preponderance of the felspars over pyroxene, which is one of the characteristics of Diabase porphyrite.

In order to compare this rock with others of the Diabase group, I have calculated twenty-eight analyses, as given in the various works at hand.* I find in them the indicative ratio to lie between the following extremes:—

Diabase (11 analyses) ...	1·00 — 1·00 to 1·23—1·00
Augit porphyr (11 analyses)...	1·00 — 1·00 to 1·13—1·00
Labrador porphyr (6 analyses)	1·24 — 1·00 to 1·81—1·00

In these calculations there is, however, this difficulty, that there is no means of knowing whether some of the silica is not free, as in the rock I have described; nor does it seem that in all, or even most, cases regard has been paid to the presence or absence of CO_2 or P_2O_5, nor, the combined H_2O. The results are, therefore, only approximate, but they may possibly serve to roughly define the limits of the groups. Such being the case, then, this Diabase porphyrite, having the indicative ratio of 1·194 to 1·000, clearly stands at the end of the Diabase series and at the commencement of those porphyritic Diabase rocks which have been called "Labrador porphyr." If, as is probably the case in some of the analyses which I have calculated, all the silica, whether *combined* or *free*, were taken into account, then the indicative ratio would rise to 1·384 to 1·000, which would bring this rock well into the "Labrador porphyr" series. Having thus discussed at length the composition and structure of the Diabase porphyrite, I now proceed to show the position it holds in the series of formations amongst which it occurs.

A mile or thereabouts up the Snowy River from Moore's Crossing, and on the eastern side, there is an excellent example of the contact of the Diabase porphyrite with the Buchan limestones. The details of the various beds, which I now give, commence with the lowest rock visible in the river bed.

1. Massive Diabase porphyrite forming the river bed. In places it contains amygdules (agate, chalcedony), and also veins and small masses composed of a crystalline aggregate of quartz and epidote. A thin slice examined under the microscope showed the following particulars:—

The structure is micro-porphyritic. The ground-mass is composed of—(*a*) a colourless basis full of very numerous minute black dust-like particles, either scattered singly or in groups, or arranged linearly; (*b*) minute felspar prisms (triclinic ?); some of the minute felspar prisms have sharply defined outlines, while in others the planes are studded with

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* Amongst others, Bischoff, *Lehrbuch*, &c., 2nd edition, 1864; Zirkel, *Lehrbuch*, &c., 1866; *Neues Jahrbuch für Mineralogie*, &c.

minute black granules, and are therefore irregular; (*c*) very numerous granules and crystals of magnetite; (*d*) very numerous prisms and needles of apatite.

In this ground-mass are:—

Triclinic felspars, most of which are compounded of rather wide lamellæ. One crystal is, however, very compound (albite law), the lamellæ being very narrow. Some few have no striations. The optical angles measured were—

OP (001).	$\infty \breve{P} \infty$ (010).	$\infty \bar{P} \infty$ (100).
3° 30′	13°	21°

Enstatite very plentiful in prismatic forms of smaller size than usual. Alteration has so far proceeded that but little remains of even the chloritic minerals. The prisms are all dull, rather opaque and cloudy, with flaws and cracks lined with iron ores.

Augite.—In less amount than usual, but otherwise similar in character, and alterations to the instances described already.

Magnetite.—A few large rectangular crystals.

The principal alteration products are enstatite to chlorite, and some of the felspars to aggregates of colourless or slightly yellow doubly refracting flakes, and of magnetite to ferric hydrate. Flakes of viridite are also numerous in some few of the felspar crystals.

2. A coarse breccia of fragments of No. 1.

3. Vesicular Diabase porphyrite. This is about fifteen feet in thickness. A thin slice showed that it consists of a ground-mass composed of—(*a*) yellowish, slightly micro-felsitic basis, (*b*) brown translucent to opaque spherulitic bodies (these are so numerous as to make the ground-mass very opaque), (*c*) many minute felspar prisms, (*d*) magnetite grains or crystals, (*e*) a few needles of apatite, (*f*) a few black thorn-like microliths. In this ground-mass are:—

Plagioclase felspars.—These are so much altered that the striations are barely perceptible. *Augite* in colourless, short, stout prisms, some of which are almost wholly converted into calcite. Beside the calcite alterations, I observed others which I believe to be epidote.

Enstatite numerous, but smaller in size than the monoclinic pyroxene. It is wholly converted into some form of viridite. The vesicles in this rock are filled by agate amygdules, most of which are more or less bordered with the minute bright green aggregate which I have before mentioned.

4. Purple to reddish indurated mud. The lower part of this bed is full of large rounded boulders of No. 3. It is three feet in thickness.

5. A fragmental bed, three feet thick. The fragments are subangular, and under 5 inches in diameter. They all seem to be varieties of felsite.

6. Purple indurated mud, two feet thick.

7. Coarse breccia conglomerate. The fragments under six inches diameter and of varieties of felsites, white to purple in colour, or banded in different shades of colour. This bed is four feet thick, and weathers very rapidly.

8. Yellowish brown clayey material, two feet in thickness.

9. A fragmental bed, six feet in thickness. The fragments under three inches diameter. A slice taken from a portion of the finer-grained materials showed them to consist of angular and subangular pieces of felsite, of crystaline quartz grains, and of more or less broken crystals of orthoclase and of plagioclase, the former being most numerous. The fragments are cemented together by lesser fragments of the above, filled in throughout the inter-spaces by quartz and chalcedony.

10. An earthy bed enclosing felsite fragments. There are, however, two bands in it of more indurated material. This bed appears to have been a felsite ash or tufa, three feet thick.

11. Indurated materials, resembling No. 10, and two feet thick.

12. A yellow earthy bed, containing numerous fragments of felsite under one inch diameter.

13. A bed a foot thick of minute fragments, resembling an ash or tufa.

14. Grey compact limestones, dipping W, at 15°.

The total thickness of beds is about 46 feet; and Nos. 4 to 13 conform in general dip to No. 14.

This section shows clearly that the limestones have been laid down upon the Diabase porphyrites and on the passage beds connected with their abraded surface. It is also evident that at the time the sediments were formed part of the felsitic materials resembled a volcanic ash. The vesicular nature of the upper surface of the Diabase porphyrite also points to its having probably been a lava; and looked at by the light of evidence furnished by the natural sections to be seen in the district, it was most likely poured out on the coast line of a sinking volcanic land.

In tracing down the river from this point to its junction with the Buchan, I made further observations. I found the Diabase rocks near Moore's Crossing to be rough, massive, and dark coloured. They weather dark brown, and are often so much decomposed as to be well described by the old name of "claystone porphyry." Further down the river they are very vesicular or amygdaloidal, or again, crystalline or microporphyritic. These rocks generally are traversed in all directions by veins of calcite and of red jasper, which also occur singly or together in geodes. In one place I observed appearances strongly suggestive of bedding; but the alterations in the rock were there so great that I was not able to determine this point to my satisfaction.

As the Buchan limestones have been generally denuded from these rocks along the river, the traces of their former existence are only observable in the extensive alterations which their contact with the igneous rocks has given rise to. The reactions have, however, been clearly subsequent to the consolidation of the Diabase rocks, and are, therefore, not to be confounded with ordinary "contact effects."

At about forty chains distance from the junction of the two rivers a change of rocks is evidenced by the different surface features, and an alteration in the nature of the soil, and the character of the vegetation. At the junction itself the rocks can be seen, and it then becomes apparent that the formation is one of the areas of Lower paleozoic (silurian ?) mudstones and sandstones in a greatly altered condition. The evidences of folding and contortion are very strong, and the rocks strikingly resemble some of the forms of metamorphic contact schists. Their present position alongside of the Buchan beds must be due to faulting, as they are highly inclined, whereas the former are comparatively horizontal. One sample examined under the microscope showed me the familiar appearance of a metamorphic contact schist. It consisted of fragments of quartz and felspars, set in a paste (mud) which had been converted into micaceous substances. Another sample of one of the most contorted varieties I found to be almost entirely mica—some of the larger flakes being evidently muscovite.

On leaving Moore's Crossing the line of section follows throughout the direction of the track, leading thence to Buchan. The Diabase porphyrites continue from the river to near the summit of the range, where come in felsitic rocks having the usual appearance of those near the Murendel River. These continue along the track to the Murendel River, but their continuity is broken in three places at least by masses or wide bands of a dark-coloured basic rock, more finely crystalline than those I have just described. The section terminates at a high hill of massive felsite on the western side of the Murendel River. This hill appears to have been an original protuberance round which the Middle Devonian marine limestones have been laid down, and which still enclose it on three sides. Immediately to the south of this hill Buchan limestones have either been originally laid down upon, or have been broken through by the olivine bearing rocks, in which the adit of the Murendel-south Lead Mine was driven. I have referred to these rocks in a former paper.* I was then inclined to regard these olivine bearing rocks and the intrusive dyke-like masses beyond the Murendel mine as being, in fact, the same. I now propose to add some further particulars resulting from more recent investigations. My remarks refer now to the dyke-like masses near the Murendel mine, and along the track, as shown in the section accompanying this paper. The extreme freshness of appearance of this fine-grained rock, and its occurrence as an intrusive dyke of considerable size in the Lower Buchan beds might lead to the suspicion that it is comparatively recent in geological age as compared with the Diabase porphyrite of the Snowy River. It even bears some resemblance, when examined in thin slices, to some of the miocene tertiary volcanic rocks of the Dargo High Plains. I hoped that by examining it carefully both by microscopic and chemical analysis, I might be able to form an opinion not only as to its position in the petrographical system, but even to hazard a conjecture as to its geological age. These data might then also bear upon the question whether the olivine-bearing rocks of Murendel south are intrusive or contemporaneous. I selected a sample for examination from the dyke-like mass crossed by the track immediately before reaching the Murendel mine.

The examination of several thin slices showed me that the rock is composed of a ground-mass consisting of :—

(*a*) A little pale, brownish yellow to almost colourless basis. In some slices this basis is almost absent.

(*b*) Minute felspar prisms in great numbers. These appear to be all triclinic, and in some slices show flow structure very perfectly. Where most numerous, they are also often arranged radially, or are clustered round augite grains.

(*c*) Grains and crystals of magnetite.

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* *Report of Progress Geological Survey of Victoria,* Part V., p. 117.

(*d*) Very numerous needles and prisms of apatite.

This ground-mass is decidedly of a micro-crystalline character, but in it are small porphyritic crystals of—

(*a*) Triclinic felspars, in which the brachypinacoid predominates, producing tabular crystals. I could not obtain any reliable optical measurements.

In some slices these felspars were much altered to aggregates of flakes, apparently micaceous. This was not the case in the rock sample which I selected for analysis.

(*b*) Crystals and crystalline grains, singly or in clusters, of an almost colourless augite. Twinning frequent, according to the ordinary law, composition face being $\propto \bar{P} \infty$ (100).

(*c*) Crystals of magnetite.

(*d*) Spaces filled by secondary products, usually quartz or agate, but also calcite, and more rarely the minute green siliceous amygdules which I have already mentioned in speaking of the Diabase porphyrite. Chloritic minerals (viridite) are rare, and, in fact, the principal pseudomorphs appear to be calcite after augite, and ferric hydrate after magnetite.

The miscroscopic examination of this rock shows many points in common between it and the Diabase porphyrite of the Snowy River, and strongly suggests that it is merely a somewhat different form of the same igneous rock.

In order to make further comparisons, I prepared slices from samples of an extremely hard and compact rock which underlies the Devonian limestone at the junction of the Buchan and Murendel rivers.

On examining it under the microscope, I found its structure to be completely micro-crystalline, being composed of a perfect network of microscopic felspar prisms, filled in by augite grains and magnetite. In this ground-mass were a few larger triclinic felspars, and rather more numerous crystals of augite, so that, in fact, the structure of this rock approached the micro-porphyritic; the porphyritic mineral being mostly augite.

In this rock, a number of the augite crystals had been removed, and the spaces filled by brown iron ore, which is also common in the slice, and is often connected with remains of magnetite.

The following quantitative analysis is of the sample selected for examination. The indicative ratio of this rock is smaller than that of the Diabase porphyrite. In calculating it, I have, as before, disregarded the free silica as being extraneous and variable in amount. The microscopic examination showed that it is to be regarded as a finely crystalline form of Diabase, and the above ratio agrees well with that conclusion :—

DIABASE—MURENDEL MINE.

	Per cent.	Molecules.	Ratio.	
$Si.O_2$	48·48	161·60	Acids, less free $Si.O_2$	= 3·760
$Al_2 O_3$	14·57	28·29	$R_2 O_3$	= 1·000
$Fe_2 O_3$	11·68	14·60		
FeO	2·83	7·86	RO.	= 1·626
CaO	9·56	34.14		
Mg.O	5·55	27·75		
$K_2 O$	1·77	3·77	$R_2 O$	= ·784
$Na_2 O$	3·33	10·74		
$H_2 O$	1·72	19·11		
CO_2	1·27	5·78		
$P_2 O_5$	·45	·63		
		101·21		

Indicative Ratio = 1·194 to 1.

Hygroscopic moisture	·85
Specific gravity	2·807

This analysis may be more readily calculated for mineral percentages than the former one, as being of a crystalline rather than a porphyritic rock. The CO_2 and $P_2 O_5$ clearly indicate the amount of calcite and apatite respectively. In the absence of alterations to kaolin, serpentine, or chlorite, the whole of the $H_2 O$ probably belongs to the ferric hydrate; and the remainder of the $Fe_2 O_3$ should indicate the magnetite. In fact, there remains, however, a small portion of $Fe_2 O_3$ over, which may be either regarded as an analytical error, or as representing ferric oxide (hæmatite, ironglance), which has not been recognised under the microscope. The alkalis may be assigned wholly to the soda and potassa felspars, leaving the remainder of the $Al_2 O_3$ as before, to give the amount of the lime felspar. The balance of the CaO, with the whole of the Mg O, together with a proportionate part of the Si O_2, should give the augite, leaving a small balance of Si O_2 for the free quartz and the agate recognised under the microscope. On this plan I have framed the following scheme :—

DIABASE.

	$Si. O_2.$	$Al_2. O_3.$	$Fe_2. O_3.$	Fe. O.	Ca. O.	Mg. O.	$K_2. O.$	$Na_2. O.$	$H_2. O.$	$C. O_2.$	$P_2. O_5.$		
Per cent,	48·48	14·57	11·68	2·83	9·56	5·55	1·77	3·33	1·72	1·27	·45	..	101·21
Molecules	161·60	28 29	14·60	7·86	34·14	27·75	3·77	10·74	19·11	5·78	·63	314·27	..
Calcite	..	..	..	..	5·78	..	..	..	..	5·78	..	11·56	2·89
Apatite	..	..	..	..	2·10	..	..	..	..	..	·63	2·73	1·04
Limnite	..	..	6·37	..	..	..	..	..	19·11	..	..	25·48	6·82
Magnetite	..	..	7·86	7·86	..	..	..	..	..	..	..	15·72	9·12
Hæmatite	..	..	·37	..	..	..	..	..	..	..	..	·37	·30
Potass Felspar	22·62	3·77	..	..	..	..	3·77	..	..	..	..	30·16	10·50
Soda Felspar	64·44	10·74	..	..	..	..	..	10·74	..	..	..	85·92	28·19
Lime Felspar	27·56	13·78	..	..	13·78	..	..	..	..	..	..	55·12	19·23
Augite	40·23	..	..	..	12·48	27·75	..	..	..	..	..	80·46	21·11
Free Silica	6·75	..	..	..	..	..	..	..	..	..	..	6·75	2·02
Totals	161·60	28·87	14·60	7·86	34·14	27·75	3·77	10·74	19·11	5·78	·63	314·27	101·32

The ratios between the minerals, as disclosed by this calculation of the analysis, are as follow :—

	Per cent.	Molecules.
Felspar	58·82 ...	173·52
Augite	21·05 ...	80·24
Magnetite	13·04 ...	19·64

or felspars, augite, magnetite, as nearly 9· 4· 1·.

This ratio indicates a Diabase rock in which the felspars are not so preponderating as in the Diabase porphyrite of the Snowy River. The ratios between the felspars are the following :—

Albite, orthoclase, anorthite, as 3· 1· 2·, nearly.

As there were no reliable measurements from which to form an opinion as to the probable character of the small porphyritic felspars, I can only follow the considerations which influenced me in the former case. If the larger felspars are regarded as normal andesine of the composition albite 1· to anorthite 1·, then there remain over potassa felspar and soda felspar in equal proportions, which may be regarded as a potassa-bearing albite, existing as the microscopic triclinic felspars of the groundmass.

There can be, it seems to me, no reasonable doubt that this rock, which at Murendel occurs as intrusive masses in the felsitic beds (Lower Buchan beds), is the same, under somewhat different structural conditions, as is found conformably underlying the Buchan limestones (Upper Buchan beds) at the Snowy River.

On the western side of the Murendel River, close adjoining the termination of the section which I have given, are the olivine-bearing igneous rocks, in which the adit of the Murendel-south Mine has been driven. I have not been able to find any natural sections in which the actual relations between these olivine-bearing rocks and the overlying marine limestones could be traced. It seemed to me useless to carry out a quantitative analysis of the former. They have undergone so much alteration that scarcely any points of comparison with those already analysed would remain. Their microscopic features I have described in the papers already quoted. For the present, it must remain undecided whether the olivine-bearing rocks form part of the great group of Diabase rocks of the neighbourhood, or are much altered basalts of tertiary ages, or melaphyrs of older. I have at present no data to decide this question.*

I have shown reasons for believing that the intrusive igneous rocks at the Murendel, and along the track thence to the Snowy River, as well as the contemporaneous rocks at the Snowy River itself, are all varieties of Diabase. To this must be added similar rocks at Back Creek, and on the eastern side of the Buchan River, near that place. It is necessary to enquire now, what are the relations of these igneous rocks to the great group of formations, called the Buchan beds, and among which they are found ?

At Buchan, Murendel, Butcher's Creek, Rodger's Creek, the Snowy River, and Gellingall, the characteristics of these Buchan beds are always the same. I have found the group to consist invariably of two well-marked divisions.† A lower series (Lower Buchan beds) of from four hundred to five hundred feet in thickness, almost wholly of fragments of felsitic and, more rarely, sedimentary rocks, with interposed felsite sheets ; the upper series (Upper Buchan beds), of from 750 to 1000 feet in thickness, consisting almost wholly of marine limestones, rich in remains of corals, mollusca, and placodermatous fish of Middle Devonian age. The exception to this completely calcareous nature is in the passage-beds at the base of the series, in which the felsitic and calcareous characters are commingled, decreasing as to the former in passing upwards, until, at heights varying from (say) ten to fifty feet, the beds are the purely marine limestones, characteristic of the Upper Buchan beds.

The two groups are not discordant to each other, the distinction being in the nature of the materials of which they are composed. In addition to the particulars relating to the contact of the Upper and Lower Buchan beds, which I have given in the previous papers quoted, I now give the following :—

I have found the contact of the limestone and fragmental beds to be well marked near the Murendel mine, and on tracing the beds further up the Murendel River, it became evident

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* Whilst this paper has been going through the press, I have had an opportunity of again visiting this locality. A careful examination has satisfied me that the olivine-bearing rocks are, in fact, part of the same group which here generally and immediately underlies the marine limestones. Here, as elsewhere, the beds are some crystalline and some fragmental. I reserve fuller particulars for a future communication.

† *Progress Report Geological Survey of Victoria*, Part V., p. 117.

to me that the same contact continued well marked throughout. There are always more or less of passage-beds. The underlying felsitic beds are not, however, of the same character in all places. Near the Murendel Mine the upper bed of the lower series is distinctly composed of a mass of felsitic fragments, among which felspar particles are recognisable—therefore probably a tufa.* Some miles higher up the river the passage-beds rest upon a true quartz felsite. Intermediately, I found felsitic rocks of both kinds, and also of varieties of which I could not say, with any feeling of certainty whether they were originally fragmental or not. I have said that in tracing the course of the Murendel River upwards, it is also possible to trace with more or less distinctness the course of the felsitic beds on which the Upper Buchan beds (Buchan limestones) rest. It is seen that the latter have not only a general westerly dip, but also a marked undulation along the strike, thereby producing a number of secondary dips at right angles to the main dip, but of limited area and extent, forming a series of synclinals and anticlinals. The felsitic rocks, the passage-beds, and the lower of the marine limestones, therefore, alternately rise and fall below the level of the stream, which may be broadly stated to flow along the contact of the upper and lower beds. Thus there are usually on the western side high and precipitous limestone cliffs, showing at their base traces of the felsitic beds; while on the eastern side are almost wholly rugged hills of harsh and massive felsites.

On approaching that part of the valley known as the Pinnacles, where the river has formed a subterranean passage through the limestone hills, and only flows over the surface during floods, the felsites no longer have the well-marked, bedded, and fragmental character of those nearer the mine, but are to all appearance characteristic examples of a reddish or salmon-coloured quartz felsite.

In certain places I found it to have a ground-mass resembling a reddish felsite, studded with rather perfect dihexahedra of quartz. The rocks are then traversed by a few joints, dipping S. 70° W. at about 26°. The river has eroded during floods a channel in these hard and massive rocks, with smooth and almost polished sides, and with many huge "giant kettles." This is very favourable for the study

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* Locally where the Diabase rocks occur the fragmental beds are either composed wholly of their fragments or of these mixed with felsitic materials.

of the rock structure. I found several places where there were many fragments of other kinds of felsites embedded. In one small area of about twelve feet in diameter I observed embedded angular fragments of red quartz felsite, fine grained grey felsite (felstone), compact grey felsite, and dark coloured, almost black, felsite. The fragments were some larger and some smaller than about an inch cube. I have made the following observations on a thin slice of this rock:—

It has a large proportion of ground-mass, in which is so large an amount of yellowish basis, that the slice remains very much obscured throughout when rotated between crossed nicols. It shows fluidal structure strongly. There are many minute granules of quartz in the ground-mass together with microscopic felspar prisms, which latter are almost invariably arranged with their longer axes parallel to the course of the flow. There is also a little iron ore (magnetite ?) in grains, and finally many dark brown, to almost black, long and somewhat ragged-edged microliths, which are otherwise undefinable. In this ground-mass are:—

(*a*) Quartz crystals, with either crystalline outlines or as fractured pieces. Sinuses of ground-mass penetrate them in the usual manner, or the ground-mass separates fractured parts. Fluid cavities are small and infrequent. The only inclusions I observed were portions of ground-mass and minute portion of slaggy-looking material.

(*b*) Felspars, some of which are orthoclase and some plagioclase. All have very imperfect outlines, more especially the former, as if partially refused after crystallisation. The triclinic felspars have all, so far as I could obtain measurements, low angles formed by the plane of vibration, namely, between 2° and 15°, and are, therefore, probably either albite or oligoclase. The felspars contain many minute green flakes, which may be a chloritic mineral.

(*c*) A few minerals having a long prismatic habit and a rhombic cross section. They are much altered to viridite and to ores of iron (magnetite ?). I was unable to observe any dichroic effects in the small portions having a pale green colour still remaining clear and translucent. The rhombic cross sections have the angles of amphibole, to which group I refer this mineral.

Finally, there are a few crystals of apatite, of which the greater number are included in the felspars.

The microscopic examination of this rock shows all the characteristic features of a quartz felsite, and I think that the most reasonable conclusion to arrive at is, that it represents a "lava flow" contemporaneous with the formation of those felsitic beds which occupy the same relative position to the limestones elsewhere, that this quartz felsite does at the place described. The numerous embedded fragments must in this case be regarded as having been taken up by the fluid lava. The full relations of this rock to the associated fragmental beds can only be ascertained by a more minute examination of the intervening parts of the Murendel valley than I could as yet make. I must, however, point out that I have observed and described a case at the Buchan River, near Mount Dawson, where I could distinctly trace the passage of a fragmental felsitic bed into completely compacted rocks, exactly resembling a quartz felsite in outward appearance. In that case I could not feel any doubt that the felsitic material had been regenerated by means of some form of metamorphism as a rock simulating a quartz felsite. In this present case, however, I cannot either feel any doubt that the rock I have just described is a true eruptive rock.

The Buchan beds, as I have here and elsewhere described them, rest as a whole upon a vast thickness of the still older Snowy River porphyries. These, which occupy at least an area of 500 square miles, are composed of felsitic rocks, such as massive quartz felsites (quartz porphyries) of a granitoid, or of a compact, or, in places, even a vesicular, character. A very large proportion consists of fragmental beds either more or less bedded, or being agglomerates, not only of the above felsitic rocks, but also of older sediments (silurian), or even of granite. The fragments are of all sizes, from dust up to many tons in weight. Felsite dykes are a feature in many places traversing them. The thickness of the Snowy River porphyries is not evident, as they extend from the summit of the table-land of Woolgulmerang, where they are best seen, down to the very water-level of the Snowy River, where the sections terminate—a depth of some 2000 feet.

The Snowy River porphyries are to all appearance younger than the Upper Silurian, and they are certainly older than the Middle Devonian Buchan beds which rest upon them. It is possible that they may represent the Lower Devonian formations which have hitherto not been recognised in Victoria. If so, it would probably have been a period of volcanic and terrestrial conditions terminating in the general subsidence indicated by the transition from the Lower to the Upper Buchan beds.

The Diabase rocks which I have described in these notes, I find at Murendel to have penetrated the felsitic Lower Buchan beds; at the Back Creek, to underlie the calcareous Upper Buchan beds, with apparently passage-beds connecting the two; and at the Snowy River, to be clearly and unmistakably in this position as regards the same formation. It seems, therefore, unavoidable to arrive at the conclusion that the Diabases of the Buchan district represent volcanic rocks, which date from the period of time marked by the change of material which distinguishes the Lower from the Upper Buchan beds. In other words, they represent at places near Murendel the "necks," while at the Snowy River they represent the flows themselves.

In some previous notes on the interbedded volcanic rocks of the Snowy Bluff,* I came to the conclusion that as they appeared to have originally consisted of the minerals plagioclase, augite, magnetite, and very rarely a little olivine, with some traces of a basis, they were to be regarded as highly altered basalts, or having regard to their being of upper paleozoic age, melaphyrs. In studying the Diabase rocks of Buchan and the Snowy River, I observed many striking similarities of composition and structure to the above, and I again examined the thin slices I had prepared of the Snowy Bluff rocks, and compared them with those discussed in this paper. The results I may thus state :—

1. The geological age of the two groups is—Upper paleozoic, those of the Buchan district being Middle Devonian, whilst those of the Snowy Bluff, are probably Upper Devonian.

2. Both rocks, to judge from the least altered samples, were composed of the minerals plagioclase, augite, and magnetite. In those of the Snowy Bluff traces of olivine are so rare, occurring, so far as I have observed, in only one of the many interbedded sheets, that its presence may be said to be the exception, proving the rule of its absence. The olivine-bearing rocks of the Murendel may yet prove to belong to the Diabase group of that district, and so become a parallel to those of the Snowy Bluff.

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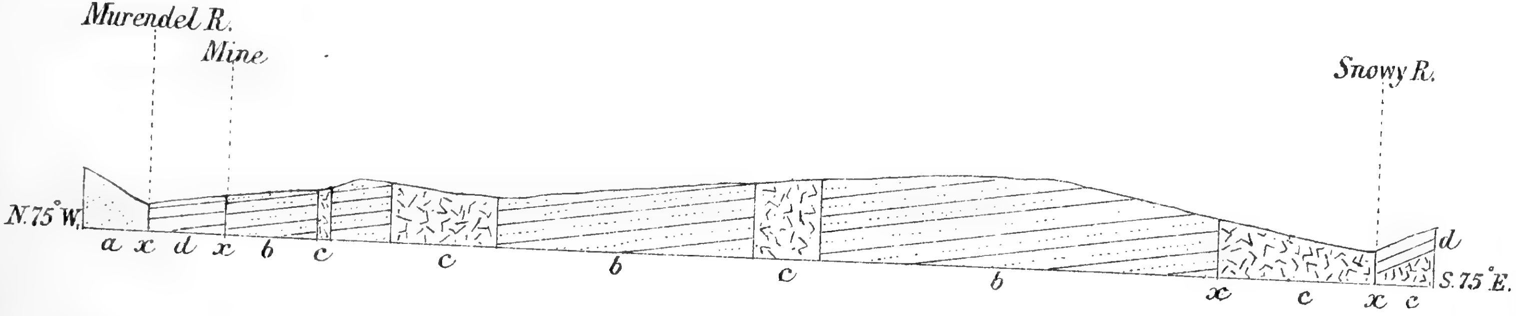
* *Progress Report*, *Geological Survey of Victoria*, Part III., p. 75.

3. The alterations which have taken place in the two groups of rocks are analogous to each other. There appears to have been more or less molecular decomposition and recomposition of the rock-forming minerals. The alteration products of the Snowy Bluff rocks have been silica and silicates, while those of the Buchan district have been silica, silicates, and also carbonates. This difference is only due to local conditions.

4. If olivine be regarded as an essential constituent of basalt, and as marking the distinction between that rock and augite-andesite, as well as between melaphyr and diabase, then this rock both of the Snowy Bluff and of the Buchan district would be referred to Diabase.



a. b. Lower Buchan Beds, c. Diabase, d. Upper Buchan Beds, x. Faults.

Diagram Section from the Snowy River to the Murendel River.

Scale, about 40 chs. to one inch.

ART. VI.—*Some New Species of Bryozoa from the Marion Islands,* with Notes on Bicellaria Grandis.*

BY J. R. Y. GOLDSTEIN.

[Read 9th June, 1881.]

ON looking over a few specimens, part of a series kindly distributed by officers of the "Challenger" while in Melbourne, but only recently brought under my notice, I found six species of Bryozoa, marked as from the above locality. One was the well-known *Idmonea marionensis.* The other five appear to be new; and as they happen to be specially interesting just now, I have considered it advisable to describe and figure them at once, rather than wait for the appearance of Mr. Busk's work on the "Challenger" collection, which will probably not be available for some time, and which may not contain the present species.

I am encouraged in this haste to announce new forms by similar contributions that have appeared recently in several numbers of the *Annals and Magazine of Natural History,* from the pen of Dr. Hincks, and an article by Mr. Busk on *Kinetoskia,*† in *Quarterly Journal of Microscopical Science* for January of the present year.

The five species described below comprise an interesting addition to the genus *Alysidium;* a pretty *Bicellaria* of small dimensions; a very interesting form, that must be placed in Busk's family of FARCIMINARIADÆ, but requiring a new genus to be erected for it; the fourth is a *Vincularia* that deserves special notice, owing to recent remarks by Dr. Hincks on his genus *Steganoporella*‡ and on the genus *Vincularia;*§ and the fifth is a curious form placed in the genus *Hornera,* not without some hesitation.

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* South Indian Ocean.

† The *Kinetoskia cyathus* there described seems to be very closely allied to *Bugula robusta,* Macgillivray, common in these seas; the cells are almost identical in the two species, but the stems are different.

‡ *Brit. Mar. Polyzoa,* p. 177. *Ann. and Mag. Nat. Hist.,* Vol. VI., No. 36, Nov., 1880.

§ *Ibid,* Vol. VII., No. 38, Feb., 1881.

It is to be regretted that the system of classification proposed by Dr. Hincks in the introduction to his valuable *History of British Marine Polyzoa* presents a primary difficulty, and a serious one for Australian observers, in that it allows of no expansion, while failing to provide places for many well-known forms. True, the work is confined to British species; but in the remarks on classification* the talented writer evidently refers to the whole class, and then proceeds to base his proposed system† on British species only. The result, unfortunately, is not comprehensive enough to embrace foreign species, and is so arranged as actually to prevent the intervention of fresh families‡ without straining and distorting the system. Thus, at the outset of the present paper, I am forced, not unwillingly, to revert to the older system of Busk, which permits the insertion of almost every known form, although arranged many years ago when comparatively little was known of the Bryozoa; while in the system that Dr. Hincks now proposes to substitute for it no place can be found for three of the five forms described below. Fam. VI., CELLARIIDÆ, seems to offer a home for the *Vincularia*, but the author has himself since relegated this genus to his Fam. IX., MICROPORIDÆ§ at the same time observing that *V. ornata*, Busk, and *V. neozelanica*, Busk, should be in Fam. VIII., MEMBRANIPORIDÆ. Accepting the statement of Dr. Hincks, that "our knowledge of the polyzoa is not yet sufficient to admit of a strictly natural classification, and our arrangement of them must still be to a large extent more or less artificial,"‖ it must be apparent that the many reiterated attempts that have been made to make the system only a little less artificial are more likely to cause confusion than to prove beneficial. The time being not yet ripe for a natural system, it would have been better to have adhered to the classical work of Busk as a standard; improvement without confusion could then be obtained by subdivision and re-arrangement of the more cumbrous families and genera.

**Brit. Mar. Polyzoa*, Introduction, pp. cxviii—cxxxiv.

† *Ibid*, pp. cxxxvi—cxli.

‡ This difficulty might have been partly obviated by omitting to number the families.

§ *Ann. and Mag. Nat. Hist.*, Feb., 1881, p.

‖ *Brit. Mar. Polyzoa*, p. 183. (It is sad to think that this is written thirty years after Mr. Busk said the same thing, using almost similar words, in his *British Museum Catalogue*, Part II., p. 63.)

It is in this direction that Dr. Hincks' work is of real service; his subdivisions of the old genus *Lepralia* are very useful, and will readily commend themselves to all students. But, with regard to the general system, observers must feel that no classification of the Bryozoa can be useful that does not take into consideration the many varieties of form found living in Australian seas and fossil in Australian tertiaries.

It may be surmised that Prof. Smitt's efforts to construct a genealogical classification, and the stress he puts upon the assumed necessity of assigning first place to the form of the cell alone in the construction of families and genera, without regard to mode of growth, have greatly influenced the labours of Dr. Hincks; and, although the latter declines to accept in its entirety a proposition so revolutionary,* he has so far followed it that he assigns a strictly secondary place to mere zoarial habit;† and yet it must be maintained that in most genera zoarial habit *is* of equal importance with the character of the cell.

I am constrained to offer these views, doing so with great diffidence, because anxious to have the assistance of a really good system in working out the classification of a very large number of strange forms, obtained during several years of constant observation confined to this particular class. And after years of hopeful anticipation with regard to the long expected work of Dr. Hincks, I must confess great disappointment on finding it so little suited for the arrangement of Australian species. It is to be hoped, however, that that talented writer may soon be induced to publish a second edition of his otherwise admirable work; and that it will contain a system of classification more in accordance with the requirements of students in all parts of the world. Mr. Busk's advanced years and fully occupied time will probably preclude all hopes of extended labours in this direction; otherwise it might be anticipated from his long and intimate acquaintance with the subject, and the broad views evinced in his dealings with its difficulties in former years, that any alterations or elaboration of his old system, from his own pen, would be cordially welcomed by all observers.

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* *Brit. Mar. Polyzoa*, p. 180.

† *Ibid*, Introduction, p. cxxix.

Sub-order CHEILOSTOMATA, Busk.

Family CATENICELLIDÆ, *Busk.*

Genus Alysidium, *Busk.*

Alysidium inornata, n. sp. Plate I.; Fig. 1.

Cells translucent, without ornament or appendage of any kind; much elongated and tubular below; aperture oblique, occupying the whole width of cell at distal end, contracted internally; operculum small, oval, central; ovicells —.

Locality.—Marion Islands. "Challenger" Expedition.

The cell walls are so transparent that in the living state this species would afford every facility for anatomical observation. My specimen has ten cells; in several the form of the zooid is plainly seen, showing, however, only the closed tentacles disappearing at the lower end in a small confused mass of clear granular matter; seeming to indicate an extremely small body of the simplest form.

Family BICELLARIADÆ, *Busk.*

Genus Bicellaria, *Blainville.*

Bicellaria pectogemma, n. sp. Plate I.; Figs. 2 and 2A.

Cells small, much expanded above, tubular long and attenuated below; each cell arising from a short tubular process on the breast of the cell below on the same side, and attached to the next cell on the other side by a slight expansion of the tube a little below where the next cell above is given off; aperture large, wide, and square at outer end, narrowing inwards; operculum wide, and nearly square above at upper and outer end; cells armed with 2-6 long curved spines, springing from a slightly raised process, set transversely across upper end of cell and about level with cell mouth; a single (?) spine slightly curved springing vertically from the centre of each cell on the dorsal surface; avicularium —; ovicell —.

Locality.—Marion Islands. "Challenger" Expedition.

This species is closely allied to *B. grandis*, Busk, but differs in several important characteristics. The form of the aperture is exactly the reverse of that of *B. grandis,* which is widest at the inner end; the latter has never more than four submarginal spines, more frequently only two, while six seems to be the prevailing number in the present species. The mode of attachment of the cells to each other is also very

Fig. 2$^{\alpha}$
×60

Back view

Fig. 2
×60

Bicellaria pectogemma

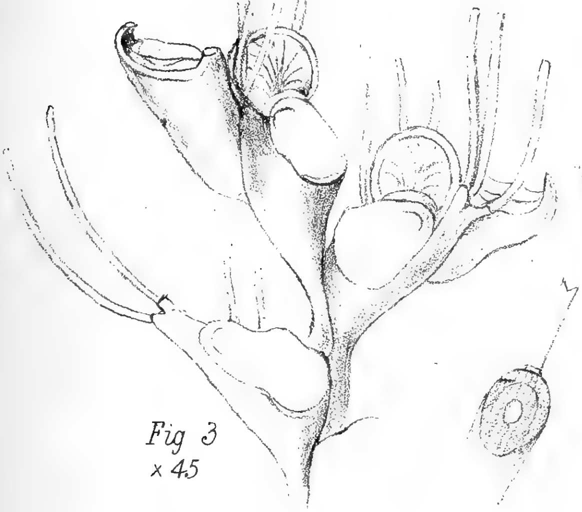

Fig 3
×45

Bicellaria grandis

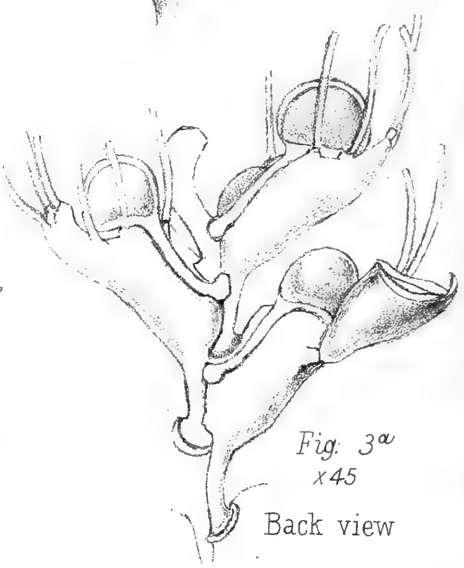

Fig. 3$^{\alpha}$
×45

Back view

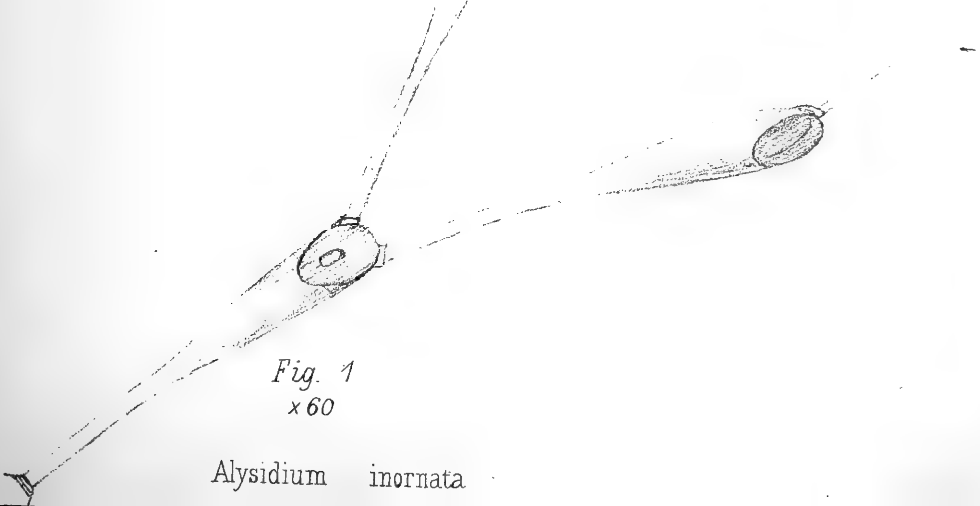

Fig. 1
×60

Alysidium inornata

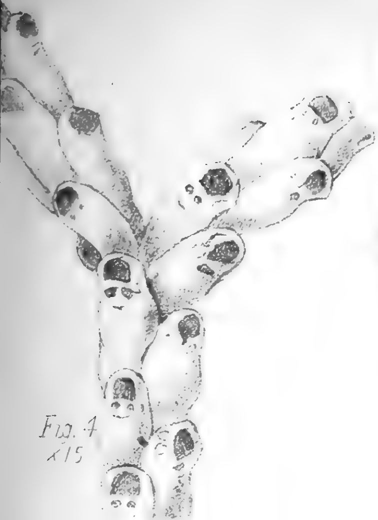

Fig. 4
×15

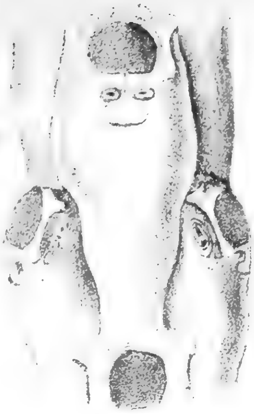

Fig. 4a
×40

Malakosaria pholaramphos

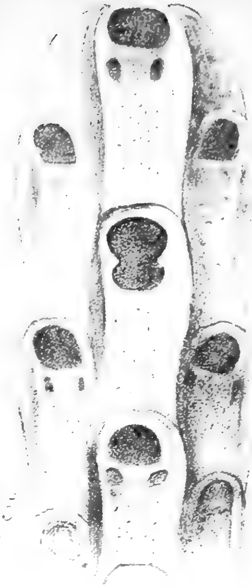

Fig. 5
×20

Vincularia steganoporoides

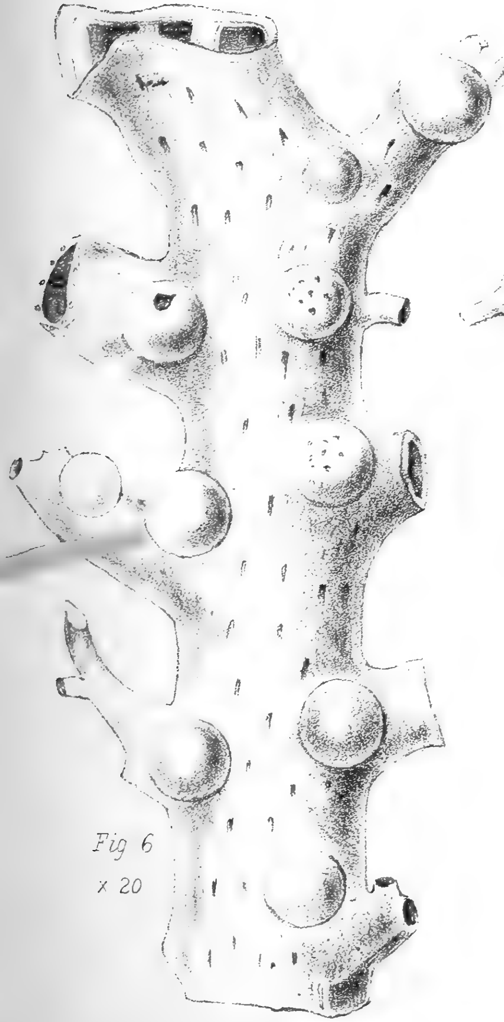

Fig 6
× 20

Hornera subdubia

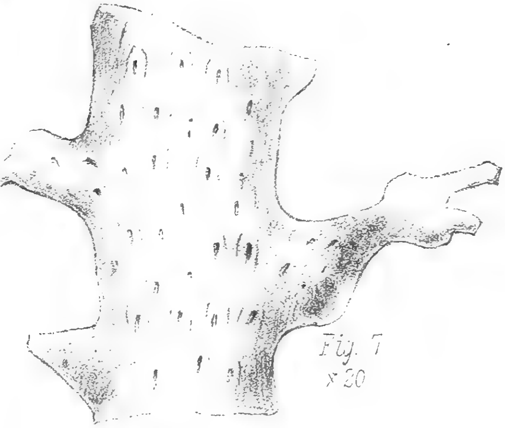

Fig. 7
×20

Back view

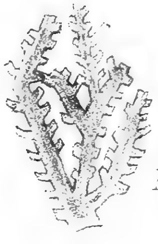

Fig. 8

Natural size

J.B.Y. Goldstein, del.

different in the two species. In the one each cell springs from a tubular process on the breast of another cell, and the cells are only attached to each other at two points, while in *B. grandis* each cell springs directly from a ringed process on the *back* of another, and the cells are more closely adnate to each other throughout their whole length. In size also there is a great disparity between the two species, *B. pectogemma* being rather less than one-third that of *B. grandis.* The submarginal spine-bearing process is much more produced in the latter species, which is very common on this coast, and exhibits only very slight variations. I append a figure of *B. grandis* (plate I., figs. 3 and 3A) showing front and back views, not only for comparison but also to show its ovicell and fine avicularium, neither of which have been figured before.

Family FARCIMINARIADÆ, *Busk.*

Malakosaria, *nov. gen.*

Zoarium chitinous, flexible, cells raised, flat, rounded, or tubular, not bounded by raised lines.

Malakosaria pholaramphos, n. sp. Plate II.; Figs. 4 and 4A.

Cells ventricose, rounded; mouth near distal end, large, arched above, narrowed below, lower lip straight, surrounded by a wide raised border, the upper angles of which are produced so as to form a short blunt process on each side, below which is an immersed oval avicularium on each side facing laterally, lying hidden from view in front; space below mouth ornamented with two circular depressions, having a fissal line between, and a sharp, raised, transverse line below, curved upwards at each end; two oval marks on the space above mouth; colour of zoarium, light brown.

Locality.—Marion Islands. "Challenger" Expedition.

There is a peculiarity about the sharp raised line on the front of each cell below the mouth, in that it looks like a lid; it may possibly prove to be a form of avicularium. The genus *Tetraplaria,** erected by the Rev. J. E. Tenison-Woods for a fossil from the Muddy Creek beds, Victoria, may seem to cover this species; but the cells are not in pairs as in that genus, which the author has placed in Busk's family of GEMELLARIADÆ on that account. At

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**Proc. Roy. Soc. New South Wales,* 1878, Vol. XII., p. 60.

first I was inclined to place the present species in the genus *Elzerina*[*] of Lamouroux; but the description of that genus so closely resembles that of Busk's *Farciminaria*[†] that it could not be used for forms without an aperture surrounded by a raised border, and as Lamouroux and Busk make this character important as generic, the erection of a new genus under the name of *Malakosaria* would appear to be warranted.

Family VINCULARIADÆ, *Busk.*

Genus Vincularia, *Defrance.*

Vincularia steganoporoides, n. sp. Plate II.; Fig. 5.

Zoarium octagonal, branching dichotomously; cells in linear series, alternate, quadrate, depressed, bounded by thin, smooth, raised lines; mouth at distal end, sloping forward above, much depressed below, round above, nearly straight below; surface of cell finely granular; an oval opening on each side below the mouth; the whole surface closely invested by a thin chitinous membrane.

Locality.—Marion Islands. "Challenger" Expedition.

This species is specially interesting just now as serving to show some of the difficulties in the way of accepting the proposal of Dr. Hincks, previously alluded to, to place Bryozoa of this description in separate families, according to the character of the cell. This species in general appearance closely resembles *V. elegans*, D'Orb; *V. ornata,* Busk; and *V. neozelanica,* Busk. The last two Dr. Hincks would place with the true *Membraniporidæ.* There is certainly a membranous covering on the cells of the present species; but, unlike the *Membraniporæ,* the operculum is distinct, and is *not* formed by a lap of the investing membrane. At first glance the cell looks as if it ought to be placed in the genus *Steganoporella* of Hincks, having the two orifices just below the mouth characteristic of that genus; but these are not openings into internal divisions as in *Steganoporella.* After removal of the membranous covering by incineration,

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[*] *Hist. des Polyp. Cor. flex.*, 1816, p. 122.

[†] It is strange that Mr. Busk should have overlooked the genus *Elzerina,* provided by Lamouroux for Bryozoa having soft cylindrical unarticulated branches, with a type of cell similar to that of *Salicornaria,* Cuvier. It would almost seem necessary to abandon the name *Farciminaria* in favour of that of *Elzerina.*

the lamina between the mouth and the two suboral orifices, though calcareous, is easily destroyed by excess of heat, showing the interior of the cell as a single chamber. I have endeavoured to show this in the figure accompanying this paper.*

Sub-order CYLOSTOMATA, Busk.

Family HORNERIDÆ, *Hincks.*

Genus Hornera, *Lamouroux.*

Hornera subdubia, n. sp. Plate II.; Figs. 6, 7, 8.

Zoarium irregularly branched, seldom inosculating; cells few, terminal on minor branches or pinnæ bestowed laterally, produced and tubular; orifice simple or slightly produced on one side; zoarium punctured on front and back; both surfaces faintly fibrillate; ovicells raised, globular, or conical, scattered freely over anterior surface.

Locality.—Marion Islands. "Challenger" Expedition.

This is a very strange form, owing to the small number of cells. The specimen I have is one inch long, and the same in width; it does not look like the old base of a colony, but has all the fresh appearance of a terminal portion. The scarcity of cells is remarkable, particularly when we regard the large number of ovicells, which literally cover the whole specimen. Occasionally a single tubular cell is to be seen on the side of the main stem, but the majority are only found on the ends of short lateral pinnæ, in companies of two, sometimes only one; and in most cases the orifice is closed as if by a calcareous deposit, or an operculum (!). A

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* I was induced to make this comparison because *Steganoporella smittii*, Hincks, assumes the habit of a *Vincularia* on the north coast of Australia. I have specimens from Port Darwin showing every stage from the ordinary encrusting form, through the free, erect, hemescharal, and escharal forms. This change of habit I consider to be a sort of mimetism, which will be enlarged upon on another occasion, when I propose to show the importance of true zoarial habit as distinct from mimetic changes of form.

I may here indicate West Australia as another locality for *Steganoporella smittii*. Two valves of *Tridacna* from that coast in my possession are encrusted by large colonies of this species, agreeing exactly with the description by Hincks of the Cornish form, except that the foramina in the West Australian form are very much larger, showing the full extent of the inner chambers; each orifice being more than half as large as the cell mouth, sometimes quite as large. The front wall of the cell is much depressed across the centre. The very curious avicularia are pretty freely dispersed over the colonies, and the ovicells numerous in patches.

transverse section of the zoarium shows two or three internal longitudinal chambers. Branches disposed in the same plane.

I would not be surprised to find that I have failed to diagnose this form correctly, but I give it just as it appears, so as to direct the attention of other observers to it.

Note on Bicellaria grandis (Busk).

In describing this species from Bass's Straits, Mr. Busk mentions 2-5 submarginal spines and a single dorsal spine; my specimens frequently show three dorsal spines, as now figured. The fine pedunculate avicularium is often abundant on some specimens. It is attached to the back of a cell by a very short peduncle, and widens rapidly upwards, the top oval and flat, occupied by a large mandible, which closes into a strong hooked beak on the outer side; the large retractor muscles, springing from near the centre of the mandible, diverge below and fill the whole lower portion of the avicularian chamber.

The ovicell is globular, covering the upper portion of the cell on which it is placed, and is open and arched below just over the cell mouth, where it is strengthened by a transverse band. The front is prettily marked by lines radiating upwards from a slight fissure near the centre of the arched band. There is a slight space between the outer and inner walls, and it is the inner wall that is ornamented. A long tubular process extends from the lower and inner side of the ovicell, obliquely down the back of the cell on which it is placed, and is then attached by a ringed process to the tubular stem of the next cell above.

This mode of attachment, or anchoring, of the ovicell suggests a curious problem—By what means does the ovicell send down this tubular process, and how does it attach itself to the neighbouring cell? Would it not appear that the anchoring stem, or peduncle, must have within its walls some active vital principle, having a discriminative power, or instinct—some prolongation from the body of the parent zooid somewhat similar to the cænosarc of the *Hydroida?* Another curious fact to be noted is that the ovicelligerous cells are generally twisted out of the normal shape. This species is common on the southern coast of Australia.

Art. VII.—*A New Form of Scale for the use of Engineers and Architects.*

By Mr. A. M. Henderson, C.E.

[Read June 9th, 1881.]

Art. VIII.—*Description of a Hagemann's Vacuum Anemometer erected at the Observatory.*

By R. L. J. Ellery, F.R.S., F.R.A.S.

[Read July 14th, 1881.]

Art. IX.—*Some Notes on the Storage of Electricity and Faure's Form of Planté's Secondary Battery.*

By W. C. Kernot, M.A., C.E.

[Read July 14th, 1881.]

Art. X.—*The Origin of Quartz Reefs and Gold.*

By William Nicholas, F.G.S.

[Read August 11th, 1881.]

Art. XI.—*Notes on the Specification of a recent Patent for the Manufacture of Gas.*

By J. Cosmo Newbery.

[Read August 11th, 1881.]

Resolved—"That, in the opinion of this meeting, there is in the specification in question nothing but kerosene and its congeners from which gas for illuminating purposes can be produced."

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ART. XII.—*Observations on Living Polyzoa.*

BY C. M. MAPLESTONE.

[Read August 11th, 1881.]

MANY of our Polyzoa have lately been described in Professor M'Coy's *Decades of our Fauna*, and some new species to this and to the Microscopical Society; but as very little has been said concerning the animals themselves, or the appearance of the Polyzoa in the living state, I think the presentation of my observations of such species as I have found living at Portland will be opportune.*

The number of the tentacles varies from 8 to 24; generally they are in multiples of 4. I had supposed always so; but *Seruparia chelata* has 10 tentacles; *Ætea anguina* has generally 12, but in some cells on the same piece I observed the polyps had 13 tentacles; *Diplopora cincta* has 13, and *Catenicella formora* 18. The number of tentacles possessed by the different species of the same genus varies, so that, apparently, these details of the structure of the polyp will not assist towards the classification of them, which will depend, as hitherto, upon the form and structure of the cell or ectokyst. It will be noticed, however, that the *Cheilostomata* have never less than 10 tentacles, and that those belonging to the *Cyclostomata* and *Ctenostomata* have only 8. I hope to be able to make further observations of the animals of the three divisions, as I have found many more species than those mentioned in such a condition that I do not despair of greatly extending the knowledge of them, and I hope to be able to elucidate their life history in the course of time.

These observations have been made within the last two or three years upon specimens either dredged, obtained from old piles, drawn up from the pier, or washed up on the beach. While some of those dredged, or carefully collected from the piles, and immediately transferred into bottles of

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* The only published observations on the living animals of Australian species are contained in a Paper by Mr. J. R. Y. Goldstein, in the "Journal of the Microscopical Society of Victoria" for May, 1880.

sea-water, never expanded, many of those found on the beach did so. I should never have expected the last mentioned to be alive; but one afternoon I was fortunate enough to fill a large bag with Polyzoa, and in the evening, on making a preliminary examination with a Coddington lens, I was surprised to find some of the animals moving within the cells, and on transferring them to the zoophyte trough I was rewarded with the view of several species expanding. I mention this as it may not be generally known that if Polyzoa be gathered soon after being washed up on the beach, or *before getting dry*, and being afterwards kept merely damp, that there is a probability of finding them living, and I have often since found them so.

Some species were very beautiful when living, with the tentacles expanded, the cilia in rhythmical motion, up one side and down the other, and (in those furnished with them) the avicularia opening and closing, such as were capitate waving about slowly. No conception can be conveyed of the splendour of the pigment layer of some—*e.g.*, *Cellepora fusca.*

I have included in the list of species examined, their colours when found alive, or moribund, but which did not expand, because, in most cases, they differ from those of the dead and dried specimens.

The following are the details :—

Catenicella ventricosa—Colour, orange ; 12 tentacles ; ova in ordinary cells.

C. lorica—Colour, orange; 12 tentacles; lateral processes very much dilated, and distended with fluid; fenestræ convex.

C. hastata—Observed mandibles of avicularia move; cells more or less spotted with purple or dark green pigment cells, the greater or less abundance of which causes the frond to appear of various shades, from orange to purple, and dark greenish grey.

C. ponderosa—Colour, red; interspaces of fenestræ; upper lip and bands on back of cells ivory white.

C. rufa—Colour, bright orange. Observed avicularia move; ovicells full of scarlet granular mass; ordinary cells also contained 3 to 5 small dark oval bodies, most probably ova.

C. formosa—Colour, pink; 18 tentacles; animal very large, compared with cell and with other species.

C. elegans—Colour, purple and brown; dark purple pigment cells; a mass of whitish, granular matter in cell visible through the back of the cell when fresh.

C. geminata—Colour, pink; 12 tentacles.

C. carinata—Colour, bright lemon yellow.

Scrupocellaria scrupea—Colour, pink; 16 tentacles. Observed vibracula in motion.

S. ornithorhynchus—Colour, pink; 12 tentacles.

Emma tricellata—Colour, pink; 12 tentacles.

E. crystallina—Colour, pink.

E. cyathus—Colour, orange.

Canda arachnoides—Colour, bright orange; 16 tentacles. Observed some delicate setæ springing from avicularia move.

Salicornaria hirsuta—Colour, delicate pink; 16 tentacles; ovicells full of scarlet ova.

S. farciminoides—Colour, pink.

Onchopora hirsuta—Colour, pink.

Scruparia chelata—Colour, whitey brown; 10 tentacles.

Caberea Boryi—Colour, orange; 16 tentacles; vibracula very active.

C. lata (?)—Colour, orange; 16 tentacles.

Bicellaria ciliata—White in colour; 16 tentacles; avicularia in constant motion; ovicells with small globular mass of orange ova.

Bugula dentata—Bluish green colour; 16 tentacles. A very beautiful species. Minute dark green, almost black, pigment cells; animal very lively; avicularia opened and shut freely, and waved about.

B. cucullata—Colour, light brown; 12 tentacles; ovicells, globose when alive; not cucullate, but became so on drying.

Flustra denticulata—Colour, light pink; 16 tentacles.

Carbasea cyathiformis—Nearly colourless; 16 tentacles; ova in ordinary cells.

C. pisciformis—Colour, orange; 20 tentacles; very long and slender; ova in ordinary cells; ovicells with scarlet granular mass of ova.

C. dissimilis—Colour, bright orange.

Diachoris magellanica—Light brown colour; avicularia moved.

D. spinigera—Very light brown in colour; avicularia moved; animal did not expand, but showed in mounted specimens apparently 20 tentacles.

Didymia simplex—Delicate rose pink colour; ovicells with red ova; animal did not expand, but noticed particles moving about in perigastric space.

Fig 1.

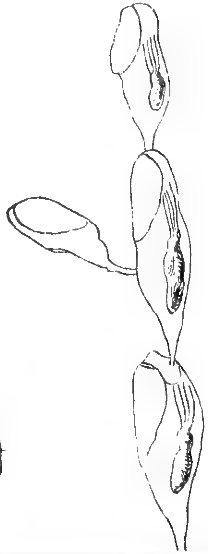

Fig 3.

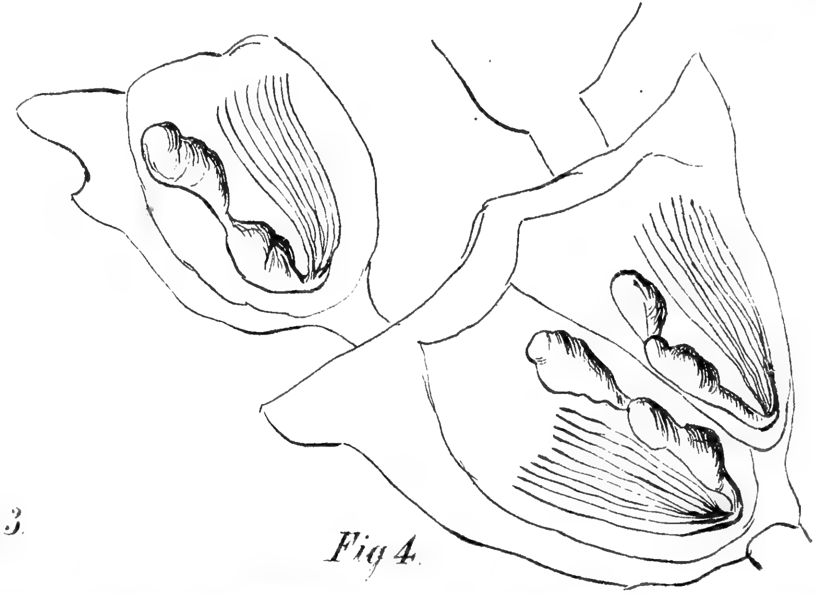

Fig 4.

Catenicella

Fig 9.

Calwellia gracilis ×45

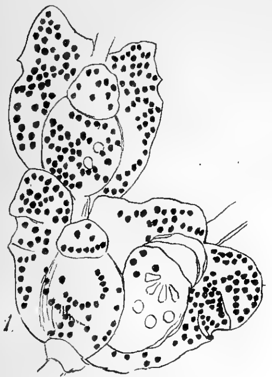

Fig 1.

Catenicella hastata
(Pigment cells) ×45

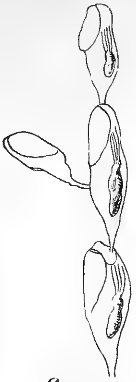

Fig 3.

Scruparia
chelata ×45

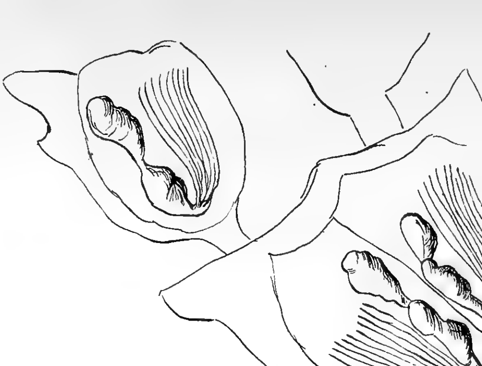

Fig 4.

Catenicella ventr
(back view)

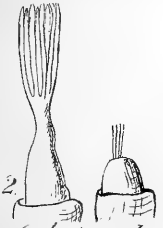

Fig 2.

(polyp) (calyx)
Serialaria ×25

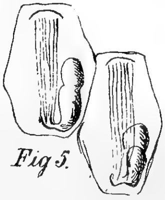

Fig 5.

Carbasea
cyathiformis ×45

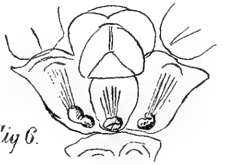

Fig 6.

Didymia
Simplex ×45

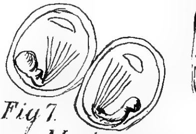

Fig 7.

Membranipara
pura ×45

den
var. qua

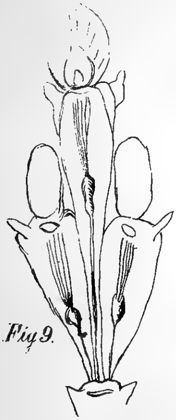

Fig 9.

Calwellia
gracilis ×45

Ætea anguina—Colour, white; 12, and sometimes 13, tentacles.

Membranipora pilosa—Light brown colour; 12 tentacles.

M. pura—Very light brown in colour; 16 tentacles.

Diplopora cincta—Colour, dark brown; 13 tentacles. Observed the true mouth open and shut, apparently by means of a sphincter muscle, as mouth opened from an invisible point to a small circular area and then closed again. A very fine polyp.

Lepralia Ellerii—Bright scarlet in colour; 24 tentacles; epidermal layer thick; the spines round the mouth protruded through it, and showed clear and colourless.

Cellepora fusca (?)—16 tentacles; colour, various, from orange to dark purple and sometimes dark dull green. Under the microscope the pigment cells in that part of the animal which invests the cell are of a red or purple, or sometimes intensely black colour; rarely distinct, generally completely coalescent, and sometimes variegated with beautiful silvery streaks—a most gorgeous sight.

Retepora cellulosa—Colour, pink and rose red; 12 tentacles.

Petralia undulata—Colour, brown; ovicells with scarlet ova.

Idmonea radians—Colour, delicate French grey; 8 tentacles.

Serialaria Woodsii and *S. Australis*—Both 8 tentacles; basal tubes with granular masses scattered about.

ART. XIII.—*Electric Fire Alarms.*

BY R. E. JOSEPH.

[Read 8th September, 1881.]

THIS paper is brought forward with a view of drawing attention to the assistance "electric fire alarms" afford to our fire brigade organisation. A system of fire alarms may be described as a means by which information as to the exact locality of a fire breaking out can be transmitted without delay to the fire brigade station.

Before describing any of the methods by which this can be accomplished, it will be as well to consider the necessary conditions that are required for an efficient system. It should be simple in construction; not liable to get out of order; certain in its action; be capable of transmitting its signals automatically—that is to say, it must not require any complicated instructions to be carried out by the person giving the alarm, for we must imagine that such person might be in a state of excitement, and could not, therefore, be depended upon to read or execute anything but a very simple direction.

The receiving mechanism must be reliable, and consist of audible and either a visual or recording alarm. If audible alone, the same signal must be repeated at short intervals, to ensure its correctness being verified.

There is very little doubt that America possesses the most extensive and perfect system. One of the earliest forms is still in use there, and works satisfactorily.

The city or town is divided into blocks, each known by a number; at a suitable place in each block is fixed a small wooden or iron case, having a door secured by a lock. On this door is painted the number of the block, and instructions where to obtain the key. There are three or more keys to each case, one being left at the nearest hotel, one at a chemist's or other suitable store, and one with the policeman on duty. In case of fire breaking out in any block, the person who wishes to give an alarm, after obtaining the key, opens the door of the case. Inside is to be seen a ring attached to a chain, with the simple instruction of "Pull." The ingenious part of the mechanism now comes into play. Irrespective of the chain being pulled either quickly or slowly, to its full length or only for a short distance, if it be held in the hand or let go, the signal is transmitted with the same certainty and regularity. Pulling the chain down raises a small lever with a weight on it that is instantly released; this starts a train of wheel-work which in rotating closes and breaks an electric circuit, transmitting signals something like the Morse code.

At the receiving station these signals come in the form of strokes at irregular intervals on a large bell; at the same time a Morse register is started, and the signals recorded on the tape in the ordinary way. These signals are repeated three or four times, the sending wheel being arranged for that purpose. With the exception of a somewhat expensive apparatus at each sending box, this system appears to be very good; it is reliable, and perfectly automatic. I do not propose entering into the details of fire stations, which in some of the large cities in America contain very elaborate means of recording and communicating with other stations, and, as described by Mr. Carpenter here some time back, "placed the harness on the horses, liberated them, and dropped the firemen into their clothes and boots, and on to the seats on the engines, all being effected by electricity!"

Several systems are now under trial in England—one very similar to the American; but the transmitting signal is sent by pulling out a small knob. This winds up a spring, which, on being released, acts on a train of wheel-work as before described. Another system consists of the transmitter being composed of two small inclined metal rails, having insulated pieces inserted at irregular intervals. A metal ball or ring running down the rails forms or breaks the circuit, and thus transmits the alarm. The ball is held up by a spring, and is released by pressing a knob. Several sets of rails can be placed in the box, the ball rolling down one and then falling on to the next, and so on, thus repeating the signals to any extent required. The signals are received on a bell and Morse instrument, and the alarm is notified as having been received by the fire station ringing a bell placed in each of the sending boxes. A similar form records its signals by ringing a bell and throwing up a number in an ordinary indicator. This necessitates a pawl and ratchet arrangement, a method that does not appear reliable for quick work; for even the Wheatstone A B C instrument, one of the most perfect of its type, often gets out of adjustment.

Another form introduced in Glasgow, and known as "Bright's system," depends on balancing the resistance of the boxes, in which are placed artificial resistances. A description of this system appears in the *Telegraph Journal* of 15th February, 1880, and a plan that I now propose might be adopted here is based on its principle. I do not think it better than the American system; but it is simple, cannot get out of order, and could be constructed at very little expense. I propose first dividing Melbourne and its suburbs into, say, ten districts. These might consist of Richmond, Prahran, St. Kilda, Emerald Hill, Carlton, Collingwood, Fitzroy, Hotham, East and West Melbourne.

Each of these districts would have a station, that might be either the fire or police station, providing an attendant always be present. These stations would be connected by the close circuit system with the central station. The station instruments would consist of a polarised relay, switch and key, telephone and transmitter, and a local battery and bell. At various places on the line, inserted in a loop, would be placed the fire alarm boxes, consisting of small iron cases having a glass door, on which would be painted, "In case of fire, break the glass."

The mechanism inside is of a simple description. A small polarised lever connects the loop-line; but which, on the glass being broken, is moved back, and then rests on a stud, and places the line to earth at that spot and through a known artificial resistance. Every box on each line would have a different resistance, increasing by 5, 10, or 15 ohms, according to the length of the line. On the signal being received at the central station a reversed current is sent through the line, which, passing through a small electro-magnet in each box, restores the lever to its original place, and at the same time shows a small disc attached to it, thus showing to the sender that the alarm has been received. In the alarm box would also be two plug-holes, by which means a telephone could be readily placed in circuit; this would prove convenient if after the brigade arrived at the fire it required extra assistance or apparatus.

The instruments at the central station consist of a relay and battery in circuit with each line; in circuit with all the relays an alarm bell and switch-board; a circular set of resistance coils, corresponding to those in the alarm boxes, and a galvanometer, the whole being arranged as a Wheatstone bridge. On the circuit being broken in any line the alarm bell will ring, whilst a number shown by the relay in action will at once indicate the particular line signalled. This line is then switched on to the resistance coils; the galvanometer needle will then be deflected; a handle attached to the line is then turned round the resistance coils until the needle returns to zero. The number corresponding to the resistance found will be the box from which the alarm is sent. The current is then switched off, and sent in a reverse direction, replacing the lever in the alarm box, as before described.

If either of the district stations be required, a reversed current sent will at once act on the polarised relay and cause the bell to ring, after which telephonic communication is established in the ordinary way. You will be able by means of this diagram to understand the whole matter better, perhaps, than I have explained it; although it may appear complicated, those conversant with circuits will perceive that it is not so. The advantages it may possess are economy of construction, automatic action, avoidance of mechanism, and facility of communicating through the boxes to district stations on the same line. The close circuit system also possesses an advantage of giving an alarm at once should either the lines, batteries, &c., be out of order. I may state that the plan of breaking the glass in the alarm box appears to meet with favour in places where it has been tried; it avoids the delay of seeking for a key. There is little liability of false alarms being given; few people out of mischief would break the glass, as it could scarcely be done without attracting notice. The subject of fire alarms and the necessity of adopting them is engaging the attention of most places that are not already provided with a system. Organisations for the extinction of fires are either a necessity or otherwise. Few people doubt the necessity; hence the establishment of fire brigades in all parts of the world. Having, then, admitted that we require fire brigades, is it not reasonable to ask that they shall be in as perfect a state as possible for the extinction of fires?

Many years ago, before the water-supply system existed in Melbourne, water-carts were employed to bring water to a fire. Would such a course be tolerated at the present time? and why not? Simply because the present means enable the brigades to obtain a supply of water quickly and in quantity, and thus they are enabled to prevent a large amount of property being destroyed. But the early intimation of a fire to the fire station is a matter of as much importance as the water supply. I believe most authorities agree that the first few moments at the outbreak of a fire are the most important. Yet, how is such intimation given in Melbourne? Either by cab or messenger, or by the man in the look-out tower, but who cannot be aware of it until after it has actually broken through the building. As before mentioned, America possesses the most perfect system in the world. They were the first to grasp the great aid that the telegraph lines afforded them for this purpose. Fire alarms have been in use there for over twenty years. In New York alone there are nine hundred fire-alarm boxes; whilst every small town, of even five thousand inhabitants, has established a system of some kind. Other countries soon followed America's example; but it is only within the last couple of years that England saw the necessity of their use, and they are only now in an experimental stage.

In Melbourne we are still further behind. That some system or another will some day be adopted here there is very little reason to doubt, and then it will be admitted as a necessary and valuable auxiliary. If it be necessary then, it is so now, and must have been years ago, or as soon as the telegraph lines in our city provided us with a means of doing so. And it certainly does appear curious that perhaps some great calamity will force us to a plan that common sense should have caused us long ago to adopt.

The number of serious fires in Melbourne average about one hundred per annum. Much valuable property is thus destroyed; and it is not too much to say that with some efficient system by which an early intimation could be given, the amount of property destroyed would be greatly diminished.

Most of the bonded and other warehouses are closed at noon on Saturdays, and remain locked up until Monday. In such places an automatic circuit-closer should be fitted in connection with the general system. These circuit-closers consist of an arrangement that closes or breaks the circuit as soon as the temperature of the room in which it is placed reaches a certain limit. They are largely used in America, the insurance offices there reducing the premium to all stores and buildings in which they are used.

Statistics furnished from New York state, "whilst in 1866, 1867, and 1868 the percentages of total destruction of buildings were 7, 6½, and 5, in 1877, 1878, and 1879 they were but 3·45, 1·14, and 1·6 respectively, the reduction being caused by the improved system of their fire alarms." And a paper recently read at a scientific section at Brussels states that, from statistics collected, with the most perfect system of fire alarms serious fires were reduced to 4 per cent.; with telegraph communication from offices alone, but without alarms, 17 per cent.; while without any telegraph communication they reached 27 per cent. I have in this paper endeavoured, in as brief a manner as possible, to explain the general ideas and advantages of fire alarms, without entering into all the numerous and ingenious devices that have been and are continually introduced for that purpose.

Remarks upon and Experiments with Faure's Secondary Battery.

BY JOHN BOOTH KIRKLAND,

Assistant in the Laboratories at the University Medical School.

Read September 8th, 1881.]

AT the last meeting of the society I had the honour of showing a modification of Plante's secondary battery, as made by M. Faure. Since that meeting I have been able to make several interesting experiments with it. Before relating these experiments, I may be permitted to shortly describe the construction of Faure's battery after the manner found by me to be most advantageous. Each cell is made up as follows:—Two sheets of felt, 12 x 36 inches; two sheets of lead, 5½ x 30 inches; one sheet of vegetable parchment, 12½ x 36 inches. The felt was laid on a flat surface, and coated with a paste consisting of red oxide of lead and dilute sulphuric acid, one to ten. A sheet of lead was then placed within half-an-inch of one edge of the felt; the remaining coated surface folded over. Of the two sheets thus prepared one was covered with vegetable parchment, then placed one on top of the other, rolled together, and immersed in dilute sulphuric acid.

Four cells prepared in this way were connected together as one cell, and charged by means of two Callans cells, operating for two hours. They were then disconnected. One cell was found capable of rendering two inches of No. 17 platinum wire (about as thick as bell wire) red hot. With four connected for quantity 5 inches of No. 17 platinum wire became incandescent.

Connected in series N P N P with a large inductorium an effect equal to that producible by six Callans was obtained.

The secondary cells after standing twenty-four hours were still capable of working that instrument as powerfully as two Callans, and afterwards being put on to an electromotor, the latter worked for half-an-hour without any apparent diminution of speed.

Four Faure's cells charged for two hours with two Callan elements, and then connected in series, decomposed acidulated water in the voltameter as follows:—

I. 60 C.C. ... ... in 30 minutes.
II. 60 „ ... ... 40 „

III.	60 C.C.	70 minutes
IV.	60 „	100 „
V.	60 „	160 „
VI.	60 „	240 „

Two Callans cells, as compared with the above, gave 60 cubic c.c., in 220 minutes.

Of four cells charged as before, three were taken out of the acid and drained, then packed in a box with sawdust. After three hours they seemed as strong as when first packed; left for twenty-four hours, nearly all electric energy had apparently disappeared. Replaced in their jars, they recovered sufficiently to drive an electromotor, and to decompose water rapidly.

The cell which had not been touched was as strong after twenty-four hours as when first charged.

One cell which had been charged for two hours was unrolled, and the plate which had been connected with the negative end of the Callan was examined.

On separating the felt so as to leave undisturbed the coating of oxide on the lead plate, this oxide appeared of a dirty white colour, and on lifting up this coating the surface in contact with the metal presented the appearance of pulverulent metallic lead.

On the outer surface of the lead plate, charged from the positive pole, a dark brown colour was observed. On the inner surface a nearly black powder had been formed.

The respective lead plates of the combination being then placed on one another, pressed together, and the terminals connected with a platinum wire, the latter became red hot. On reducing the pressure much less heat was given out. The lead plates were then rolled up, replaced in acid, and worked out. These being again unrolled and examined, the coating of material on the plate which had been connected with the zinc, or negative, pole of the battery was found to have lost its metallic appearance, and to have become of a dirty white colour, both inside and out. The coating of material on the plate which had been connected with the positive pole of the battery was not nearly so dark in colour as when charged. I noticed after a week or so that the first charge of acid was not sufficient to keep the secondary battery properly in action, and that the latter required more primary current to get the same effect. It, however, seemed to recover after a time upon the addition of fresh acid of 1 in 10 strength.

Before paper or parchment paper was used in the construction of the battery the effects produced were very similar to those observed in the case of the original Plante secondary element, the effects merely lasting for a very short time.

Parchment paper, from its toughness, has been found by me to be best adapted for the preparation of secondary elements.

The oxide of lead should, previous to applying it to the lead plate, be well mixed with the acid. If water simply be used for this purpose the cells are with difficulty charged, and oxygen and hydrogen gases are given off, the lead oxide being only decomposed on the outer surfaces.

After a time it was observed that the lead terminal which in charging had been connected with the positive pole of the battery had become brittle, possibly from absorption of oxygen.

It may be observed that the chemical action going on in the Faure battery is not at present well understood; but it seems that the first action which takes place consists in the removal of the lower oxide present in the red lead by the action of the sulphuric acid with the formation of lead sulphate.

In charging the lead plates, which, as arranged, may be looked upon as a form of voltameter, the one connected with the positive pole of the primary battery becomes surcharged with oxygen, while in the plate connected with the negative pole hydrogen is absorbed with the formation of water and reduction of the oxide of lead to the metallic state.

The metallic lead so formed, being in a very porous condidition, may then be capable of absorbing large quantities of hydrogen.

Two Callans cells put on to one cell of the Faure battery cause a considerable disengagement of free hydrogen, whilst apparently no oxygen was eliminated.

In the case of the same number of Callans used with four secondary cells nothing like so much gas was evolved.

Unfortunately, up to the present, I have been unable to charge the instrument by means of the dynamic machine, either by using an intensity or a quantity armature.*

For the use of these machines I am indebted to the kindness of Messrs. Josephs and Danks.

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* NOTE.—Since the paper was read, we have succeeded in charging the secondary cells by making them part of the circuit of a dynamic machine in the act of producing light. Curiously enough, under these circumstances, the electric light appeared, if anything, better and steadier.

The Drainage of Melbourne.

By W. W. Culcheth, M.I.C.E.

[Read 13th October, 1881.]

The present condition of the drainage of Melbourne and the measures necessary for its improvement have attracted fresh attention by the recent award of the Mayor's prize for the best essay on the subject. The judges' selection of one essay, as the best of those that were submitted, has met with general approval; but the decision has been misunderstood as signifying approval of the scheme proposed, and it has accordingly been suggested that it should be carried out forthwith. It would be, however, very unwise to do this before the proposals have been criticised, and public opinion has had an opportunity of expressing itself on the subject. The essay possesses many merits, but is too brief to be entirely satisfactory; hence, perhaps, the proposals are liable to be misunderstood. In this paper, it is intended to give a brief outline of the scheme recommended by the essayists; then to point out some of the defects revealed by a careful perusal of both the essay and plans. To dwell only on the advantages of the scheme would not tend to call forth additional particulars, which are much required. The time allowed will not permit of the essay being thoroughly examined; its defects only can be considered just now. Perhaps some of the defects are merely apparent, due to the absence of detail; but whether apparent or real, they need to be explained or removed by further information.

2. The drainage, as dealt with in the essay, may be classed as follows:—

- (*a*) Subsoil water.
- (*b*) Surface drainage, consisting of—
  - 1. Rain water flowing off roofs, court-yards, and the less populous thoroughfares.
  - 2. Ordinary winter rainfall in the streets where there is heavy traffic, or a portion of the ordinary drainage of such streets. This may be conveniently called "street drainage."
  - 3. Flood water in excess of the ordinary rainfall.
- (*c*) Waste water from houses or manufactories—
  - 1. That which is too offensive to be allowed to flow

into the street gutters, which may be conveniently termed "house drainage."

2. That which has been used for motive-power in manufactories, for cooling in breweries, and for baths, termed in the essay "harmless drainage."

The essay provides for the treatment of the above in one of two ways:—

I. Allowed to flow directly into the Yarra—Subsoil water (*a*); rain water from roofs, &c. (b_1); flood water (b_3); and harmless drainage (c_2).

II. Conveyed through sewers to a filtering area—Street drainage (b_2) and house drainage (c_1).

3. The proposed means for effecting the removal of the drainage are—(1) Street gutters; (2) storm-water drains; (3) porous earthenware pipes; and (4) sewers. By means of these the drainage will be collected and conveyed to its destination by the following arrangements, viz.:—

I. THE YARRA.—Subsoil water (*a*) to be collected by porous pipes, laid at a sufficient depth to drain house foundations and cellars, but not connected with the sewers. Rain water from roofs, &c. (b_1), and harmless drainage (c_2) to flow into the street gutters and be carried off as at present. Flood water (b_3), where the greatest accumulation occurs, to be carried off by underground storm-water drains.

II. THE FILTERING AREA.—Street drainage, where the traffic is greatest (b_2), to be admitted from the gutters into the sewers, the openings being sufficient for only a small quantity of the dirtiest water. Of house drainage (c_1), it is remarked, not one drop of offensive waste water ought to escape into the street channel; it should be intercepted and carried into the sewers.

4. It is proposed to enlarge the gutters, at the same time widening the street pavements without reducing the available carriage way. The only storm-water drain provided is in Elizabeth-street, which is spoken of as the most important locality to be dealt with. Subsoil water, collected by porous earthenware pipes, is to be allowed to escape into the Yarra at as many points as convenient; but it is remarked that it will not be possible thoroughly to drain cellars in some portions of the area, owing to their low level, except by pumping. Arrangements for pumping this water do not, however, appear to be included in the scheme. It is particularly pointed out that the subsoil drainage pipes must not communicate with the sewers.

5. The system of sewers is arranged to convey all the sewage to the pumping station "in the sandy ground west of Sandridge." Here the sewage "will be pumped up on to a sloping perforated platform, from which the more solid substances can be readily collected and carted away, while the liquid portion of the sewage will pass through the perforations into carriers, which will take it" to the filtering beds. The filtering area is to consist of "three divisions, each of about forty acres, laid out with open drains running in the direction of the out-fall, and drained not less than six feet deep with agricultural tile drains." The area for the present considered sufficient is 120 acres; but 200 acres more, or 320 acres altogether, are provided to meet an increase of the population up to 500,000. For pumping the sewage, "the engine-power required at present will be, including a reserve in case of accident, an engine of 53-horse power, and one of 26, and three centrifugal pumps, each capable of throwing 6100 gallons per minute 15 feet high."

6. The localities dealt with are, with the exception of some thinly populated portions, Melbourne City, Fitzroy, Collingwood, Richmond, Prahran, St. Kilda, Emerald Hill, and Sandridge. Provision is made for connecting Hawthorn, if required. The area included is not stated. The present population of these localities is, probably, about 200,000; but it is remarked the main works are sufficient for an increase of the population to 500,000. The pumping machinery is limited to what is required at present, facilities being afforded for connecting additional engine-power when required.

7. The approximate cost of the works to be carried out first, in the streets, at the pumping station, and in preparing the filtering area, is £275,000. The total ultimate cost of the whole scheme sufficient for a population of 500,000, is estimated at £336,250. The storm-water culvert in Elizabeth and Little Bourke streets is to cost £26,512 in addition. It is, however, remarked that it is impossible, from the data supplied, to give anything like an exact estimate. The annual cost of pumping is put down at £900 at first, and at £1850 ultimately. No other working expenses are mentioned.

8. Such is an outline of the scheme proposed in the essay. Reasons are given for coming to certain conclusions on a few main points only, such as—(1) the necessity for subsoil drainage, (2) removing a portion only of the rainfall by the

sewers, (3) recommending the introduction of water-closets in place of the dry-earth system, (4) the selection of a site for the final disposal of the sewage, and (5) dealing with the sewage by the system known as "intermittent downward filtration." But even on these points the information is very meagre, and the data on which the results generally are based are not given; it is, consequently, often very difficult to make out what the essay really allows for various purposes.

9. In criticising the essay it will be well to commence with the estimate of probable outlay for the works, which is one of the first things to attract the attention of the public, who will have to find the money. The estimate cannot be criticised in detail, but the total sum may usefully be compared with the cost of works executed elsewhere. The cost of the main drainage of London was "£1, and its annual expenses 1s., per head of the population;" and it has been remarked that "these figures contrasted most favourably with the prime and annual cost of any other system in use," in England or elsewhere.* The drainage of Paris probably cost about £2 a-head.† It would not be surprising, therefore, if a complete and efficient scheme for Melbourne should cost more than stated in the essay; the ultimate cost allowed being only two-thirds of the London rate.

10. Pumping is the only item of annual working expenses mentioned in the essay. There is, however, much else to be allowed for, such as—(1) wear and tear of machinery, (2) repairs to sewers, traps, gratings, and works of all kinds, (3) flushing the sewers and clearing out obstructions now and then, and (4) removing the sludge from the gratings at the filtration area, and digging it into the ground. The interest on a loan must also be provided, as well as a certain sum for the repayment of the loan. Then there would be the establishment required to enforce the rules that would have to be adopted, and to superintend generally the working of the scheme; a certain office establishment would also be necessary. A drainage scheme cannot be left to each local authority to do what it pleases; there must be one central authority over the whole; this, indeed, the essay insists on. As above remarked, the annual expenses of the drainage of London amount to 1s. a-head; the drainage of Paris costs still more. At 1s. a-head, the annual cost in Melbourne for

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* "Proceedings of the Institution of Civil Engineers," vol. 49, p. 219.
† *Ibid*, vol. 53, pp. 193, 201.

the existing population of 200,000 would be about £10,000, instead of £900 only, the sum provided in the essay. If it be urged that the sum of £900 is, as stated in the essay, for pumping only, not one of the numerous other items just mentioned is provided for.

11. The next point that may be considered is the engine-power allowed for pumping. The work to be done by the three pumps is to raise 18,300 gallons—equal to 183,000 lbs.—per minute to a height of 15 feet, or 2,745,000 foot-pounds per minute. One effective horse-power being represented by 33,000 foot-pounds per minute, it is clear that the *effective* power required is that of over 83 horses. Adding one-fourth to cover loss by friction, &c., the result is that 104 horse-power engines ought to be provided, instead of 79 only. Professor Rankine's rule* gives the same result. The point is, perhaps, chiefly a question of the definition of terms; one manufacturer asserting that his engines are capable of doing more work than that expressed by their nominal horse-power. Whatever pump-makers may, however, promise on behalf of their machinery, it would be only prudent to make a considerable extra allowance for safety. In any case, the question could be settled by adding to the amount of the estimate.

12. A very important point in any drainage scheme is how the sewage is to be finally disposed of. The locality selected in the essay for Melbourne is a portion of the Sandridge Flat. It is little more than two miles from the heart of the city in a south-west direction; and it is due west of Sandridge and Emerald Hill, close to the former and about a mile and a half from the latter place. As the wind blows from one or the other of these two points for nearly a quarter of the year in an average season, it is most important that there should be no doubt as to the area being sufficient and suitable for purifying the sewage at all times, without the risk of being offensive in any way. Yet it is scarcely possible to inquire into the provision made in the essay for this part of the scheme without serious misgivings.

13. The area said to be at present required is 120 acres, formed into three divisions of 40 acres each; one division to be in use for four months or longer, while the other two divisions are being cultivated. It is suggested that irrigation

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* Rankine's *Civil Engineering*, p. 734.

should be encouraged; but the sewage farm mentioned in the essay is apparently considered a matter of secondary importance, being chiefly intended for the disposal of the sludge collected by the strainers. Only a very small portion of the sewage could be used for irrigation at this farm, and that in dry weather merely. Since, therefore, no special provision is made for irrigation on a scale sufficient to affect the result, the 120 acres of filtering beds must be capable of purifying the whole of the sewage.

14. The case of Merthyr Tydvil is referred to in support of the recommendations made in the essay. But Mr. Bailey Denton, by whom the arrangements there were designed in 1871, wrote six years afterwards, that, *for a time*, 20 acres of land sufficed at Merthyr for the purification of the sewage from a population of 30,000 persons,* or 1500 per acre; and he believed purification by the same process "could have been assured for a permanency by the use of 75 acres,"† which would give 400 persons to the acre. The population of Melbourne being taken at 200,000, and an area of 120 acres being provided for the permanent purification of its sewage, the average is 1667 persons per acre, instead of only 400, as at Merthyr; while for the four months that the sewage would be flowing on to 40 acres only, each acre would have to purify the sewage of 5000 persons, instead of only 1500, as at Merthyr.

15. Again, if the quantity of sewage to be dealt with is considered, the filtering area still appears to be inadequate. The quantity of sewage is nowhere definitely stated in the essay; the only information on the point is furnished in the statement of the work the pumps are required to do. Supposing two of the three pumps (leaving one as a reserve), each raising 6100 gallons a minute, to be working, the quantity of sewage to be disposed of would be 17,568,000 gallons—equal to 2,810,880 cubic feet—in 24 hours. This poured over 40 acres, or 1,742,400 superficial feet, would give a depth of over 19 inches to be absorbed daily. This certainly would be in wet weather only; the dry weather discharge might be half this, or a depth of nearly 10 inches. The average of the year may be taken at one pump working every day, and a second pump every third day only; this would give a little over one foot daily to be absorbed. My own experi-

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* Bailey Denton's *Sanitary Engineering* (1877), p. 327.

† *Ibid*, p. 329.

ence with irrigation in India would show that no culturable soil could absorb anything like so much pure water even, day after day. Sand might perhaps absorb this quantity of water, but not so much sewage for a continuance, I should say.

16. Again, the depth of soil through which the sewage is to pass being 6 feet, giving 9680 cubic yards of soil per acre, from 22½ to 45 gallons of sewage, or an average throughout the year of 30 gallons, would have to be purified daily by each cubic yard of soil. On this point, Mr. Denton states that soil has a cleansing power varying from 4 to 12·4 gallons of sewage per cubic yard per diem. Dr. Frankland, who made some experiments for the Rivers Pollution Commissioners, stated before the Institution of Civil Engineers that the average result obtained by him was 9·6 gallons per cubic yard in 24 hours. In one case a good soil purified so much as 15·2 gallons for a time, but there were indications that it would not keep up this high rate; while another soil failed entirely to purify sewage; sand purified 5·6 gallons per cubic yard.* These results (which, it should be noted, were obtained in the laboratory, and are, therefore, more favourable than can be expected in practice) are very different from the 30 gallons per cubic yard to be purified at the filtering area provided for Melbourne, according to the particulars given in the essay.

17. Comparing, then, either the area provided in the essay with the population, or the quantity of soil with the volume of sewage to be purified by it, and taking as an example the case of Merthyr Tydvil (which is referred to in support of the recommendations made in the essay), the filtering area provided for Melbourne appears wholly inadequate. Mr. Denton recommends, where suitable land can be obtained at a fair price, the sewage should be disposed of ordinarily by irrigation, and that an area for intermittent downward filtration should be added as a kind of safety valve. In this way only, he considers, the loss which is inseparable from any other mode of disposing of sewage, "may be turned into a profit."† He says one acre for 1000 persons should be set apart for filtration, out of one acre for 100 allowed for irrigation.‡ This would give, for a population of 200,000, an

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* "Proceedings of the Institution of Civil Engineers," vol. 48, pp. 192, 193.
† Bailey Denton's *Sanitary Engineering*, p. 339.
‡ *Ibid*, p. 340.

area of 200 acres for filtration, in addition to 1800 acres for irrigation; whereas the essay provides 120 acres only for the one process alone.

18. But there is yet another question which concerns the proper filtration of the sewage in the locality selected, even if a sufficient area should be taken up—How far is the level of the land suitable? Drains are to be laid six feet below the surface, and these drains must be sufficiently above the water level of the bay to admit of the effluent water flowing off at all times, besides allowing a slope in the drains themselves to give the requisite discharge. Is the ground high enough for this? If it is not, it could certainly be raised to the required level; but does the estimate provide for this? A sum of £2500 is shown as the cost of preparing filtering ground, equal to nearly £21 an acre for the 120 acres at first required. According to a report by Mr. Rawlinson, "the works at Merthyr cost £230 per acre, while those at Kendall cost £280 per acre."* On what data then is £21 an acre considered sufficient in the case of Melbourne, not only to underdrain the land and prepare the surface, but also to raise it?

19. With regard to the sewers, a few remarks may be now usefully made. It is stated in the essay—"The smaller street drains, being designed to carry off the sewage immediately, before it has time to become putrid, do not require flushing in general, but they should be washed out occasionally by turning on the Yan Yean water into them to assist the ventilation."† Flushing would thus seem to be considered necessary to remove putrid matter only, and not solid substances generally, putrid or otherwise, which are liable to lodge in drains. It is usually found that, as the flow of sewage in the smaller drains and sewers is intermittent, they are particularly liable to be stopped up by paper, hair, grease, &c., and that frequent flushing is necessary.‡ Water from baths is especially suitable for flushing house drains and the smaller sewers to remove these obstructions, since it flows off in a rush; yet the essay says it is not to be used. It is also most plentiful in summer, when Yan Yean water from the mains can least be spared, and flushing is most required.

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* "Proceedings of the Institution of Civil Engineers," vol. 48, p. 246.

† See paragraph 31 of the essay.

‡ Baldwin Latham's *Sanitary Engineering* (1878), pp. 184, 286, and 482.

20. The importance of frequent flushing not being recognised, the absence of the allusion to the gradients of the sewers leads one to doubt whether this point has received full consideration, especially as it is remarked in one place—"Melbourne has for the most part favourable gradients for the employment of small sewers," and again, "the sewage will flow away wherever the ground is sufficiently inclined. In general, there is ample fall to secure this."* The only misgivings as to the slope obtainable generally, are expressed in the remarks made regarding the special treatment proposed for certain flat areas; this treatment will be examined in the next two paragraphs. To explain what the sewers are capable of doing, the gradients to be given to them are necessary to be known, as well as their sizes; the essay gives the sizes only. The efficient and economical working of the system, as well as much of the comfort of the inhabitants, will depend largely on sufficient gradients being given to the sewers, particularly to the smaller ones.

21. Where the slope of the ground is very slight—Richmond Flat, Collingwood, head of Wellington-street, and part of Sandridge are specially named in the essay—it is proposed to use cast-iron pipes, the contents of which might be forced "into the main sewer once or twice a day by hydraulic pressure from the water main, the house sewers being fitted with reflex valves."† It would be interesting to know the details of the proposed arrangement, where it has been tried, and how it has been found to answer. If it is intended to connect the water main with the sewer in order to obtain the hydraulic pressure mentioned, this arrangement is open to the very serious objection, that the water in the main would be thereby liable to contamination occasionally by sewer gas. In any case, Yan Yean water would be required, and, apparently, a considerable quantity of it, to work this system.

22. These cast-iron sewers are not, however, to be introduced till the localities named become more populous; for the present, it is proposed that the house drainage should continue to flow into the gutters, and be swept into the main sewer by manual labour. This would not be much of an improvement, if any, on the existing state of things; and it is not likely to be satisfactory to the ratepayers of the

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* See paragraphs 6 and 14 of the essay.

† See paragraph 44 of the essay.

localities to be so treated. Some better plan, surely, might be devised. Why should certain places, " the natural direction of the drainage" of which is not " unsuitable," be omitted from the general system " because the sewer levels would be too low to be directly connected with the main sewer" ?* If one locality is too poor of itself to pay for exceptional or additional measures being taken for its efficient drainage, other localities ought to contribute. It would not be to the advantage of the wealthier and more favourably situated localities to have in their midst imperfectly drained places—hot-beds of disease, due to bad drainage. The drainage of Melbourne and its suburbs must be treated as a whole, and difficulties properly met, not avoided.

23. The openings to admit to the sewers a small quantity of the dirtiest water from the streets, whenever rain falls, are placed at the bottom of the street gutters. The principle by which the admission of this water is to be regulated requires explanation. On the one hand, the drainage of streets where there is much traffic is found to be as foul as the worst sewage, consequently, ample provision for passing it into the sewers is necessary; on the other hand, unless the sewers are of sufficient capacity, they are liable to overflow in long-continued wet weather, and to flood low-lying yards and streets. Merely trapping house drains would not prevent this serious evil. Further, what is to prevent much of the street grit, which the essay remarks should be excluded, from being washed through these openings into the sewers ?

24. Owing to the limited time allowed for reading this paper, a few other points will be only just noticed by one or two questions :—(1) What are the respective quantities of house and street drainage the sewers are designed to carry ? The only information as to the volume of sewage to be dealt with is contained in the statement of the work for the pumps to do. (2) Is the remark in the essay, " that the sewage cannot be brought to any filtering ground by gravitation," borne out by the levels given on the plans as regards the higher parts of Melbourne ? Owing to all sewage having to be pumped, much has been excluded from the sewers that might be admitted with advantage, such as water from baths and from court-yards. (3) What provision is made for getting rid of that portion of the subsoil drainage, which the essay says,

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* See paragraph 19 of the essay.

owing to the cellars being too low, would have to be pumped up? (4) As regards flood water, is the 30,000 cubic feet* mentioned in the essay, the whole or only half of the flood water provided for? From what area is this to be collected? Is the discharge calculated at 15 cubic feet per acre per minute, which the essay says would flow off in very heavy rainfall? This would give only a quarter of an inch of rain per hour—not much to allow for a heavy thunderstorm.

25. The following summary will show at a glance the chief points alluded to in this paper:—

(1) No provision made for pumping subsoil water from places too low for it to flow into the river.
(2) Pumping-power for sewage deficient by about 25 per cent.
(3) Absence of the means of *regulating* the admission of street drainage to the sewers.
(4) No provision made against the danger of sewers in places overflowing in long-continued wet weather.
(5) Importance of *frequently* flushing the sewers not recognised.
(6) Yan Yean water to be used *occasionally* for flushing, while water from baths, which is most suitable for the purpose, is not to be used.
(7) Inadequate provision made in dealing with certain flat areas in the suburbs.
(8) Filtration area too small, considering the population and the quantity of sewage to be dealt with.
(9) The case of Merthyr Tydvil fails to support the recommendations of the essay.
(10) Level of land selected appears to be too low for the effluent water to flow off freely.
(11) Estimated cost of preparing the land appears extremely low.
(12) Probability of both the first cost of the whole scheme and of the subsequent annual charges exceeding considerably the amounts stated in the essay.

26. Although so many defects have been brought to notice above, I do not wish it to be understood that I think there is a want of merit in the prize essay. I heartily approve of several of its recommendations, and only regret that time will not allow of its favourable, as well as

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* See paragraph 25 of the essay.

unfavourable, points being noticed. The object of this paper is, by calling forth a discussion on the subject generally, but more particularly to the points above noticed, to lead to further information being obtained, and a clearing up of all difficulties. Some of the difficulties can, doubtless, be easily explained when the key is once given; but at present the key is wanting, and, in consequence, the scheme proposed in the essay *now appears* very incomplete. If I can be shown to have misrepresented the essayists, I shall be glad to correct my remarks. Some of the defects pointed out in this paper could be removed simply by an addition to the estimated cost of the works; but to get rid of others would involve material modifications of the scheme proposed in the essay. A satisfactory and efficient scheme will be devised only when there appears a decided wish on the part of the public to have one, and a determination to overcome the difficulties which are now in the way. It is to be hoped, therefore, that the discussion now invited will serve to keep public interest alive to the importance of the subject.

On the Sea-cell as a Possible Source of Danger in Torpedo Experiments.

By H. Moors, Esq.

[Read 13th October, 1881.]

One of the results of the late unfortunate accident at Queenscliff, whereby a boat's crew was destroyed through the premature explosion of a torpedo, has been to bring into considerable prominence the current from what is known as the sea-cell, and the possibility of its being a source of danger in torpedo experiments. When the cause of the accident was being keenly discussed by all who were interested in or conversant with the subject of electricity, the sea-cell current was naturally spoken of, and this was more particularly the case after it had been satisfactorily established by the Board appointed to inquire into the circumstances of the accident that the explosion did not occur through an accidental contact through or by means of the firing key.

A casual conversation with the President of this Society induced me to give some attention to the sea-cell current as a possible cause of the accident, and at his request I embodied the results in a memorandum which the Board published as an appendix to its report.

Now, if the reasoning in that memorandum were unsound, it could have been shown to be so; my calculations were equally open to correction. But those who have objected to my conclusions have not attempted to show that there is any fallacy in the one or the other. They have contented themselves with denying the conclusions; and some who have spoken as with authority have boldly, and, as I think, rashly, asserted that it is impossible for the explosion to have been caused by a sea-cell current.

The question, however, can hardly be considered as finally disposed of by such objectors. Mere assertion is not argument; and as the question is by no means exhausted, I have thought it desirable to bring together in this paper such considerations as seem to be salient to the subject, to view them in the light of some recent experiments, and to invite the members of this Society to give the subject a more thorough and scrutinising examination than it has hitherto met with.

In doing so I shall, of course, have to repeat the substance of the memorandum I have referred to. I have since been informed, however, that the wire used in the fatal experiment was No. 16 B.W.G., and not No. 15 B.W.G., as I had been given to understand. This has rendered necessary some slight alterations in my calculations as to lengths of wire through which fuses may be expected to explode, and I only mention the fact for the benefit of those who may be at the trouble of comparing the two documents.

It appears that the case containing the fatal charge was of zinc. Now, it is a common practice to attach the earth-wire of the charge to the metal case, which thus becomes the earth plate. I do not know whether this course was adopted in the Queenscliff experiment; but if it was not, it is easy to understand how the earth connection, though left loose, might come into contact with the zinc. And if we further assume that some portion of the copper of the firing line came into contact with the iron body of the "Cerberus," the zinc, the iron, and the sea constituted what is termed a sea-cell, and a simple test with the galvanometer will show any one who may care to make the experiment that under these circumstances a considerable current passes along the wire. The only difference between this sea-cell and a cell consisting of a tumbler of sea-water, with slips of zinc and iron, would be in their internal resistances; the electromotive force would be the same, but the internal resistance of the small cell would be considerable, while that of the sea-cell is inappreciable, and may be regarded as nothing.

It is easy to see how there *may* have been this contact between the copper wire of the firing line and the iron body of the vessel. The exposed end of the wire may, for instance, have touched some portion of the vessel, or its metal fittings, metallically connected therewith, and not originally covered with paint, or from which the paint had been removed.

But I do not say there was such a contact. Indeed, my object in this paper is not to usurp the functions of the Board by investigating the cause of the accident, but to call attention to what may prove a source of danger, and perhaps of disaster, in similar experiments, conducted under similar circumstances.

The important question, therefore, is, whether the electrical action of a sea-cell composed of a zinc case like that used in the fatal experiment, the body of an iron vessel, and the sea-water in or on which both are lying, is sufficient to produce a current equal to or approaching within dangerous proximity to that which is known to be sufficient to explode an ordinary fuse.

By the well-known law called Ohm's law, the electromotive force in any circuit, measured in Volts divided by the current circulating in the circuit, measured in Vebers, is equal to the total resistance of the circuit, measured in Ohms. Given any two of these quantities, and the third can at once be ascertained.

Poggendorff (as quoted by Sabine) gives the electromotive force of zinc and iron in a concentrated solution of chloride of sodium (common salt) as—

$$\begin{aligned} &\cdot 476 \text{ of a Daniell's element,}\\ &= \cdot 476 \times 1\cdot 079 \text{ Volt,}\\ &= \cdot 514 \text{ Volt.}\end{aligned}$$

From tabulated results obtained by Professors Ayrton and Perry, and given in Everett's *Units and Physical Constants,* the value would appear to be ·564. It is found thus:—

Difference of potential between copper of wire and iron = − ·146
" " " iron and sea-water = − ·605
" " " sea-water and zinc = ·565
" " " zinc and copper of wire = ·750

Total ... ... = ·564

The latter is probably the more reliable authority, and it is certain that the electromotive forces of the more generally known forms of cells, as calculated from Ayrton and Perry's results, agree with those which, from other measurements, we know to be correct.

The first and fourth of these differences of potential are for contacts in air. I do not know what difference, if any, there would be for contacts in sea-water. In the case of the accident, one of these contacts was probably in air; the other may have been either.

The detonating fuse usually made use of for submarine purposes is that numbered 12 in the table given in the *Chatham Instructions in Military Engineering.* It consists of a bridge of ·3 inch of fine platinum wire, the resistance of which, when cold, is ·325 Ohm; at the fusing point, ·74 Ohm; and the current sufficient to fire a charge through it, ·75 Veber. A more sensitive detonator (No. 13) is sometimes used for land service. It is made of finer wire, and its resistance, when cold, is about 1·08 Ohm; at the fusing point, about 2·6 Ohms; and the current to fire a charge through it, ·32 Veber.

The wire used in the unfortunate experiment was, as I have said, of No. 16, B.W.G. I have measured the resistance of the length of wire actually used, and found it to be ·69 Ohm. Its length was 87½ yards. According to this, the length of one Ohm resistance was 126·8 yards, or at the rate of about 13¾ Ohms per mile. This is the value which, for obvious reasons, I have adopted in this paper.

Assuming that the fuse used was No. 12, and the electromotive force to be as given by Everett, we have, for the firing current:—

$$\text{Total resistance in circuit} = \frac{.564}{\cdot 75} = \cdot 752 \text{ Ohm},$$

and this resistance consists solely of the fuse and the wire, that of the cell being nothing.

If the resistance of the platinum wire did not increase as the temperature of the wire increases, we should have—

Total resistance of circuit	·752 Ohm
Resistance of fuse when cold	·325 „
Leaving for resistance of the conducting wire	·427 „

which resistance = about 54 yards.

This is the greatest length of wire through which the current would fire the charge, on the supposition that the resistance of the wire is constant.

Through that distance the charge might not be expected to explode, but I could not assert that it would not explode. The current would probably heat the wire, though perhaps but slowly; the resistance of the wire would increase with the temperature, and this increase would most probably reduce the current to a strength at which it would not fire the charge. It is in the first rush of the current through the conductor that the danger would lie, for that first rush might raise the wire to a temperature considerably higher than that at which it could maintain it, and that higher temperature might be dangerous.

From Bloxom's *Chemistry*, third edition, page 503, I find that gun-cotton, which is the material in a properly made fuse which is in contact with the platinum wire, and is first fired by it, "is more easily exploded than gunpowder. The latter requires a temperature of at least 600° F., whilst gun-cotton may explode at 277° F., and must explode at 400° F." It further appears that the average temperature at which gun-cotton explodes when in the condition most favourable to its rapid heating is about 300° F.; and this, it is important to note, is a temperature much nearer the lower than the higher of the two limits given.

According to the *Chatham Instructions in Military Engineering*, the resistance of the platinum wire increases ·07 per cent. per degree F. As its resistance at 60° F. is ·325, at 277° F. it would be—

$$\cdot 325 + \frac{\cdot 325 \times \cdot 07 \times 217}{100} = \cdot 374 \text{ Ohm}$$

And at 400° F. it would be—

$$\cdot 325 + \frac{\cdot 325 \times \cdot 07 \times 340}{100} = \cdot 402 \text{ Ohm}$$

For the lower of these resistances we have—

Total resistance of circuit ...	·752 Ohm
Resistance of fuse at 277° F. ...	·374 „
Resistance of wire ...	·378 „

which resistance = about 48 yards; and for the higher—

Total resistance of circuit	...	·752 Ohm
Resistance of fuse at 400° F.	...	·402 „
Resistance of wire	...	·350 „

which resistance = about 44½ yards.

Through any length of wire considerably exceeding 48 yards, therefore, contact of the wire with the body of the vessel would be comparatively safe. Through all lengths of wire between 48 yards and 44½ yards the charge might or might not explode, according to the quality of the gun-cotton. Through lengths less than 44½ yards the charge certainly should explode.

Bearing in mind that the resistances of the best made wires and fuses will vary as the quality of the metal, the size of the wire, and, in the case of the fuse, as the lengths of the wire vary, it will be apparent that no sane person would for a moment trust his own life or the lives of others to the chance of a charge not exploding through any length of wire at all near the higher of the limits I have given.

Different results follow from using the more sensitive fuse, No. 13, and by taking the lower value for the electromotive force. The results are embodied in the following table:—

Electromotive Force.	No. of Fuse	Lengths of No. 16 wire between which explosion may be expected.
·564	12	48 yards — 44½ yards
·564	13	65¾ „ — 54 „
·514	12	39 „ — 35½ „
·514	13	46 „ — 34 „

For lengths exceeding the greater lengths the charge may not be expected to explode; for lengths shorter than the less the charge should explode.

In such a circuit as that in question the fuse of itself forms so large a portion of the total resistance of the circuit that a slight variation in its resistance has a very appreciable effect. The resistance of the fuse when cold is equal to that of about 41 yards of No. 16 wire. If the bridge of the fuse consisted of ·2 inch instead of ·3 inch of platinum wire, its resistance would be about ·1 Ohm less. Hence, to maintain the same strength of current, an addition of ·1 Ohm, or about 12½ yards, might be made in the length of the firing line. But as a less current would fire such a fuse, more than 12½ yards might be added without decreasing the efficiency of the current.

It may be thought that in these calculations I have been unnecessarily particular, as, for instance, in allowing for differences of temperature, &c.; but I have thought it best to be precise. There will always be a margin of uncertainty in such calculations, for the constants used can only be regarded as approximately correct; but I have been anxious not to add to that uncertainty by any laxness in the use I have made of the constants.

Doubtless the Torpedo Inquiry Board has good reasons for not having tested the foregoing purely theoretical considerations by a series of experiments, which would have decided the question of the strength of the sea-cell current. Perhaps it may even yet adopt that course.

In the meantime, I proceed to give the result of some experiments recently made by Messrs. Geo. S. Caldwell and Geo. Smibert, both of the Post and Telegraph Department, and both well known as practical and scientific electricians. Mr. Caldwell's previous experience as an electrician had convinced him that, under certain circumstances, the current from a sea-cell was of considerable magnitude. Hence, from the time of the accident he suspected, and he is the only person I know who from the first did suspect, that the accident might have been caused by a sea-cell current. Instead, therefore, of regarding as decisive the negative results of certain experiments we have heard of through the daily papers, these gentlemen resolved to test the question for themselves. They did not intend to publish the results, but, at my request, have kindly placed them at my disposal.

The experiments were made from on board R.M.S. "Malwa," as she lay alongside the Railway Pier at Williamstown. A zinc plate, 7 feet by 3 feet, was lowered over the side of the vessel, well clear of the hull; and, to complete the circuit, a small portion of the main rail of the ship was scraped clean of paint and rust, and touched with the end of the wire. After some preliminary tests with the galvanometer, eight fuses were experimented on, with the following results:—

1. Exploded on first contact through about 8 yards of wire.

2. Exploded through the same length, but only after a considerably longer contact, showing a decided difference in the sensitiveness of the fuses.

3. Exploded through 10 yards.

4. Exploded through about 14 yards.
5. Exploded through about 24 yards.
6. Exploded through about 41 yards at moment of contact, showing that the fuse was of great comparative sensitiveness.
7. Exploded through about 21 yards.
8. Exploded through about 17 yards, but only after long contact.

By actual measurement the resistance of the wire used gave 1 Ohm to 175 yards. The proportion of 175 to 126·8 is very nearly as 7 to 5. If, therefore, we take five-sevenths of the length of wire used by Messrs. Caldwell and Smibert, we get very nearly the corresponding lengths of wire of the same resistance as that used in the Queenscliff experiment.

The fuses used were sent out to the colony some years ago for use in the Torpedo Corps, and, it is to be presumed, were manufactured with proper care in the Government workshops at home. By measurement, I find the resistance of them to vary from about ·6 to about ·7 Ohm; but I cannot say what current is supposed to be sufficient to fire them, as I do not know the size, &c., of the wire employed. I can only say that they were regulation fuses, for use in torpedo work, and that they were not " made for the occasion."

From these experiments, in connection with some tests with the galvanometer, Mr. Caldwell suspected that in the hull of the " Cerberus" there was a more potent metal exposed than iron, and he concluded that, possibly, there were some copper surfaces connected with the vessel exposed to the action of salt water. He ascertained that a sheet of zinc, 7 feet by 3 feet, in conjunction with a sheet of copper 18 inches square, will unfailingly fire these regulation fuses through short lengths, say about 12 feet of the wire usually employed.

My calculations have reference to the power of an iron and zinc sea-cell; but the presence of an exposed surface of copper in the bottom of the iron vessel would, undoubtedly, increase the electromotive force of the cell. Now, it is a fact that in the bottom of the " Cerberus" there is an amount of copper surface exposed to the action of the sea-water, and the same may be said of R.M.S. " Malwa."

With reference to the experiments from the "Malwa," however, the consideration must not be lost sight of that in the sea-water just within the entrance at the Heads there is a much larger proportion of salt than there is in the water off the Williamstown Railway Pier. With the same metals, therefore, the electromotive force of the cell would be less at Williamstown than it would be at Queenscliff.

I would invite your attention to the differences in the fuses used. They are supposed, and certainly were intended, to be uniform, and yet we find them to vary greatly in point of sensitiveness; and this naturally leads me to repeat the remark that some degree of uncertainty attaches to the constants that enter into calculations like the present. Thus, I have had to use two values for the electromotive force of the cell, of which values both cannot, and neither may be, correct, for the true value may lie between the two. These two values, as well as the other constants I have made use of, must be regarded as the mean or average values, resulting from a number of measurements. Hence, a current that will explode one fuse will fail to explode another supposed to be similar; and if theory shows that a certain kind of fuse should explode through a certain length of wire, one fuse may explode through a greater while another may fail to explode through a less length.

Thus the foregoing calculations point to a doubtful and dangerous region between the positively will and the positively will not, a region in which a fuse may or may not explode, according to circumstances not fully known to us, and which, therefore, cannot enter into our calculations; and if it be an object to avoid an explosion, we should make it a point to keep as far from this region as practicable.

This is fully recognised in the instructions for guidance in torpedo operations. If it be an object to make an explosion certain, it is usual to provide a current double that which theory shows to be just sufficient. If, on the other hand, it is necessary to send a current through a fuse without exploding it, as in certain testing operations, which I need not particularise, it is important that the current should be so small as to preclude danger of an explosion. And as bearing on the subject of the late accident, it is of interest to note what is considered as the limit of danger. The *Submarine Mining Drill Book* forbids the use of a larger current for testing than ·3 Veber; any current exceeding that, is presumed to be more or less dangerous. A sea-cell current between the hull of an iron vessel and a large zinc plate through the wire used at Queenscliff and a No. 12 fuse would be from ·5 to ·55 Veber.

Viewed in the light of the foregoing remarks, the experiments of Messrs. Caldwell and Smibert may, I think, be fairly regarded as confirming the conclusions I had come to from considerations purely theoretical.

They certainly prove that, notwithstanding assertions to the contrary, a sea-cell consisting of an ironclad like the "Cerberus" and a large zinc case with short lengths of No. 16 wire does produce a heating current through a regulation fuse.

It may be asked how certain experiments carried out in this and in an adjoining colony, and which did not produce like results, are to be explained. For my own part, I may say that I do not feel called upon to explain them. I have given the results of experiments made by persons of known experience and skill under circumstances sufficiently explained; but I am not called upon to explain the cause of the failure of experiments all the circumstances of which I do not know. Moreover, this is one of those cases in which one well-authenticated experiment that succeeds is of more importance, as a warning of danger, than are fifty that fail.

Whatever may have been the cause of the accident, it seems clear that in the Queenscliff experiment the experimenters were treading on dangerous ground. All that was necessary to produce a dangerous current was an accidental contact between the end of the wire and the iron body of the vessel. And the fact that the position was one of danger would remain, even though it could be proved that the explosion occurred through the presence of dynamite in the charge, or from some other cause at present, perhaps, unsuspected.

The conclusions I deduce from the foregoing remarks may be briefly summarised as follows:—

It is not proved that the explosion was caused by a sea-cell current. There is no proof that the circuit was completed; and neither by theoretical calculation, nor as yet by experiment, has it been shown that a sea-cell current would explode a fuse through such a length of No. 16 wire as that made use of.

But whatever may have been the cause of the accident, and it will probably never be known, it seems clear that the sea-cell current was a source of danger in the experiment. It would still have been so if the accident had not taken place; though, in that case, the danger would have remained unsuspected. I have not before seen attention called to this danger; but I consider it so great that any officer in charge of an ironclad who would allow of experiments being made from on board with charges in zinc cases would incur a very heavy responsibility.

I do not concur in the blame that in some quarters has been thrown on the officer conducting the Queenscliff experiments for using a zinc case for the charge; and, in simple justice to that gentleman, I may state that every person of any knowledge of electricity to whom I have spoken on the subject, including some of considerable experience in torpedo experiments, has candidly admitted that he would not have suspected danger from the iron, zinc, and sea-water combination.

But if it would not have occurred to any of those electricians, it may escape the notice of other gentlemen conducting similar experiments at home or elsewhere. It is for that reason I am desirous that the power of the sea-cell current, under certain circumstances, should be properly recognised. I may have over-estimated the danger, and some of the constants I have used may require correction. That of the firing current, for instance, may be too low; but if there be danger at all, its presence should be known and guarded against. It is better in torpedo operations to keep well on the safe side than, by misplaced confidence, to endanger, and perhaps sacrifice, valuable human lives.

Art. XVII.—*Floods on the River Barwon.*

By W. W. Culcheth, M. Inst. C. E.

[Read 8th December, 1881.]

(With Diagram.)

1. It may make this paper more clear to many to state at the outset that the Barwon floods formed the subject of a trial lately at Geelong, where damage was said to have been caused to certain mills by reason of the construction of the railway across the river having raised the level of the flood which occurred in September, 1880. The verdict of the jury was to the effect that negligence, in a legal sense, had been shown in the construction of the railway, and that the flood had been raised, at the mills in question, one foot above the level of a former flood which occurred in 1852. The matter having been so far settled, this paper has been written to elucidate the points of scientific interest in a way that was not possible in a court of justice, where, of course, all technicalities were, as far as possible, avoided in laying the matter before the jury. Some of the evidence sworn to by witnesses in court is evidently incompatible with other evidence, and has had to be rejected by the author; but in doing so, he does not wish to cast the slightest reflection on any witness, as he fully believes each one was actuated with a desire to testify to facts. Mistakes have undoubtedly been made, and this is not surprising, especially in the case of the flood of 1852, which took place twenty-nine years ago. In many cases, perhaps, a little extra information would have served to explain differences; but in others, doubtless, mistakes have been made which render the information useless.

2. Widely different opinions were expressed by professional witnesses on various points. The author is of opinion that some conclusions were drawn after merely a superficial inquiry into a very difficult subject, which many engineers may not have had opportunities of studying. From several years' experience in hydraulic engineering, the author has found that the facts which first attract attention are often misleading, and it is not till an almost exhaustive inquiry has

been instituted and all facts carefully compared, that an engineer is justified in feeling sure that he has proper data to work upon. At sudden contractions, sharp bends, and wherever obstructions occur in the stream, single flood-marks should be accepted with caution. It will be seen further on that much discretion is required in making use of levels obtained at such places.

3. Two or more series of levels were taken to ascertain the relative heights of various points. The datum to which all these have been reduced is mean low-water level of Hobson's Bay, obtained through the railway engineers, it is understood. Several cross-sections of the river were also taken at suitable points. Without these cross-sections, calculations of the quantities of water and velocities at various places could not have been made, nor could the action of the flood have been properly investigated. The omission of this part of the inquiry by some engineers has led to erroneous views having been put forward as to the action of the flood. Some of the data on which calculations have been based are, for convenience, given in a tabular form in an appendix to this paper. The main results of the calculations made by the author are shown in the accompanying diagram, forming a longitudinal section of the portion of the river where the action of the floods has been complicated by the two embankments formed since the great flood of 1852. The upper embankment is the Colac-road causeway, forming the approaches to the iron bridge, also known as the Moorabool-street bridge. The other, a mile and a-half lower down the river, is the railway embankment, which was formed about the year 1875.

4. The author is greatly indebted to Mr. T. B. Muntz, city surveyor of Prahran and a member of this Society, for permission to make use of the cross-sections and of the levels, and much other information collected and arranged by him: also for the loan of a plan* of the river showing the course of the flood of 1880. The author has also to acknowledge the receipt of much valuable information from Mr. Robert Watson, the well-known railway engineer; and from Mr. W. C. Kernot, of the University.

5. The catchment basin of the River Barwon, with its tributaries—the Moorabool, Yarrowee (or Leigh), and several small creeks—is estimated to have an area of about 1500

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* The plan has not been printed.

square miles. From the junction of the Barwon and Moorabool Rivers at Fyansford, about four miles above Geelong, no stream of any size falls into the river till immediately below the existing railway embankment, where the Waurn Ponds Creek joins it. This creek enters the valley of the Barwon above the embankment, in which an opening was left so that the waters of the creek might flow on in their natural channel. Five or six miles below Geelong the Barwon discharges into Lake Connewarre, which is connected with the sea. The influence of the tides extends as far as Geelong, but is very slight, excepting, perhaps, as some say, during the prevalence of strong southerly winds.

6. There was a great flood in the Barwon in May, 1852, when there appears to have been no artificial obstruction of importance (that is, compared with existing obstructions) across the river. Where the iron bridge now is (C.S. No. 6), connecting Moorabool-street in Geelong with the Colac-road on the other side of the river, there was a wooden pile bridge, which was washed away by that flood; but the obstruction caused at this place was confined, as far as the author can ascertain, to the ordinary river channel; there were no raised approaches as at present. The iron bridge was afterwards erected in place of the wooden bridge. About one and a-half miles below this, the railway was, in 1875, constructed across the valley, with a large bridge over the ordinary bed of the River Barwon, and a smaller bridge over the Waurn Ponds Creek. At a gorge (C.S. No. 1), one and a-half miles further down—a point of considerable importance in this inquiry—a tannery was erected a few years after the flood of 1852, causing, as far as can be ascertained, only a slight obstruction in the flood of 1880.

7. Though the River Barwon when confined to its ordinary bed (200 to 300 feet only in width) may present few difficulties, such is not the case when it is in flood. At such a time there are here and there obstructions to the flow of the water, while above and below these the water spreads out into what, in a bird's-eye view, would appear as lakes, but the water generally flows through these in a broad stream, which in one place is nearly a mile in width. Owing to the absence of any length of moderately uniform channel, it would not be easy to calculate accurately the volume of water flowing past any point in a flood, even if the level of the water remained constant for a sufficient time to note its main features. When, however, as in this case, a few flood-

marks, obtained long after the water has subsided (which marks may have been caused at various times during the flood), form the only data, the case becomes very complicated. The levels of the actual flood, as well as can be ascertained, are shown in the accompanying diagram by black lines, the shaded line representing the midstream section.

8. The volume of water flowing down the river during the flood of 1880 is found by the author to have been as follows:—At two p.m. on Sunday, 12th September, when it is said the flood level at the mills reached its highest, probably a less quantity than 65,000 cubic feet per second was flowing off. The level at the mills is said to have remained constant till five p.m., when it is calculated the quantity of water coming down the Barwon was 69,000 cubic feet per second—67,000 under the iron bridge and 2000 over the Colac-road; this was the quantity flowing through the railway bridges at five p.m. It is said that the flood level at the mills fell after five p.m.; but it must have gone down very slowly, since the next morning it had decreased nine inches only; it is also said that the flood some miles up the river, as well as at the gorge, one and a-half miles below the railway embankment, was not at its greatest height till about eleven p.m. All this time the bank must have gone on cutting away; and the author estimates that 600 square feet of waterway were added during the six hours from five to eleven p.m., which would have denoted a largely increased discharge, but for the fact of the water level above the embankment falling; this in turn gave a larger difference of level at the iron bridge, allowing the increased volume of flood water to come down the river without raising the level on the upper side of that bridge. By equating the quantities, it is calculated that about 2000 cubic feet per second was the additional quantity of water flowing down the Barwon at eleven p.m., making the total discharge then 71,000 cubic feet per second.

9. Some water would also without doubt be coming down the Waurn Ponds Creek, though it does not seem to have been observed. It may safely be assumed that it was being carried off by the breach in the railway embankment (70 to 90 feet in length) which had occurred near what is called the Marshalltown crossing, about half a mile south of the Waurn Ponds bridge. As, however, this water would have to pass through the gorge (C.S. No. 1) one and a-half miles below the railway, it is necessary to form some estimate of the quantity. The area drained by the creek being

taken at 40 square miles, the flood discharge would probably be 4000 cubic feet per second; but the catchment area being so much smaller than that of the Barwon, the flood from the creek would have begun to subside long before that from the Barwon was at its height. The author considers that 2000 cubic feet should be added for the discharge of the Waurn Ponds Creek when the flood coming down the Barwon was at its height (at eleven p.m.). This would make the quantity passing at that time through the gorge (C.S. No. 1) 73,000 cubic feet per second.

10. The water impounded by the railway embankment, when it began to flow off, would also pass through this gorge; but, except for the cutting away of the banks, the impounded water would not, under the conditions of the case, flow off till the water level below the embankment had begun to fall. As regards the effect of the cutting away of the bank in this case, it is allowed for in the calculation of the additional water (2000 cubic feet) coming down at eleven p.m. In any case, the increase due to the impounded water flowing off could have been but very small. Taking the area at 36,000,000 square feet, and the fall in the water level at nine inches by the next morning (say, in twelve hours), the mean quantity would be only 625 cubic feet per second; but as up till eleven p.m. the fall is estimated by the author at only $\frac{1}{10}$-foot, or a little more, the increase was, in the first six hours, less than 200 cubic feet per second. After eleven p.m., as the flood was decreasing, the additional quantity of the impounded water flowing off (a little over 1000 cubic feet per second on the average of the six hours, less at first and more afterwards) did not affect the maximum discharge at the gorge (C.S. No. 1). Evidently, when the flood level was falling, less water must have been flowing past this point, unless some special cause were at work to produce any other result.

11. Having ascertained the volume of the flood, it is possible to inquire into its action at various important points. The water was flowing with a velocity of nearly 9 feet per second through the two openings of the iron bridge, aggregating about 400 feet in length, into a basin of comparatively still water at least 1600 feet wide; the stream was, in fact, confined at first to a width of 400 feet only out of the 1600 feet width of the river; but its width rapidly increased as it advanced, and its velocity was retarded. In consequence of the contracted waterway, the set of the

stream was against the north bank of the river, overflowing in a continuous wave* the ground where the mills, which suffered damage by the flood, were situated. At C.S. No. 5, taken opposite the mills, it is estimated that only one-third of the flat on the south side of the ordinary river channel was in the current. The level of the water was on the north side of the river higher than on the south side, the difference being considerable at first, and decreasing as the velocity of the water became more nearly uniform on both sides.

12. Below the railway the same result followed from the contraction of the waterway, though to a much greater extent than at the iron bridge, owing to the greater contraction. The lineal waterway of both railway bridges was a little less than 600 feet originally, but was increased during the flood to a little more than 1050 feet, out of a width of 4000 feet for the whole river, measured *along* the railway; taken square with the stream about the same proportion would be found, but it is difficult to give the exact figures. The stream immediately below the railway thus varied from less than one-sixth to about one-fourth of the width of the river. The consequence was a great difference in the flood levels here. Those obtained from Mr. Muntz show that at one place, *in the stream,* the water rose to R.L. 20·89; while at another place, *out of the stream,* the water did not rise higher than R.L. 18·53. The levels obtained from the engineers who gave evidence for the Railway Department show a level of 20·42 at one place (Haworth's tannery) and only 18·77 at another place (Corrigan's house). These differences of level are very important, and will be referred to again.

13. At C.S. No. 3, a short distance further down, where the stream was again forced over by the railway embankment in a wave* to the north side of the river, the current was confined to about 1400 feet out of a total width of the river at that point of 2500 feet. Some distance below C.S. No. 2, owing to the bend in the river, the set of the stream was against the south bank. A little above the gorge (C.S. No. 1), one and a-half miles below the railway, the water was observed to flow with great force between some outhouses there and the bank, and after dashing against the wall of the tannery to pour down alongside of it into the main stream, with a fall of one foot in a length of

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* **Shown in the diagram by a whole unshaded black line.**

about 150 feet.* How the water behaved at the gorge itself is not accurately known, though one witness said it seemed to be much lower in the middle of the river. It was at first thought that the level (16·06) obtained from a well-defined flood-mark made in 1880 in one of the rooms of the tannery there, represented fairly the level of the water across the gorge; but further investigation throws much doubt on this. The mark being at a sudden contraction, and at a bend in the river, the level, *as a mean for the section,* should (as before remarked) be accepted with caution. Owing to the stream being confined at this place to the south side of the river, there was probably as great a difference of level in the flood on the two sides of the river as below the railway embankment (see last par.). After much careful consideration of the point, the author is of opinion that R.L. 15·00 is more likely to have been the average level of the section than 16·06. Calculations of the 1852 flood support this view.

14. A few words regarding the method of calculation adopted may be useful to those wishing to follow up the subject, or to apply the same method to other cases. The ordinary rules and formulæ are not strictly applicable to such irregular channels as the portion of the Barwon River dealt with in this paper. The formulæ given in manuals on hydraulics for irregular channels are, however, generally so complicated that often, rather than use them, one prefers to obtain the results by a series of approximations with the ordinary formulæ. In many cases, the results obtained by either method must be looked upon as mere approximations; but it is better to accept them as such, than, because exact results are not obtainable, remain in total ignorance of the quantity of water to be dealt with, its velocity, and other conditions of motion.

15. In this case, the first thing done was to sketch on the plan the probable course of the stream, and to take the sectional areas of such portions only of the river as would, under the special conditions of the case, be in the stream. Next it was assumed generally that the velocity varied inversely with the area in the stream. Then, at each of the cross sections, the information required has been calculated from the known data on the supposition that the section is that of a uniform open channel. The last

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* Shown in the diagram by a dotted black line.

two propositions are not strictly true unless the changes from point to point are very gradual; but they sometimes form the only means of arriving at even an approximate result. An additional loss of head, beyond what the regular calculations give, has been allowed, according to circumstances, when a sudden reduction of velocity takes place; since, in irregular channels where side currents and eddies are formed, such loss always takes place. The loss of head at each contraction is shown on the diagram; the fall appears as a step where the contraction is great and sudden, as a wave or double curve where the contraction is gradual. The fall or loss of head increases as the *difference* of velocity increases at any given point. The formulæ adopted for the calculations were those ordinarily used in hydraulic investigations. Their application in the manner above described explains some of the difficulties of this case; while the neglect of such calculations appears to have led more than one professional witness to erroneous conclusions.

16. One great difficulty in the case was the following:—The actual level of the flood at one point below the embankment was about 3 feet above the level of the floor of one of the mills, and yet engineers gave evidence to the effect that the flood would have risen a few inches only on the floor of the mill, had the railway embankment not been in existence. A jury might well be excused for preferring the fact to the theory; still the paradox is capable of explanation, though it must needs be a somewhat lengthy one. Omitting the influence of wind in an open channel or reservoir, water is motionless so long as the surface remains level, but so soon as a difference of level takes place, motion commences, the water flowing from the place of higher to that of lower level. The greater the difference of level, the more rapid the motion; or, in other words, the greater the velocity of flow; and conversely, the greater the velocity, the greater the difference of level must necessarily be. Now, in any channel of given width, the depth of water and the slope of its surface adjust themselves to the volume of water flowing down it. If the width of the channel be reduced at any part, it is necessary in order that the same quantity of water may pass through the contracted part, that both the depth and velocity should be increased in one of two ways—(1) if the contracted part be uniform in section and slope for such a length that the depth of water would remain uniform, the increased velocity would be obtained by the increase of depth alone; but (2)

if the contracted part of the channel be short enough to allow the surface slope to vary, the depth would increase to such an extent only as would discharge the same quantity of water with increased surface slope and depth combined.

17. Applying these principles to the case of a stream confined to one portion of a channel, the necessity for a rise in the surface level becomes apparent. The great difference of level below the railway embankment, already mentioned (see par. 12), is an example of this. The calculations made at each contraction give the same results, which are shown in the diagram. As a general rule the cross-section of any stream shows a horizontal line for the surface of the water only when the depth and velocity right across are uniform, or nearly so. When one part of a channel is much deeper than the rest, and the velocity of the water in that part is much greater than in other parts, the level of the water is raised there, so that the surface line is uneven, and not level, as often supposed. When the stream is confined to only a portion of the channel, the rest being still or backwater, the irregularity of the surface line is greatest. This is exemplified by the flood levels obtained immediately below the railway embankment (see par. 12). This effect may be often observed when pouring water from a jug into a basin; it may be seen also in some of the large drains in Melbourne, at the bottom of Elizabeth-street for instance. Where the velocity of any stream is greatest, the surface is generally higher than elsewhere on the same cross-section.

18. Calculations made on the foregoing principles in connection with the flood of 1880 having given results as nearly in accordance with the facts as could be expected, considering the conditions of the case, other calculations were made to show what the levels of the flood would have been, had the two embankments above alluded to not been in existence; that is, if it had occurred in 1852, when the river was comparatively free from obstruction. The results obtained by the author are shown on the diagram by the shaded red line. The starting point is R.L. 15·00 at C.S. No. 1 (see par. 13), and the following are the differences of level worked out:—Immediately above the railway embankment, the water would have been about 4¼* feet lower; opposite the mills (C.S. No. 5), nearly 3¾† feet lower; and just

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* R.L. 21·20—R.L. 16·90 = 4·30 feet.

† R.L. 21·50—R.L. 17.80 = 3·70 feet. Inside the mills the water would have been upwards of 4 feet lower.

above the iron bridge nearly $4\frac{3}{4}$[*] feet lower; further up the river the differences would gradually become less and less. Had the river been as before 1875—that is, the Colac-road causeway in existence, but not the railway embankment—the author calculates the water would have been as shown by the dotted red line, viz.:—In the Victorian Woollen Mills, more than $3\frac{1}{2}$[†] feet lower than it actually was, and above the iron bridge $1\frac{3}{4}$[‡] feet lower, and less further up the river.

19. Attempts have been made to learn the facts of the flood of 1852, but owing to the uncertainty regarding the levels, this has been a most difficult task. The levels which the engineers appearing on behalf of the railway department in the late trial seem to have accepted, would, without modification, give a result which the author feels compelled to reject. Owing to the great slope between the extreme points, or even reducing it by nine inches at an intermediate point to agree with other evidence produced at the trial, the quantity of water would be about 150,000 cubic feet per second, which could not in itself, perhaps, be objected to; but when it is found that for this quantity of water to escape at C.S. No. 1, the level there would be lower than half that quantity of water attained in 1880, it is clear that it must be wrong, unless it can be shown that material alterations have been made in the river below, sufficient to account for this difference. As far as can be ascertained, very little obstruction has been caused at a level that would affect the above results.

20. After numerous failures to arrive at a satisfactory result, the author has obtained one that may be accepted as fairly within the bounds of probability. Above the iron bridge, a flood level—which the author is informed was taken a few months after the flood occurred (or, nearly 29 years ago)—has been adopted in place of the high level (22·80) lately obtained at the Albion Mills by the railway engineers. A little latitude has also been allowed to the other levels, which, considering the number of years since the flood occurred, and the uncertainty of the marks, can scarcely be objected to. On such data the author's calculations make the flood discharge of 1852 to have been about 120,000 cubic feet per second. The author is, however, strongly of opinion that this is more than the actual quantity, but as it is not convenient to enquire for further

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[*] R.L. 23·05—R.L. 18·35 = 4·70 feet.
[†] R.L. 21·90—R.L. 18·30 = 3·60 feet.
[‡] R.L. 23·05—R.L. 21·30 = 1·75 feet.

data, the 120,000 cubic feet per second may be accepted for the purpose of this paper. The mid-stream section, as worked out by the author, is shown in the diagram by the shaded blue line.

21. The last series of calculations made were with a view to show what levels another flood similar to that of 1852 would give under the existing condition of the river. The result is shown by the dotted blue line, which immediately above the railway embankment rises 2½ feet above the flood of 1880; that is, if a flood similar to that of 1852 were to occur now, it would go over the top of the embankment some distance south of the Waurn Ponds bridge, unless the banks cut away as they did in 1880. It is not improbable that the flood would rise still higher, since the increase at and above C.S. No. 1, due to the stream being confined to a portion of the river, is not (considering the section of the actual flood of 1880) fully allowed for. The rise that would be caused is not calculable owing to the direction of the mid-stream being so complicated by the obstructions at the railway embankment. If this is the result given by 120,000 cubic feet per second, it may be left to those who are interested in the matter to decide what would happen if the volume were 150,000 cubic feet per second, as the exact levels given by the railway engineers would require.

22. The deductions from the foregoing investigation are instructive. The railway engineers asserted at the trial that the provision, so far as length of waterway is concerned, for the highest known flood is ample; but the author can only suppose that they omitted to inquire into the volume of water to be dealt with. Notwithstanding the failure of the embankment across the Barwon, and the damage caused by the late flood, not only to private property, but also to the railway itself, the only modification which it is understood the railway engineers now agree to be necessary is to raise the embankment and bridges a few feet. This is in consequence of the flood level having been taken too low at first; it is now said that an error of more than 3 feet in the flood level of 1852 was made when inquiries were instituted preparatory to the construction of the railway. Considering all the facts of the case, it is difficult to understand how simply increasing the headway for floods will, without lengthening the waterway, remove all danger. Another flood similar to that of 1880 would, in the present condition of things, be only a shade less

disastrous than that was. The water would rise to within a very little of the level it then attained; for it must be remembered that it only rose to the levels shown by most of the flood-marks after the bank had cut away to nearly the extent of the existing waterway. The mean velocity of the water flowing through the Barwon bridge (obstructed by struts, &c.) would, in another similar flood, be about 5½ feet per second; while, through the Waurn Ponds bridge it would be more than 7 feet per second. Under these circumstances, can it be expected that the banks, in their present unprotected state, would not again cut away? It may well be questioned whether anything short of masonry abutments would be perfectly safe in case of another flood similar to that of 1880; certainly nothing less could withstand another flood similar to that of 1852. Supposing, however, the banks to be adequately protected, there would still remain the risk of a serious scour under both bridges. In the author's opinion, it is necessary considerably to lengthen the waterway at the same time that the headway under the bridges is increased, before the line across the Barwon can be considered safe.

23. This is a subject, it may be remarked, which does not require an engineer experienced in railway construction to decide; it is especially one for a hydraulic engineer. Considerations of the waterway apply as well to a bridge for a common road as to one for a railway. Flood waters and large volumes of water in motion generally are not to be controlled, except by proper methods, based on sound hydraulic principles. General rules, the result of long experience in all parts of the world, are laid down in standard works on this branch of engineering; and when such, accepted and constantly used by the heads of the profession, are set on one side, good reasons for so doing should be forthcoming. Practice is a most valuable guide; but in order that it may be turned to the best account, it requires to be supplemented by theory, or a thorough knowledge of the principles of construction and of the sciences on which engineering depends. In hydraulic works, an engineer requires to know, as nearly as possible, the volume of water he has to deal with, its velocity when in motion, and such other information as, under the special conditions of the case, he is able to obtain. If exact results are unattainable, an approximation is better than total ignorance on these points; though the more uncertain the results, the greater the margin for safety

to be allowed, as a rule. Without some information on the above-mentioned points, no engineer can feel sure that any works which interfere with a channel are safe. It is not enough in such a case to know merely the highest flood level; if that is all the knowledge obtainable, a channel should always be kept as free as possible from obstruction. And in questions of this nature, it must not be overlooked that where a river in flood overflows its ordinary banks, the channel to be considered is not merely the summer bed of the river, but the whole width in which there is a downward current. If there is not intended to be any contraction of the waterway, the knowledge of the highest flood level might often suffice; though it would be always more satisfactory to ascertain, if possible, the flood discharge as well as the flood level. Many of these remarks may appear very commonplace, but that they are not wholly unnecessary is clear from the points alluded to having been overlooked in the case of an important river like the Barwon.

24. In conclusion, the author desires to state his decided conviction that the whole of the trouble and expense (in the late trial) resulting from the flood of September, 1880, arose from the neglect of the foregoing considerations when designing the railway across the Barwon. Had a proper inquiry into the action of the flood of 1852 been made before the line was constructed, the iron bridge on the Colac-road would not have been taken as the sole guide for the waterway to be given to the railway bridge over the same river, as it was admitted at the trial was done. It may be further remarked that the unfavourable conditions of the site fixed upon for the railway bridge (contrasted with those of the iron bridge site) were not properly allowed for. The iron bridge has an unobstructed waterway with a clear channel below, but the railway bridge has neither of these advantages. Fortunately, however, other arrangements, without being designed for such a contingency, in a measure counteracted some of the errors that were made. The Barwon bridge was evidently intended to carry off the flood waters of the River Barwon, and the Waurn Ponds bridge those of the Waurn Ponds creek; but, in reality, in September, 1880, the latter bridge served the purpose of a safety-valve to the Barwon; and when the flood was at its height, it (with the adjoining gaps in the embankment) discharged about the same quantity of water as the Barwon bridge itself. Certainly, the cutting away of the railway

embankment in several places prevented the damage to private property above the embankment being more serious than it was. The fact that no train dashed into one of the gaps in the embankment is a matter of congratulation; there would have been more than a possibility of such an occurrence had the flood happened on any day but Sunday; and it ought not to be overlooked that, under present conditions, there will again be the same risk when the next flood takes place. Under these circumstances, the subject possesses an importance that should secure a remedy for the existing defects.

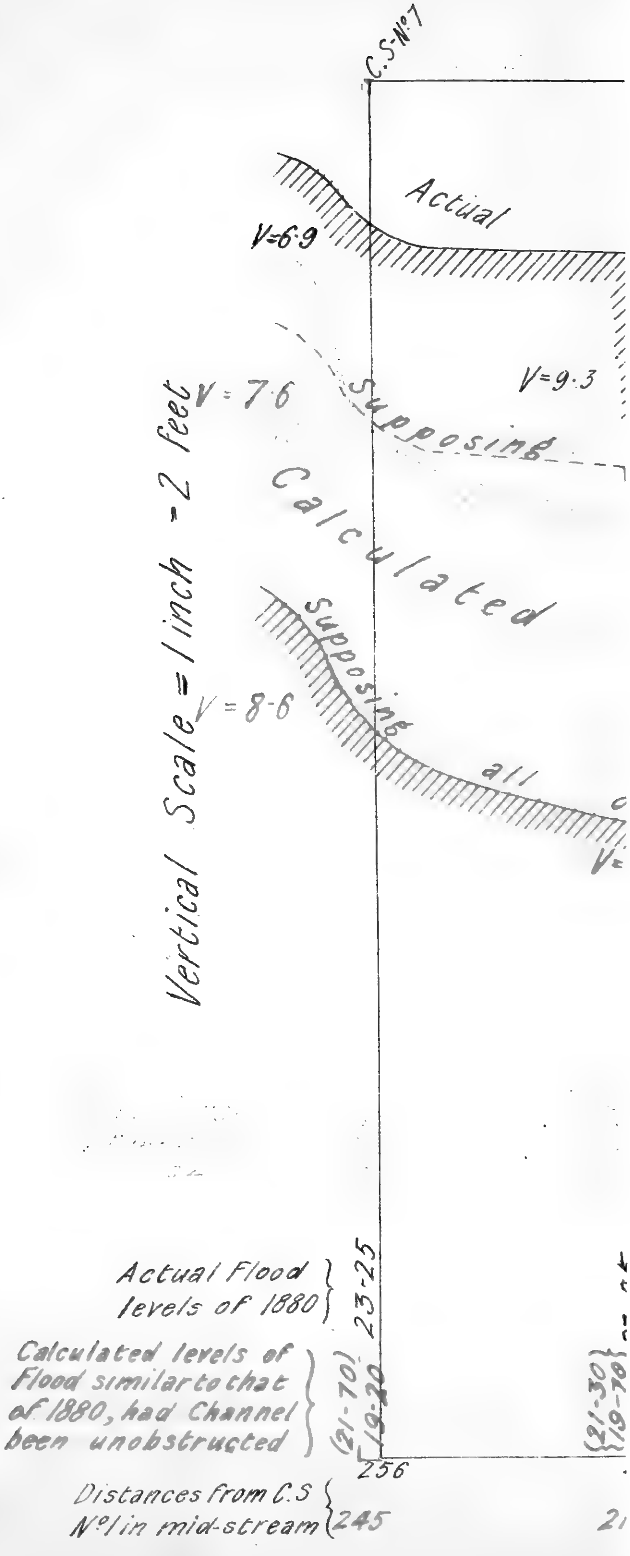
See Appendix, on next page.

·APPENDIX—*Giving some of the Data in connection with the Floods on the River Barwon in* 1852 *and* 1880, *on which are based the Calculations referred to in the foregoing Paragraphs.*

Cross Section No.	Distances above C.S. No. 1, measuring—			Reduced Levels* in Mid-stream of Flood of 1880.	Width of Stream at given Levels.		Sectional Areas of Stream at given Levels and Widths.		Percentage of unobstructed area effective in 1880.	Remarks.
	Along Ordinary Summer Channel.	By the Stream when in Flood.			Possible, if Obstructions did not exist, as in 1852.	Estimated as effective in the Flood of 1880.	Full Width, unobstructed, as in 1852.	Estimated as effective in 1880.		
		Unobstructed, as in 1852.	Obstructed, as in 1880.							
	Chains.	Chains.	Chains.	Feet.	Feet.	Feet.	Supfl. Feet.	Superficial Feet.		
1	..	..	..	15·00 17·00†	750	640	9,960	9,670	97	A tannery, built since the flood of 1852, obstructs slightly the flood waterway at this point. The higher level (17·00) was a little above the gorge. Widths and areas of stream refer to R.L. 15·00.
2	41	41	41	17·60	2,200	?	23,000	?	..	Flood-mark on north bank was higher than the level here given for mid-stream, which in this case is somewhat uncertain. Width and area of stream are also uncertain.
3	92	86	86	18·70	2,500	1,400	24,800	15,300	62	Section taken at a narrow part of river, a little below railway embankment. On north bank flood-mark was much higher, and on south bank lower, than in mid-stream.
4	124	106	110	19·70 21·20†	4,000	600 originally, increased during flood to 1050	‡ 44,000	§ 9000 originally, increased during flood to 13,900	14 to 26	Section alongside railway embankment, but not crossing the river at right-angles to stream. The areas here given cannot be fairly compared with those of the other sections, owing to obstructions in the waterway of bridges.§
5	206	192	194	21·50	3,000 1,400	1,150 700	33,200 6,300	14,500 3,150	45	South side of river and main channel. North side of river (about R.L. 17·00) overflowed in both floods.
6	242	218	228	21·90 23·05†	1,600	400	17,600	7,660	44	Section taken alongside the Colac-road causeway.
7	270	245	256	23·25 23·85†	500	500	10,130	10,130	100	Levels are somewhat uncertain at this section, which was taken at a gorge, where there are no well-defined marks.

* Above mean low-water level of Hobson's Bay. † These are the higher levels, where there was a sudden fall in the stream. Width and areas refer to the lower levels only. ‡ No. 4 does not give a fair sectional area of river, owing to the section not being at right-angles to the stream. § See note A (over leaf).

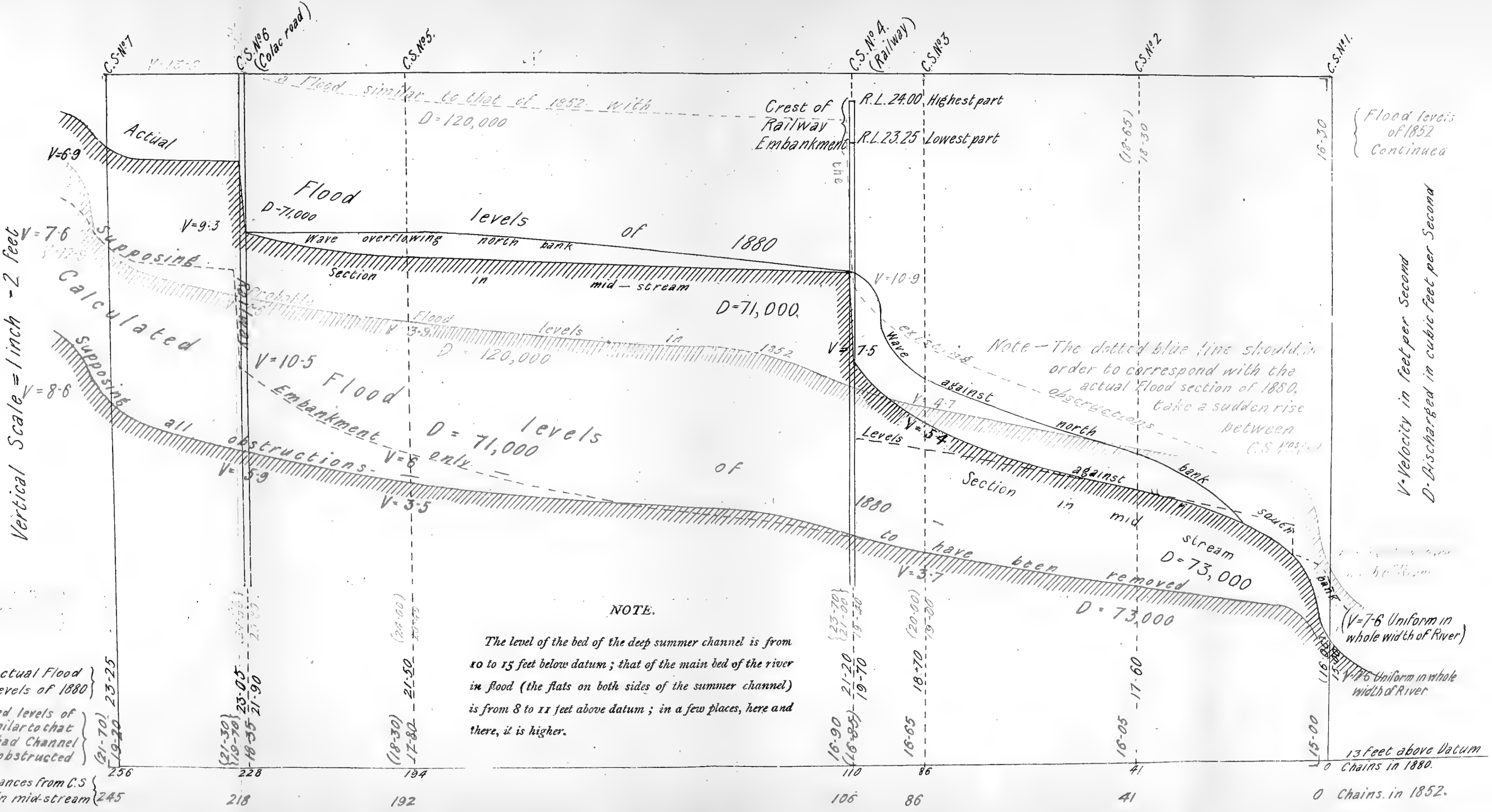
Diagram



Note—Datum is mean low-wa

Diagram showing levels of the Floods in the River Barwon in 1852 and 1880.

(For References to the paragraphs illustrated by this Diagram, see B opposite)



NOTE.

The level of the bed of the deep summer channel is from 10 to 15 feet below datum; that of the main bed of the river in flood (the flats on both sides of the summer channel) is from 8 to 11 feet above datum; in a few places, here and there, it is higher.

Note—Datum is mean low-water level of Hobson's Bay. The levels in brackets refer to the dotted sectional lines: the other levels refer to the shaded lines

Note A (*see Appendix*).

The elevation of the Barwon railway bridge (C.S. No. 4) shows about 23 per cent. of each span obstructed by piles and struts, which, besides contracting the waterway, reduce the co-efficient of discharge very materially. The area of the waterway, taken on the skew (at right-angles to the probable direction of the stream in flood), is somewhat less; but a larger co-efficient of discharge than in the other case, with a certain velocity of approach for the current, may be adopted. Considered in any way, however, the conditions of the case are very unsatisfactory, and the calculation of discharge correspondingly complicated.

Note B (*see Diagram*).

References to the Paragraphs illustrated by the various Lines of the Diagram.

	Par.
Black shaded line—Mid-stream section of flood of 1880	7
Black unshaded lines—Levels against banks in 1880	11 & 13
Red shaded line—Calculated levels of flood similar to that of 1880, with all obstructions removed; or, as the river was in 1852	18
Red dotted line—Calculated levels of flood similar to that of 1880, with railway embankment only removed; or, as the river was between 1852 and 1875	18
Blue shaded line—Probable levels of flood of 1852	20
Blue dotted line—Probable levels of a flood similar to that of 1852, with existing obstructions in the river (N.B. The sudden rise between C.S. Nos. 1 and 2, which occurred in the flood of 1880, has not been allowed for in this case)	21

ART. XVIII.—*The Physical Features of the Australian Alps.*

BY JAMES STIRLING.

[Read 9th December, 1881.]

(WITH DIAGRAMS.)

ARTICLE 1.—THE MITTA SOURCE BASIN.

INTRODUCTORY.

INTERSECTED by the 37th parallel of south latitude and by the 147th and 148th meridians of east longitude is situate a tract of mountainous country, which has not been inaptly called the Alpine regions of Victoria, exhibiting a polymorphic variety of physical features at once interesting and instructive—an area within which are situated the highest elevations of the Victorian Cordillera, lofty peaks and elevated snow-clad plateaux (the latter connected to the main range by ridges of varying width and surface contour), amid whose perennial springs most of the principal streams flowing into the Gippsland lakes on the south and the Murray River on the north find their sources. The general trend of the Dividing Range is here north-easterly, and the different source basins it divides are the Indi, Mitta Mitta, Kiewa, and Ovens, flowing northerly, and the Buchan, Tambo, Mitchell, and Macalister, flowing southerly. Owing to their elevation, the more prominent peaks and plateaux are annually covered with snow, which does not melt from their southern and more shaded slopes for many months of the year; and those heights which exceed 6000 feet above sea level are devoid of shrub vegetation. The greater part of the Dividing Range, however, is covered with a vigorous growth of vegetation, principally eucalypts, with undergrowth scrub (thickly growing olearias, pomaderris, Lomatias bedfordias, and other well-known arboreous shrubs), most luxuriant amid the heads of those gullies starting from the southern side of the range. The conformation of the Dividing Range is not that of an anticlinal ridge throughout, but presents a diversity of contour, rising into dome-shaped heights, as at Mount Hotham (6100 feet above sea level); opening out into flat expanse of tablelands at lower levels, as Paw Paw and Precipice Plains (5300 feet); descending into low gaps, as Tongio Gap, near Omeo (3000 feet), thus affording an easier access from the northern basins to the sea-board; and again rising into rugged and serrated mountains, as the Cobberas (6025 feet). The tablelands north of the Divide are Bogong High Plains (6000 feet) and the Omeo Plains (3000 feet); and south of it are the Snowy Plains (about 5000 feet), Dargo High Plains (5000 feet), and the Nuninyong and Gelantipy tablelands, each over 3000 feet above sea level. The physical features of the higher plateaux are distinctively Alpine—flat expanses of moorland and undulating rises, covered with Alpine flowers and snow grasses; mosses and lichens, at the sources of springs, and groups of gnarled and stunted gum scrub on the lower lying shelves. Although the surface is rocky in parts, the soil, a rich volcanic, is highly productive, and during midsummer (about the beginning of February) these highlands are covered with a most luxuriant verdure, the richness and softness of which is hardly conceivable by those who have not seen similar localities. The bright, emerald-tinted carpeting of the snow grasses, with crystal streams (small source runnels) traversing the area, make a most striking contrast to the brown and parched appearance of the lower lands and valleys, literally languishing in excessive dryness at this season of the year. The grandeur and sublimity of the surrounding scenery—seas of mountains rising, wave-like, on every side, presenting almost infinite shades of blue and purple colouring, the extreme rarity of the air, and other conditions which lend an additional charm to the landscape—leave an impression on the mind of the beholder not easily effaced. Although these highlands form excellent summer pasturages, upon which stock fatten rapidly, so rich and nutritive is the herbage, yet, owing to severe frosts, snow, and sudden climatic changes, they are for the greater part of the year perfectly inhospitable. Snow frequently falls to a depth of 12 feet in these regions, and, where at all shaded from the sun's direct rays, remains throughout the entire summer, forming young glaciers, which, however, never mature, owing to variations in summer temperature, to which even these elevated regions are subject.

In close proximity to one of these plateaux (Bogong High Plains) the highest peaks in the colony are situated—

notably Mount Bogong, 6508 feet at its northern extremity; Mount Cope, 6015 feet at its eastern rim; and Mount Feathertop, 6303 feet at the south-west margin. The Main Dividing Range, as at present existing, is not an original axis of elevation, but, on the contrary, has assumed its present position by a long-continued process of denudation and erosion from a once extensive highland existing during miocene time, and of which such peaks as Mount Wills and Mount Gibbo north of it, and Black Mountain, Mounts Bindi, Baldhead, and Wellington south of it, are some of the remaining representatives. Some of the evidences of this ancient highland are found in localities now occupied by coatings of basalt, overlying miocene flora resting on Silurian rocks, some of the present river valleys having eroded their courses along the margin of these lava flows, leaving the height of the underlying strata and the depth of the basaltic coating plainly discernible. Such a case is noticeable at Mount Tabletop, along whose margin the deeply eroded valley of the Dargo River passes, leaving this isolated patch of basalt as a connecting link between the partially denuded coatings on the Bogong and Dargo high plains. The numerous igneous dykes* traversing the metamorphic schists along the valley of the Livingstone Creek (admitting their contemporaneousness with the lava flows existing on the higher elevations) seem also to me to point to a period of higher elevation than at present exists, the igneous dykes being the undenuded portions of an ancient lava flow covering the then existing miocene plateaux.

The present elevated plateaux, as might be expected, form the gathering grounds of most of the principal streams. The Omeo Plains tableland, however, is a noticeable exception to this. Covering an area of 24 square miles, this depressed tableland has a small lake in its centre, 3½ miles long by 1½ wide, which is fed by rains and the storm-waters from the surrounding hills. It has no visible outlet, the character of the country surrounding it consisting of open, treeless plains, merging by gentle slopes into the encircling timbered ranges.

Owing to the proximity of the coast line, about 49 miles

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* There are two sets of igneous dykes within the area, the one intrusive from deep-seated sources, the other as indicated—probable remnants of surface lava flows.

distant from the most southern prolongation of the Dividing Range, at the head of the Livingstone Creek, and probably to the degrading and eroding influence of southerly and south-westerly moisture-laden winds, the southern slopes are steeper than those within the northern basins. This is more especially the case with the Mitchell and Mitta Mitta basins, the former having a more rugged and serrated surface configuration than the latter, which is more undulating and rounded.

Recent observations made by me at Omeo for Mr. Ellery, when compared with records of rainfall at Grant, which is in the centre of the Mitchell basin, give interesting results, at Omeo that for 1880 being 29·92 inches during 114 days, and for same period at Grant 58·59 inches during 154 days. This difference of 38·67 inches, although slightly affected by elevation (Grant being 3700 feet above sea level, and Omeo 2108 feet), is, I think, still due to the following causes:—That as the principal rainfall at Omeo is brought by southerly and south-westerly winds from the Southern Ocean, these moisture-laden winds are deprived of their aqueous matter by condensation south of and along the crest of the Dividing Range, and are then raised into the higher regions of the atmosphere, from which they are attracted by the higher peaks and plateaux; there, by the action of colder currents of air or electric forces, re-condensed, and deposited in the form of snow. Were the surface within the Mitta Mitta basin as much subjected to the action of heavy deluges of rain as that of the Mitchell appears to be, it is probable that the river valleys of the former would be more deeply cut into gorges by erosion, and the peaks present a more splintery outline than they do at present, owing, in a great measure, to the petrological characteristics of the area—crystalline schists, which, as I understand, have a tendency to weather into sharper outlines than their unaltered congeners, the Silurian rock masses occurring in the Mitchell basin. If this view be correct, the undulating and rounded outlines of the ranges within the Mitta Mitta basin would probably result from the more gradual disintegration of the rock masses by frosts and snows. The more important characteristics of the source basins comprised within the area indicated at the commencement of this paper are as follows:—The Indi, although unimportant commercially, is still interesting from a topographical and geological point of view. Forming the head waters of the Murray River, some of its eastern affluents find their sources amid the perennial springs issuing from the highest of our Australian Alps, Mount Kosciusko. One of these affluents, the Pilot River (rising at Mount Pilot, 6020 feet, a coned peak), has deposits of stream tin on its upper courses now being tested. Several of the western affluents are auriferous; while its most southern affluent, the Limestone Creek, runs through a patch of crystalline (marbleiferous) limestone of Devonian age, on which are situated some fine caves, the stalactites being more pearly and translucent than any others I have seen in the colony, while the calcitic crystals which line the sides of the caverns are exceedingly beautiful in appearance.

The Mitta Mitta source basin (the subject of this paper) has not only the greatest surface diversity, but supports the largest population—mining, pastoral, and agricultural—scattered over its area. Within it is situate the Omeo township and its gold workings along the Livingstone Creek, the Omeo Plains agricultural settlement, the gold workings at head of the Gibbo River and at Wombat Creek.

The Tambo source basin has also pastoral, mining, and agricultural operations carried on within its area, quartz and alluvial mining on its western affluent, Swift's Creek, and an agricultural settlement at Bindi, situate on a patch of fossiliferous limestone of Middle Devonian age, intersected by an eastern affluent, Bindi Creek.

The Mitchell source basin has principally mining and pastoral interests within its area. Its northern affluent, the Dargo River, rising at the Divide near Mount Hotham, and draining the Dargo High Plains, has a patch of open, undulating granite country, and some rich alluvial flats, a short distance above its junction with the parent stream. On the latter flats is situated the Dargo settlement, where sufficient agricultural and dairy produce is raised to supply the elevated mining township of Grant, and the quartz mining operations being carried on in the surrounding hills. A western affluent—the Wonnangatta—finds its principal sources in the Snowy Plains tableland.

The delineation of this source basin, with the more important geological and botanical characteristics, will, I trust, form the subject-matter of a subsequent paper.

DETAILED TOPOGRAPHY OF THE MITTA MITTA SOURCE BASIN.

The heads under which I propose to delineate this area (enclosed with red lines on feature-map presented with this paper) are—(1) Its topography; (2) geological structure; (3) botany, or vegetation. To give even a fair outline in each of these subjects would occupy more time than is allowed for the reading of this paper, so that, for the present, I shall confine my observations to its surface configuration, or topography. The area under consideration embraces fully 1050 square miles of territory, made up of the following drainage areas :—

1. Southern affluents	Livingstone Creek,	138	square miles.
	Victoria River	81	,, ,,
2. Western affluents	Cobungra River	98	,, ,,
	Bundarah River	65	,, ,,
	Big River	160	,, ,,
	Wombat Creek	61	,, ,,
3. Eastern affluents	Benambra Creek	233	,, ,,
	Gibbo River	112	,, ,,
Mitta Mitta, between Cobungra and Big Rivers		78	,, ,,
Omeo Lake drainage area		24	,, ,,

Owing to the western affluents draining the Bogong High Plains, and to the general altitude of the western watershed line, the volume of water brought down by these affluents constitutes the principal source supply of the Mitta Mitta. And, as an instance of the effect which the higher plateaux have in regard to the collecting capacity of a source basin, it is interesting to note that, although the Victoria River only drains an area of a little more than half as much as the Livingstone Creek, yet the former empties almost as great (if not quite as great) a volume of water into its recipient, the Cobungra, as the latter does into its recipient, the Mitta Mitta; the Victoria rising at the Paw-Paw Plains, and draining those tablelands, over 5000 feet above sea level, while the highest point drained by the Livingstone Creek hardly exceeds 4000 feet.

Taking into consideration, first, the physical conformation of the western watershed line which intersects the highest plateau, the Bogong High Plains, we find it starting from Mount Hotham, on the Dividing Range (at a much lower level than that height), as a well-defined, narrow ridge, separating the Kiewa sources on the west from the Cobungra on the east. Rising two miles distant to almost a level with the latter mountain, it again depresses fully 2000 feet, and again rises towards the rim of the basaltic coating constituting the Bogong High Plains.

The highest elevation of these plains covers an area of seven square miles, and in it the Cobungra on the south, the Bundara on the east, and the Kiewa on the west, find their sources. From the eastern slopes the watershed line proceeds by easy undulations to Mount Cope (a coned peak), distant about 9½ miles from Mount Hotham. From thence the watershed line traverses a rugged surfaced plateau in a northerly direction towards Mount Bogong; rising into rounded heights devoid of shrub vegetation; stretching into moorland flats; forming into rolling, rocky-crested ridges; narrowing into sharp razor backs, where the source runnels of the different streams interlace each other; and again forming gentle grassy slopes, until at a point about five miles south of Mount Bogong these highlands give place (at a much lower level) to a narrow, serrated ridge, so rocky and sinuated as to render the ascent of the mountain difficult even on foot. The head waters of the Big River skirt this narrow ridge, and wash the base of Mount Bogong (a granite mountain), while the western affluents of Kiewa have sculptured the steep western slopes of this important mountain, the distance between it and Mount Hotham being about twenty miles. From this point the main watershed line between the Kiewa and Mitta Mitta proceeds northerly, forming first a series of rugged surfaced plateaux similar to those south of the mountain, and then forms a distinct anticlinal ridge, descending in elevation towards the Murray flats. South-easterly a minor watershed line, forming a high range, separating the Snowy Creek on the north from the Big River on the south, proceeds to Mount Wills (a bold peak, 5758 feet, having huge escarpments of rock on its eastern face); from thence two ridges radiate, encircling Wombat Creek, the most northerly one forming a finely outlined range, on which are situated Mounts Martin and Cooper, important landmarks on the road between Omeo and the lower Mitta Mitta.

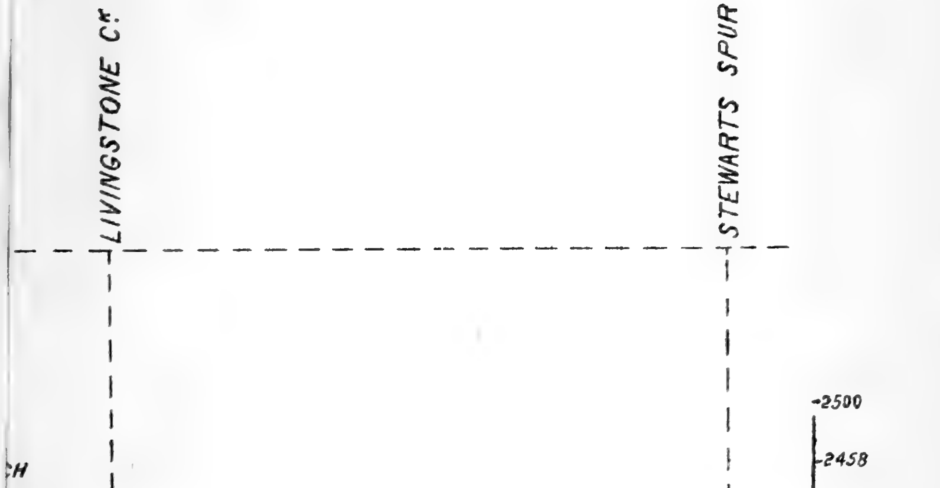
The general configuration of the minor watershed lines dividing the western affluents is that of gradually sloping terraces and shelves, open grassy flats, with thickly timbered rises, occasionally rocky (the timber taller than that on the higher plateaux). The steepest slopes prevail on the southern side of the watershed lines, being frequently precipitous. This peculiarity of the east and west streams seems to me to be in a measure due to the influence of the prevailing southerly winds driving the surface currents of these streams on to their northern banks, and the latter being rocky would cause the streams to gradually wear away towards the north, eating under the rocky cliffs. However, this is merely an opinion, open to objection, as there are so many causes at work by gradual operations, extending over great periods of time, that it would be indeed difficult to form a positive opinion, even as to the proximate causes which led to this peculiar characteristic of these streams. Possibly meteorological conditions during the past may have been more powerful than at present, causing more extensive denudation of the then surface, and eroding the courses of streams in directions which the then existing composition and position of the rocky strata have exercised an important influence in maintaining since that period. Owing to the rapid fall of most of these western affluents they have become eroded down to the bed rock, except in those places where hard bars of gneissose rocks or igneous dykes cross the streams, and by longer resisting the abrading forces of the water have formed above them deep troughs, into which a gravelly wash becomes settled. These deposits are frequently auriferous, and have been worked for gold.

The southern affluents, the Livingstone Creek and Victoria River, are partly encircled by the Main Dividing Range, the character of the country along their courses being much more open and undulating than the principal tracts of country intersected by the western affluents; in fact, almost the whole course of the Livingstone and the greater part of the Victoria includes rich pasture lands, more open and gently undulating along the eastern and south-eastern watersheds of these streams—the former comprising the rolling pasture hills stretching from Omeo township towards Tongio Gap, and north-easterly towards the Omeo Plains, and the latter the still more open and gentle grassy slopes of Parslow's Plains.

The physical conformation of the Divide where it forms the watershed line of these streams is, first, a rather flat expanse of tableland—Paw Paw and Precipice Plains (the south-western edge of these plains being precipitous where the Dargo River valley skirts it); it then depresses somewhat, and again forming an anticlinal ridge towards Mount Phipps, a flat-topped, thickly-timbered height some 16 miles distant, and about 4300 feet above sea level.

An extension of the Precipice Plain tableland forms the watershed line between the Victoria and Cobungra, the surface configuration being a mere modification of that on the higher plateaux. From Mount Phipps a minor watershed line trends north-easterly in a rather circuitous direction towards Mount Livingstone (a rounded height near Omeo), and separating the Victoria River from the Livingstone Creek; while southerly from the former mountain the Main Divide forms an elliptical curve, enclosing the extreme southerly sources of the latter creek. Continuing thence as a well-defined ridge, it suddenly breaks away along the eastern watershed of that creek into two low gaps—Swift's Creek and Tongio Gap—the latter forming the principal (and natural) outlet from the Mitta Mitta source basin to the seaboard *(viâ* the valley of the Tambo River). From Tongio Gap the country slopes gradually towards the Omeo township (five miles distant), while southerly it falls away into a deep gorge formed by the valley of the Tambo.

From this gap the Dividing Range forms a clearly outlined anticlinal range, northerly towards Mount Sisters, at the eastern margin of the Omeo Plains tableland (ten miles distant). Within the Livingstone drainage area is situated the township of Omeo; its actual position, 37° 06′ S. lat., and 147° 26′ E. long., at an elevation of 2108 feet above sea level. It enjoys a mean annual temperature of about 50° Fahrenheit; a climate both salubrious and exhilarating, its greatest summer heat being tempered by cooling mountain breezes, while the winter's snow seldom remains longer in the immediate vicinity of the township than a few days. The Omeo goldfield, although one of the oldest in the colony, remains at present practically undeveloped. An important feature connected with the auriferous deposits near Omeo consists in their situation. Occupying the valley of the Livingstone Creek, since the lower Silurian rocks became metamorphosed into the present crystalline schists, were a series of ancient lakes, or tarns, into which, by the breaking-up of the ancient lava flows, masses of igneous boulders became deposited; subsequently the gradual wearing down of the metamorphic schists, with their associated auriferous quartz veins, filled up these ancient lake-beds with a deposit of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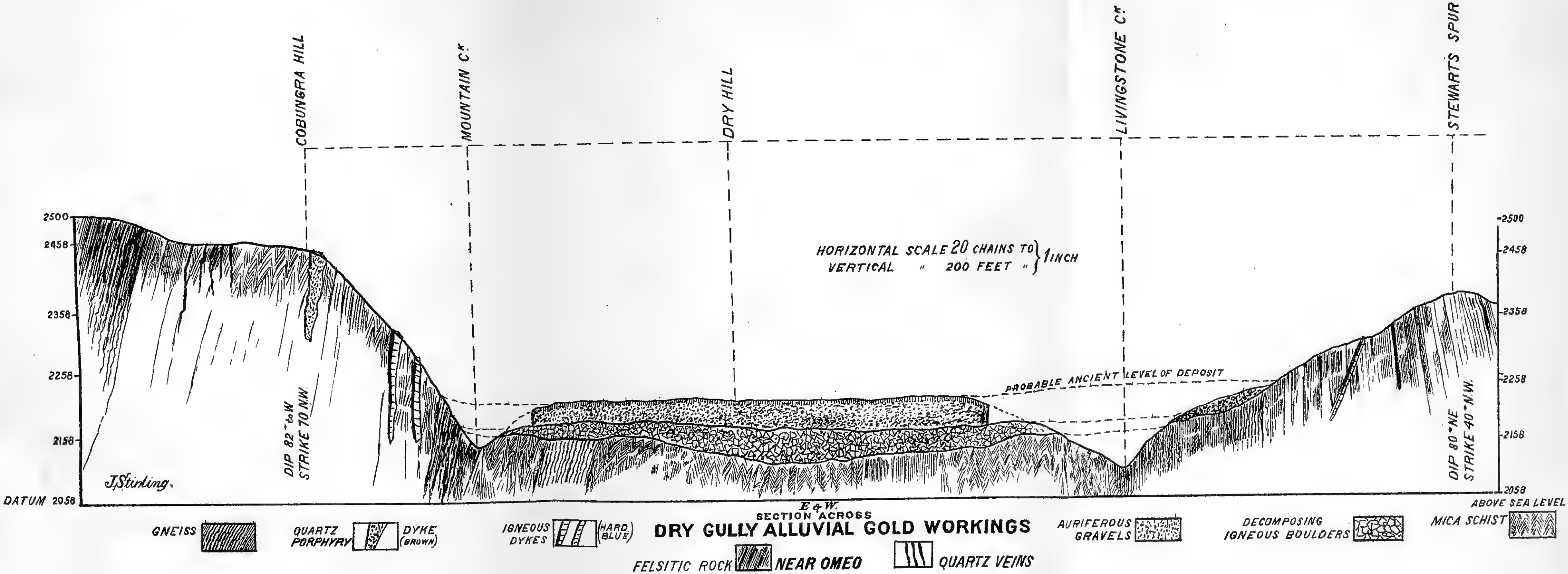

E & W.
SECTION ACROSS
DRY GULLY ALLUVIAL GOLD WORKINGS

boulders and auriferous gravels. Ultimately the Livingstone Creek (instead of wearing a passage through the centre of the area so filled in) eroded a channel along its margin, leaving the deposited gravels, with their underlying false bottom of igneous boulders, literally high and dry above the present bed of the latter stream. At Dry Gully, near Omeo (a section of which I give), these auriferous gravels have been worked profitably, by sluicing operations, for gold during the past twenty years, and are now profitably worked.

A recent discovery of rich quartz reefs on the hills *in situ* is likely to prove deeply interesting, both from a mining and geological point of view. The character of the rocks in which these reefs exist may be briefly described as intercalcated bands of gneissose, micaceous, and quartzitic schists (strike, 70° N.W.; dip, 80° S.W.), intersected by hard blue igneous dykes and bands of brownish quartz porphyry (the latter apparently not descending more than 200 feet below the surface).

The reefs run in a general northerly direction, varying from 20° N.E. to 10° N.W., with a dip of about 60° to S.W.* An interesting problem that is likely to be opened out by the working of these reefs (independently of the rich field for observation in a study of the interrelations of these altered rock masses) consists in the question whether these auriferous reefs existed as such in the Silurian strata prior to its metamorphism into crystalline schists, as the result of aqueous solution, or whether they are derived by gaseous sublimation from the rock masses during the process of metamorphism, whether by hydro-plutonic causes or otherwise. As I find, by observation, these metamorphic schists are here corrugated parallel to the line of strike, it seems feasible that reefs, if existing prior to the action of the forces producing the corrugations, would be exceedingly twisted and contorted along their line of strike. However, these are questions outside the limits of this paper, and which properly come within the scope of an inquiry into the geological structure of the area.

Returning to Mount Sisters, at the margin of the Omeo Plains, we note a low rolling ridge of pasture hills, separating

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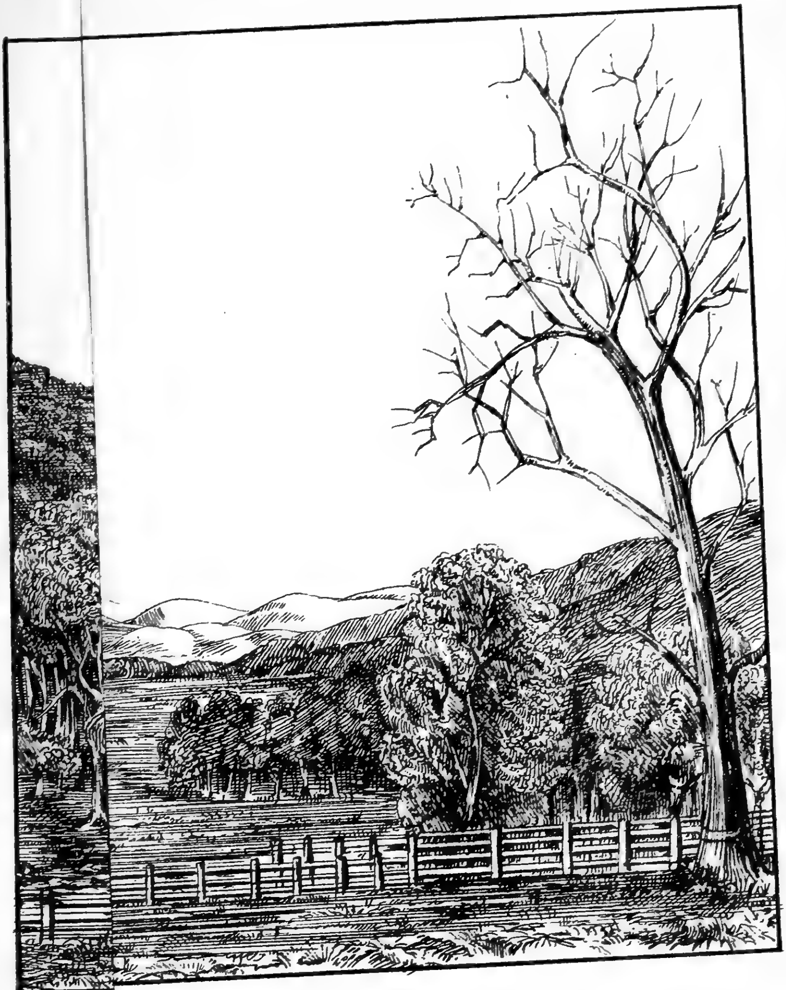
* Since writing the above, a number of claims have been opened out, showing a dip of 60° to E ; strike still northerly.

the undulating ranges near Omeo from the Omeo Lake basin drainage area.

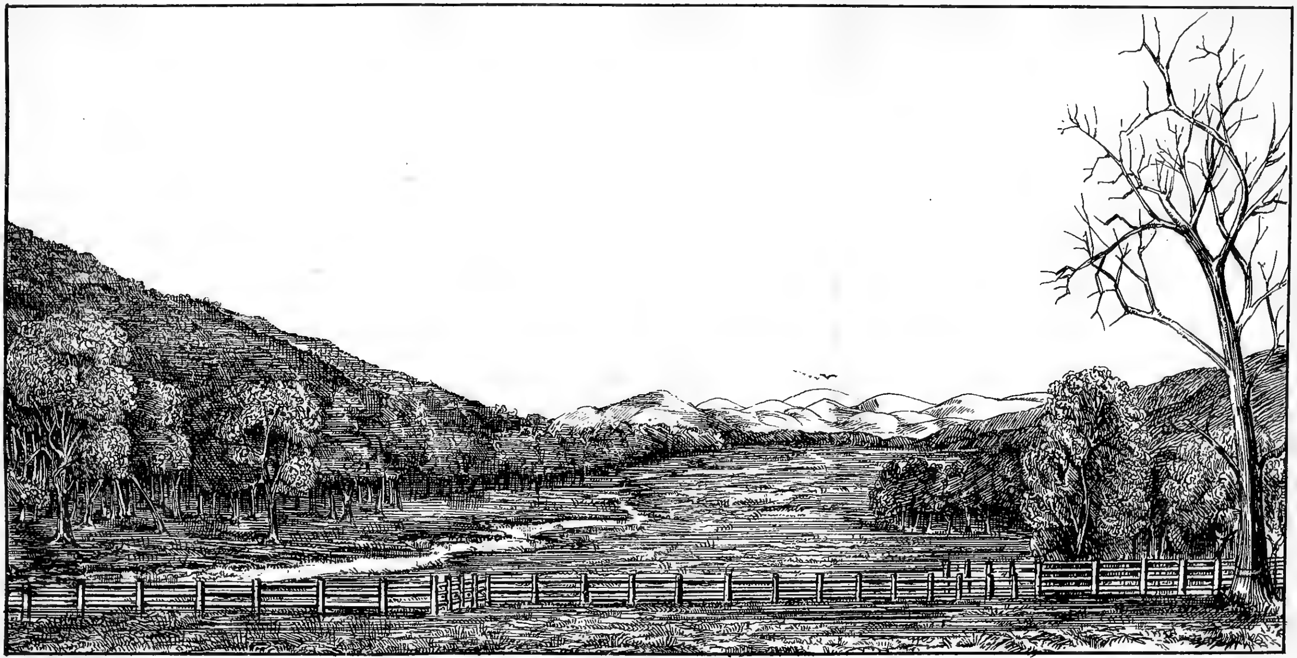
Of the 15,360 acres constituting the latter, fully 14,000 are now occupied for agricultural purposes. Another open ridge (consisting of a series of cone-shaped hillocks, whose bases merge into the open plains on either side) separates the Omeo Lake area from the Benambra Creek catchment basin, thus dividing the whole of the plains into two portions. From Mount Sisters the Dividing Range is well defined, rising at Mount Tambo, five miles distant, to 4700 feet (the latter a mass of purple conglomerates, resting on sandstone of Devonian age); it depresses somewhat, and again rises towards a rounded granitic peak (Mount Leinster, near the head of the Tambo River). From thence it winds in a general north-easterly direction to Mount Cobberas, the Pilot, and Mount Kosciusko (the culminating point in the range), at an elevation of 7256 feet above sea level. The eastern watershed of the Mitta Mitta—*i.e.*, of its eastern affluents—comprises a high, well-defined range, which, starting from a point on the Dividing Range midway between Mounts Tambo and Cobberas (at the extreme northerly source of the Tambo River), proceeds northerly, finding its highest elevation at Mount Gibbo (a coned peak 5764 feet above sea level), and divides the head waters of the Benambra Creek and its tributary, Mount Leinster Creek, from the Indi River. From Mount Gibbo a number of watershed lines radiate in a northerly direction; a minor watershed line, forming the northern watershed of the Gibbo River, terminates in a prominent peak—Toaks Gibbo—near the Mitta Mitta River. Of the streams forming the eastern affluents of the Mitta Mitta, the Benambra Creek is the most important, embracing an area of 233 square miles, its upper courses opening out into some fine open upland flats, marsh lands now partially drained, consisting of flats averaging one mile in width, treeless, except on their margins, of which I give sketch.

The ridiculous reports as to the unexampled severity of the frosts on these fertile uplands has to a certain extent militated against their settlement. However, from the Omeo Plains as a centre, settlement is slowly extending along these upland tracts. Only so far back as 1875 the Omeo Plains were reported to be inhospitable, and unfit for agriculture, owing to climatic causes, although the richness of the soil was admitted; now they are completely occupied by a



James Stirli

(and MITTA MITTA)



James Stirling Delt.

(BUCKWONG M^TS^) on divide between INDI RIVER) **BENAMBRA C^K^** _ uplands (and MITTA MITTA) farming population who have produced crops of wheat and other cereals that are excellent both as regards quality and quantity (as high as 50 bushels of wheat to the acre having been obtained close to the Omeo Lake).* I believe, therefore, that from the Omeo Plains as a centre, the higher uplands will be occupied quite up to 5000 feet above sea level; and even should agriculture fail at this elevation, the richness of the pastures will amply repay their occupation for grazing purposes.

The Gibbo River intersects more ruggedly mountainous country, and has gold workings on its upper courses.

The Wombat Creek (an eastern affluent) has also gold workings along its course, the character of the country it intersects being similar to that of the Gibbo River.

From what has been previously stated, it will be gleaned that the eastern watershed of the Mitta Mitta source basin is more suited for settlement than the western, which ascends to the highest elevations in the colony. As a matter of fact, the eastern watershed is now being rapidly settled upon, including the splendid area embraced by the Omeo Plains. Whether agricultural or pastoral pursuits will be most profitable remains to be seen; but, independent of this, the known auriferous character of the country (practically undeveloped) is likely to cause the district to become more important in the future. Hereunder I give a list of the drainage areas described, classifying the land into land suited for immediate settlement, good grazing land, and inferior grazing land :—

	Selectable.	Good grazing.	Inferior.
Benambra Creek	40,000	80,000	29,120
Big River...	10,000	60,000	32,400
Livingstone Creek ...	30,000	50,000	8,320
Gibbo River	8,000	40,000	23,680
Cobungra River	5,000	40,000	17,720
Victoria	10,000	30,000	11,840
Mitta Mitta (minor) ...	5,000	30,000	14,920
Bundara	3,000	27,000	11,600
Wombat Creek	1,000	20,000	18,040
Omeo Lake	15,360	—	—
Totals	127,360	377,000	167,000

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* The probable yield for present season will average 30 bushels of wheat to the acre.

Of the 127,360 acres of selectable land about 50,000 is already occupied by selectors, under the provisions of the Land Act 1869, and about 9000 purchased, leaving a balance available of 68,000 acres.

I regret that the limited time allowed for the reading of this paper has prevented me giving a more detailed description of the area. I trust, however, that the facts noticed may lead to a better knowledge of this portion of the Victorian Cordillera, and I hope shortly to prepare a paper, dealing not only with the geological structure of the area, but its characteristic native vegetation.

ART. XIX.—*On a New Form of Secondary Cell for Electrical Storage.*

BY H. SUTTON.

[Read 9th December, 1881.]

THE great utility of some thoroughly practical method of conserving electric force has caused a great deal of attention to be applied to the subject. No system of electric supply can be considered perfect until some means is used to so store the force generated that it may be drawn off equally and regularly, and this whether the generator be on or off.

If we take as an example of electric supply the present systems of electric lighting, it is at once seen, should an accident or stoppage take place in the machinery generating the current, the whole of the apparatus, such as lamps or motive machines, would be influenced. Should there be a reservoir of electricity between the generator and the apparatus for utilising the force, this inconvenience could not occur, as the reservoir would then supply the necessary force.

All the present systems of storing electricity depend on certain chemical changes produced by electrolysis; the first effective apparatus being that discovered by M.

Plante, and which consisted of two sheets of lead immersed in dilute sulphuric acid. When these plates are made the positive and negative electrodes of a few voltaic cells or other source of electricity of sufficient power, the oxygen of the decomposed solution combines with the positive electrode, and forms a coat of the insoluble peroxide of lead. On disconnecting the charging source, the plates have the power of generating a powerful current of electricity, owing to the great affinity the oxygen of the peroxide has for the hydrogen of the solution when the circuit is closed.

A recent form of this cell has been devised by M. Faure, in which the lead plates have a coat of red oxide of lead painted on, the chemical change in this case being—the red oxide on the positive electrode on charging becomes exalted to the state of peroxide, whilst the hydrogen combines with the oxygen of the negative red oxide coating and reducing metallic lead; the chemical change of discharge being precisely the same as in Plante's cell.

This red oxide cell has caused a great stir in the electrical world, owing to some exaggerated reports having gone through the press.

Although there is a great deal that is pernicious in exaggerated press reports, they have one virtue, and that is, the incentive they give to workers to improve, or, if possible, discover new means of producing the same results. This was shown in the invention of the telephone; and the same will occur in connection with electrical storage.

These reports reminded me of an experiment I made some time previously on the behaviour of peroxide of lead as an element in voltaic cells. I prepared some peroxide by treating red oxide of lead with dilute hydric nitrate till the brown precipitate of peroxide fell; collected the precipitate, and made a conglomerite of it, and using it as an element in a small voltaic cell.

I have since then gone through a long series of experiments in storing electricity, and made many different forms of cell; one being a porous pot containing dilute hydric sulphate and a sheet of lead, and an outer containing vessel, having a sheet of lead immersed in a solution of acetate of lead, the plate in the porous pot being made the positive electrode. This cell had the power of storing electricity, by peroxidising the positive electrode and depositing metallic lead from the solution on the negative electrode, the acetate being then converted into a solution of acetic acid. On discharging the peroxide is reduced and the apposed element oxydised, the oxide formed combining with the acetic acid, and forming acetate of lead.

During my experiments I found that the red oxide of lead is a bad conductor of electricity; that peroxide of lead is a good conductor; and that by amalgamating lead plates with mercury a marked increase was immediately manifest in polarisation effects, the plates being more uniformly and rapidly peroxidised, and local action entirely disappearing. These mercury amalgamated plates at once gave me an advance over other cells.

I used them in many ways, constructing cells in which the positive electrode was amalgamated lead, the negative being coated with prepared peroxide or with the red oxide, or amalgamated, or combinations of these and solutions of various kinds.

I also made cells of peroxide, and also of red oxide, formed into porous conglomerites, having a wire projecting from each end, the conglomerite being immersed in dilute hydric sulphate. I constructed cells in which the plates were parallel, and the red oxide, as also the peroxide, being filled in between the plates. In this case the red oxide is useless and peroxide efficient, owing to their relative conducting power. In all cases in which amalgamated lead was used as a positive electrode the effects were very marked.

Having thoroughly tested the amalgamated lead, and found it the most efficient positive electrode for conserving the oxygen of the decomposed solution, I investigated the behaviour of various forms of negative electrode, having always the object in view, of making the hydrogen of the decomposed solution do some work; the proper thing, of course, being to make it assist in depositing metal from the solution on the negative electrode.

I thought by having negative electrodes, whose oxides should be soluble in the solution remaining after electrolysis, and which could be redeposited from the solution, or by having metallic solutions from which the metal could be deposited—the resulting solution being such that on the oxidation of the deposited metal it would combine with the oxide, and again form the original solution—I should produce a perfect means of storing electric energy by conversion into chemical energy, and which would economically return the current as the chemical affinity ran down.

Having started from this foundation, the results obtained are such as to have an important practical bearing on the future of electric work.

The experiments comprised lead amalgamated with mercury as a positive electrode, with negative electrodes composed of either zinc, iron, or copper; in each case the solution between the electrodes being a salt of the metal composing the negative electrode. With zinc a solution of zinc sulphate was used; with iron, sulphate of iron was the solution; and with copper, sulphate of copper.

In all these cases the results were not only far more powerful than any form of cell I had hitherto devised, but also remarkably constant.

The cell with zinc negative electrode I discarded, owing to the necessity there would be to keep the zinc plate amalgamated to prevent local action; the iron negative cell being set aside owing to the iron oxidising when not in use. In both the zinc and iron negative elctrodes the evil effects only show when the cell is charged.

The cell having a negative electrode of copper is the one I have adopted as a thoroughly economical, lasting, and practical form of storage reservoir. The chemical changes in this cell are exceedingly interesting and beautiful.

The cell is composed of a sheet of lead cleaned with dilute sulphuric acid, and amalgamated thoroughly with mercury, and a sheet of thin copper, a little shorter; the two sheets are perforated with a number of holes. The copper is placed uppermost, and separated by bands of rubber, having pieces cut out every few inches, the whole being rolled into a spiral; the object of the holes in plates and pieces cut out of rubber being to allow the solution to have free access to the plates. This combination is immersed in a solution of cupric sulphate, and the amalgamated lead made the positive electrode of a suitable source of electricity. The chemical action being the oxygen of the decomposed solution, combines with the lead, and forms a coating of the insoluble peroxide of lead, the hydrogen replacing the copper in the solution, and metallic copper being deposited on the negative electrode. As decomposition of the solution proceeds it becomes colourless, and more acid, until, when the whole of the copper is deposited, we have the solution transformed into dilute sulphuric acid, the amalgamated lead peroxidised, and pure copper deposited on the negative electrode.

During discharge the peroxide of the lead element is reduced, the copper element becoming oxidised; the oxide combines with the acid, and forms cupric sulphate, the solution returning to its original azure blue colour. This change in colour forms a beautiful means of knowing when the cell is fully charged. The power of this cell is very great and constant; it can be made to last for hours, the length of time being dependent on the quantity of cupric sulphate being decomposed in solution. I have, by the decomposition of one pint of solution cupric sulphate, obtained over two hours' effective work as electric energy.

It will be seen from the foregoing that this method of conserving energy has a wide field before it.

NOTE 1.—The amalgamated lead electrode will not peroxidise if free cupric sulphate crystals are present in the solution, it being essential that the solution become acid.

NOTE 2.—The charging is accompanied with a peculiar rattling noise, and is not due to escaping gas, as the noise occurs when no gas escapes from the solution, but may be due to change of form in spiral due to deposition of copper.

ADDENDUM.

THE secondary, in its present form, consists of a flat copper case, having the form of the outer containing vessel of a Grove's cell. In this copper cell is a sheet of lead amalgamated with mercury, and which has a piece of flannel, or other porous material, enveloping it tightly, the object of which is to prevent the peroxide (which forms a thick layer) from falling off by the wash of the solution, or by jarring. I have removed as much as six ounces of peroxide, which has been formed in a single charge in one of my cells.

The amalgamated plate is supported in middle of copper cell by being held in a groove in a piece of parrafined wood lying at the bottom of copper cell, and also by a parrafined wood cap, which closes the top; it is charged with a solution of cupric sulphate, containing one-twelfth of hydric sulphate.

The amalgamated lead is made the positive electrode, and the copper case the negative, the inner surface of the copper case receiving the deposited copper when charging with electricity. The electromotive force of the cell is about two volts.

ART. XX.—*Descriptions of New, or Little Known, Polyzoa.*

PART I.

BY P. H. MACGILLIVRAY, M.A., M.R.C.S., F.L.S.

(WITH PLATE.)

[Read 9th December, 1881.]

Beania decumbens, n. sp. Fig. 1.

CELLS much elongated; two or three short spines at the top; spines 14—16, on each side, arching over the cell, and those of opposite sides interdigitating; at each upper angle a small capitate avicularium; connecting tubes springing from the extremities, so that the cells are entirely decumbent.

Port Phillip Heads, Mr. J. Bracebridge Wilson.

Spreads in long, irregular lines over calcareous nodules. The connecting tubes are very short, and the cells are almost always arranged end to end, but occasionally one springs from the side of another. In many cells there are one or two tubes from the sides, fixing them to the body on which they grow, or occasionally extending to the sides of a cell of a crossing series. These tubes are in the situation of the lateral tubes of *Diachoris.* From the other species of *Beania* this differs, especially in the cells, in consequence of the connecting tubes springing from their extremities, being entirely decumbent instead of semi-erect.

Mr. Wilson considers that it ought to be referred to *Diachoris,* in consequence of the presence of avicularia and the mode of connection of the cells. It agrees with *Diachoris* in the avicularia, which, however, in the other *Beaniæ* are evidently represented by the ear-like processes; while it agrees with *Beania* in the connecting tubes being only attached to the ends, or occasionally to the side of a cell. The semi-erect position in the other species is a character of no value, as the same occurs in *Diachoris crotali,* where also the avicularia are imperfectly developed. Hincks has recently described a very interesting form, *D. intermedia,* from Tasmania, in which the connecting tubes are four, and the avicularia very small. The two genera are so closely connected by the present form and *D. intermedia* that, in my opinion, the species with the (abortive or perfect) avicularia at the summit of the cell ought to be referred to the older genus *Beania,* while the others might find a place elsewhere.

Membranipora acifera, n. sp. Fig. 2.

Cells elongate-quadrate, wider in the middle; aperture occupying the whole front, except a minute corner on each side inferiorly; margin much raised; one or two sharp incurved spines on each side, and usually a small round spine at each upper angle; avicularium in a separate area at the base of a cell, mandible very long and narrow; ovicell small, immersed in the base of the cell above.

Queenscliff, a single specimen.

Membranipora flagellum, n. sp. Fig. 3.

Cells arranged in regular transverse series, elongate-quadrate, separated by much-raised margins, the lower fourth filled in by a perforated plate, a little more extensive on one side; upper margin deeply arched; two conical stout spines superiorly on each margin common to two adjacent cells; an enormous whip-like vibracular spine below the aperture on one side, and one or, occasionally, two small spines on the margin of the aperture on the other side.

Port Phillip Heads, Mr. J. B. Wilson.

Membranipora papulifera, n. sp. Fig. 9.

Cells arranged in more or less regular, contiguous lines, narrowed below, oval, very slightly filled in below; margin thickened, strongly crenulated, the lower part raised into an elevated prominence.

Port Phillip Heads, Mr. J. B. Wilson.

Membranipora albispina, n. sp. Fig. 10.

Cells elongated, narrowed downwards; aperture occupying upwards of two-thirds of the front, rounded below; mouth very large; on each side a series of 3—5 enormous, pod-like, white, articulated spines, and generally two or three smaller ones from the upper margin.

Queenscliff.

The only species with which this can be confounded is *M. ciliata,* the spines of which are sometimes of great size, and arranged and articulated in the same manner. The figure of *M. ciliata* in *The Decades* is badly drawn, the artist having represented the spines as too small and rigid, in this respect resembling *M. spinosa.* The illustrations which are now given of the three species will, I hope, render their recognition easy.

Membranipora serrata, M'G. Fig. 5.

(*Trans. Royal Soc., Victoria,* 1869.)

Cells quadrate, very much elongated, truncate above and below; from each side of the margin projecting inwards is a series of short processes, expanding and dividing at the ends; avicularium on a separate area at the base of a cell, mandible very long; ovicell small, projecting into the base of the cell above.

Encrusting sponge, Schnapper Point and Queenscliff.

At once distinguished from all other species by the curious marginal processes which bear some resemblance to those found in certain forms of *Flustia denticulata,* from which, however, it differs in the absence of the characteristic minute denticles and in the much longer and narrower mandible of the avicularium.

Membranipora armata, M'G. Fig. 6.

(*Trans. Royal Soc., Victoria,* 1869.)

Cells quadrate, elongated, separated by narrow raised margins; surface finely granular; mouth lofty, arched above, straight or slightly hollowed below, with a large blunt process on each side; operculum hinged; avicularium situated at the base of a cell, mandible broadly lanceolate, with a membranous margin and directed vertically upwards.

Queenscliff, on algæ.

This species is closely allied to *M. mamillaris,* from which it differs in the form of the avicularium. In *M. mamillaris* the stirrup-shaped support of the mandible is situated close to the edge and prolonged into a narrow point upwards, while in *M. armata* it is broader, shorter, and situated at some distance from the margin. *M. armata,* moreover, is white, while *M. mamillaris* is brown or purple.*

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* In my original description of *M. mamillaris,* the avicularium is described as oblique, from an abnormal specimen, instead of erect. Lamouroux's description of the same species as *Flustra mamillaris* was overlooked; a matter, however, of little consequence, as the prominent mamillary processes suggested the same specific name.

M. mamillaris, armata, dispar, and *Woodsii* differ from the other species in having the operculum distinctly hinged, and form a well defined subgeneric or, rather, generic group, for which I would propose the name *Thairopora,* the definition being—Cells separated by raised margins; front entirely membranous or membrano-calcareous; operculum articulated by a distinct hinge.

Membranipora permunita, Hincks.

This species is the same as I described in 1869 as *M. falcata;* but as my description was taken from a bad specimen, in which the peculiar marking of the ovicell was obliterated by calcareous overgrowth, and was accompanied by no figure, I think it preferable to adopt Mr. Hincks' name. Sometimes the rim on the ovicell is scarcely, or not at all, perceptible, and the ovicell projects much more than usual. It may always be distinguished by the peculiar structure of the falciform avicularium, one side of the mandible of which is thickened and the other expanded into a thin, membranous wing. In some specimens there are one or two blunt, rounded elevations at the base of the cells.

Membranipora polita, Hincks, Fig. 8.

Mr. Hincks has recently described the present species from specimens obtained at Glenelg. I have little doubt that it is identical with Lamouroux's *Cellepora alata.* The cells are very porcellanous, close together, distinct, narrowed downwards. The aperture occupies about one-third or more of the cell. Below, the cell is elevated into a rounded or oval protuberance, and on each side of the aperture is thickened into an oval or elliptical mass. These convexities are not always distinctly marked; occasionally there is a thick collar all round the aperture, and sometimes there are several transverse marks across the front of the cell. At the growing extremity of one specimen the cells spread irregularly, in the manner of *Membranipora catenularia,* to which it is nearly related. The latter species is usually described as an *Hippothoa,* from the true species of which it differs entirely in the structure of the cell; and I quite agree with Hincks in referring it to the Membraniporidæ, of which it ought probably to form the type of another genus, including the present species and *Hippothoa crassa.*

I have found it at Queenscliff, encircling the stems of *Cymodocea antarctica.*

Membranipora Rosselii, Fig. 4.

I am not quite satisfied that the *M. Rosselii* of *The Decades* is identical with the European form. The cells are arranged much more regularly than in the only English specimen I have seen, and they are more rhomboidal in shape, although agreeing so far with Hincks' figure. In many cases the upper margin of the aperture is not straight, but is extended slightly forwards in the middle or towards one side, to form a broad sinuous projection, occupying about two-thirds of the width. The avicularium is very large, replacing a cell, with a long rounded mandible, directed upwards and forwards, and occupying the whole width of the cell; the upper edge of the avicularium is calcareous and projects considerably forwards. In some cells there is a little additional thickening, filling in the lower angles of the area, and there is occasionally here a small rounded process, on one or both sides, close to the margin of the cell below.

Membranipora patellaria, Moll sp. Fig. 13.

Mollia patellaria, Smitt, *Floridan Byozoa,* Pt. II., p. 12. Fig. 72.

Diachoris patellaria, Waters' *Ann. and Mag. Nat. Hist.*, Feb., 1879.

Cells slightly separated and connected by short tubes, oval and lozenge-shaped; margins raised, crenulated; lower two-thirds filled in by a minutely granular calcareous membrane; aperture nearly semi-circular, occasionally somewhat trifoliate.

Port Phillip Heads.

Of this I have dredged a single specimen, growing on a small sandy and calcareous nodule. It agrees perfectly with the form described by Waters, from the Bay of Naples, as *Diachoris patellaria*, var. *multijuncta.* The cells are only slightly separated, and, in parts of the specimen, are so close together that the connecting tubes are scarcely distinguishable. Each cell is connected with the adjacent ones by usually about twelve tubes. In my specimen there are a few imperfectly developed ovicells on the summits of some of the cells at the growing margin; they are rounded, smooth, and closely adherent to the cells above. In the typical form, as figured by Smitt and Waters, the connecting tubes are much fewer. These naturalists consider Heller's *D. simplex* as the same species which they refer to Moll's

Eschara patellaria. I have not seen Moll's work; but Heller's figure certainly looks different, and he shows the cells all connected by six tubes. No avicularia have been seen.

It agrees with *Diachoris* in nothing but the disjunction of the cells, and seems to me certainly a true *Membranipora.*

I add a list of species of *Membranipora,* known to me to occur in Victoria:—

M. membranacea, L.
M. pilosa, L.
M. flagellum, M'G.
M. umbonata, Busk.
M. cervicornis, Busk.
M. Rosselii, Sav.
M. patellaria, Esper.
M. Lacroixii, Sav.
M. papulifera, M'G.
M. acifera, M'G.
M. serrata, M'G.
M. pyrula, Hincks (= *lineata,* M'G.).
M. corbula, Hincks.
M. flustroides, Hincks.

A form differing only from the English in having the spines longer and narrower, and the ovicell narrower and deeper, has been dredged by Mr. Wilson, and by myself at Port Phillip Heads. I have not seen the avicularia.

M. punctigera, Hincks.
M. Flemmingii, Busk.

I have examined two imperfect specimens, seemingly referable to this species, dredged at Port Phillip Heads by Mr. Wilson.

M. (Lepralia) trifolium, M'G.
M. spinosa, Q. and G.
M. ciliata, M'G.
M. albispina, M'G.
M. radicifera, Hincks.
M. permunita, Hincks.
M. catenularia, Hincks.
M. crassa, M'G.

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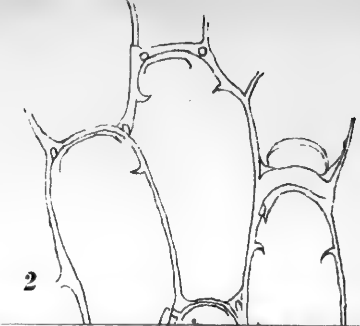

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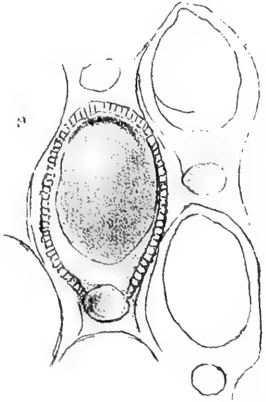

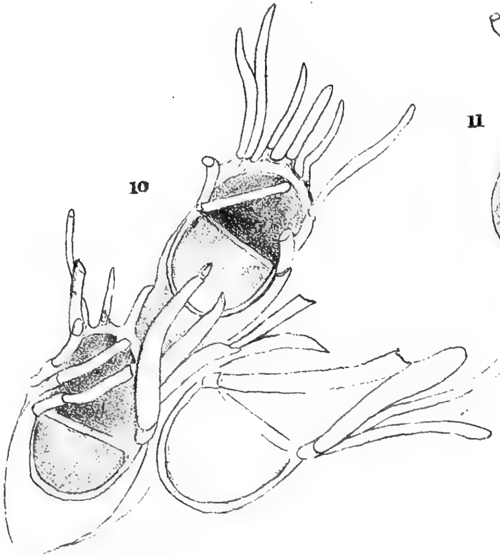

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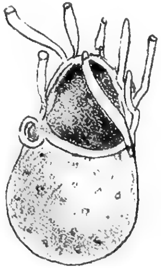

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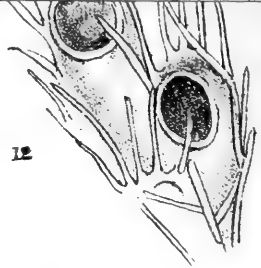

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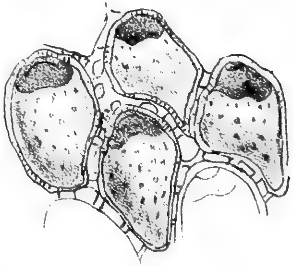

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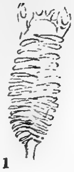
P.H. Mac Gillivray.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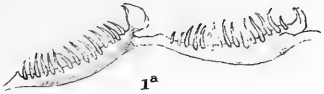
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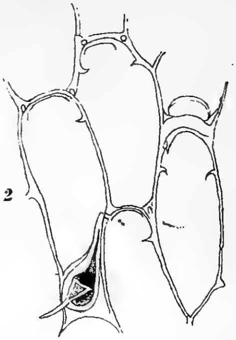
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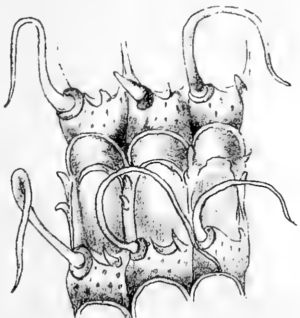
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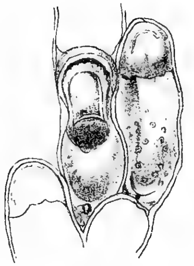
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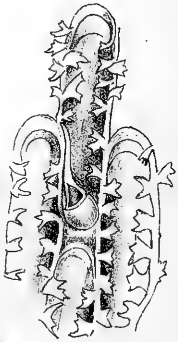

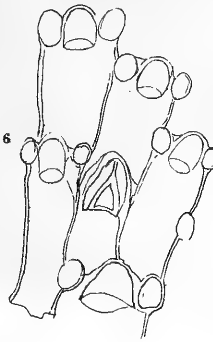
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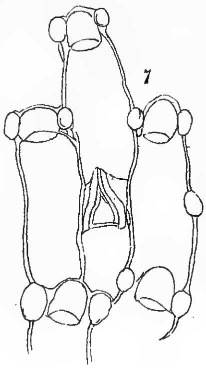
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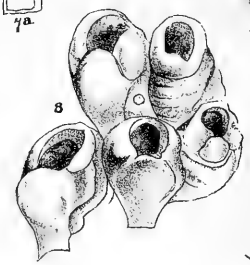
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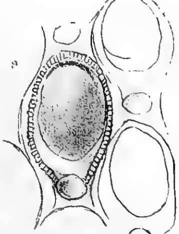
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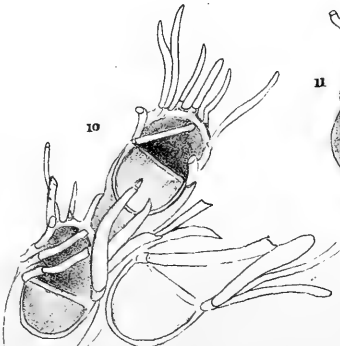
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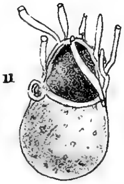
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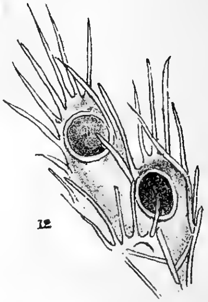
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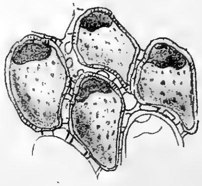
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P.H. Mac Gillivray.

M. polita, Hincks.
M. (Thairopora) Woodsii, M'G.
M. „ *dispar,* M'G.
M. „ *mamillaris,* Lamx.
M. „ *armata,* M'G.

Micropora coriacea Esper, var. wanting the nodular enlargement of the margin.
M. perforata, M'G.

EXPLANATION OF PLATE.

Fig. 1. and 1*a*. *Beania decumbens.*
Fig. 2. *Membranipora acifera.*
Fig. 3. *M. flagellum.*
Fig. 4. *M. Rosselii* var. showing an avicularium.
Fig. 5. *M. serrata.*
Fig. 6. *M. armata ;* 6*a*, mandible of avicularium.
Fig. 7. *M. mamillaris ;* 7*a*, mandible of avicularium.
Fig. 8. *M. polita*
Fig. 9. *M. papulifera.*
Fig. 10. *M. albispina.*
Fig. 11. *M. ciliata.*
Fig. 12. *M. spinosa.*
Fig. 13. *M. patellaria.*

ART. XXI.—*Description of Vacuum Apparatus.*

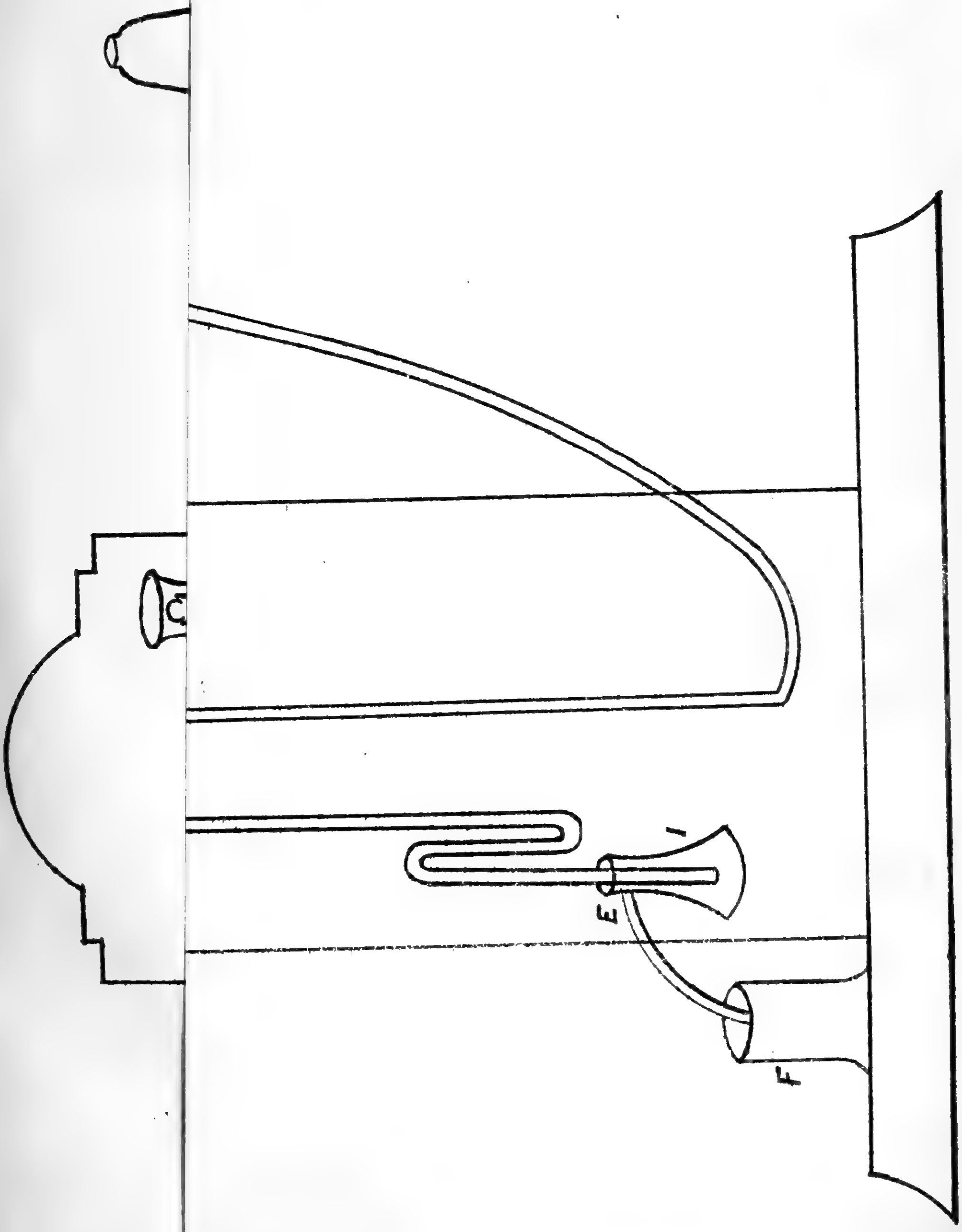
BY H. SUTTON.

(WITH DIAGRAM.)

[Read 13th December, 1881.]

THIS apparatus is the outcome of several forms of vacuum apparatus I have devised for the rapid production of high vacuum suitable for electric lighting by the incandescent system, or investigations such as Mr. Crookes has recently given to science.

A mercury bottle (m) when held up, allows mercury to rise in tube (A), filling reservoir (B), and rising in branch pipe (C) isolates lamp globe (H) from reservoir (B). The mercury passes by outlet pipe (D), filling vessel (G) till it overflows by pipe (E) into vessel (F); (G) is a glass tube of large diameter, having a glass stopper in each end, both stoppers being covered by a mercury jacket; the lower half of this tube is filled with broken pumice, soaked in sulphuric acid to absorb any moisture, the upper half being filled with pumice, gilded with gold leaf to absorb traces of mercury vapour. On lowering mercury bottle, the mercury descends in reservoir (B) and pipe (C), leaving a Torcillian vacuum in (B), the mercury in (D) being supported by atmospheric pressure. On lowering (m) sufficiently, communication is established between reservoir (B) and vessel to be exhausted (H) by means of branch pipe (C) and dissecting apparatus (G), the air in (H) then expanding over into (B); the mercury bottle (m) is then raised again, and the mercury rising in (B) drives out the expanded air by outlet pipe (D). This pipe is bent back on itself at the lower end; this is to prevent the ingress of any air that might collect on end of pipe in vessel (I), alternate raising and lowering the mercury bottle (m) producing a vacuum.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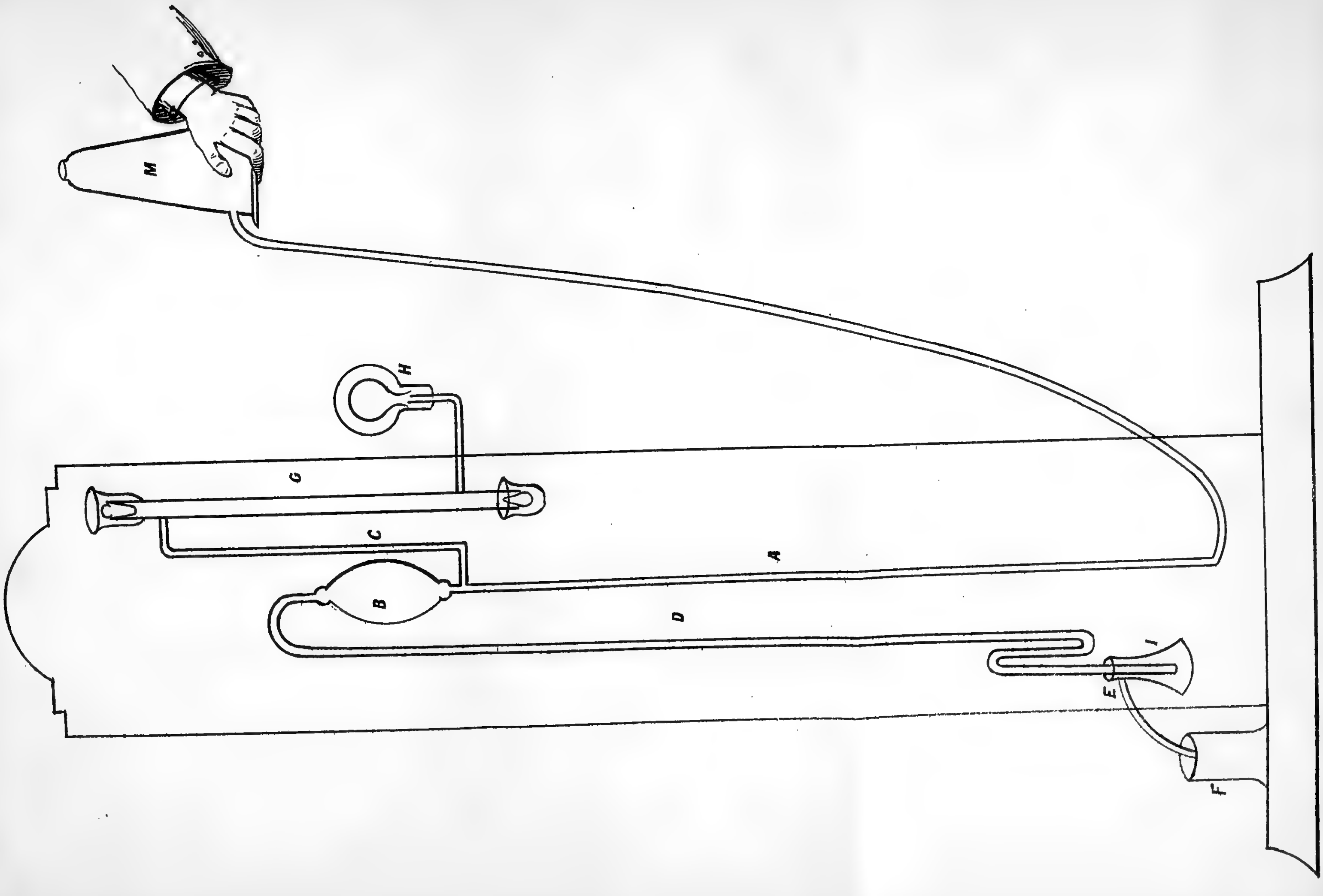
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Obituary.

FREDERIC JOY PIRANI, M.A., C.E.

Frederic Joy Pirani was born at Birmingham on the 23rd of December, 1850. At the age of nine he was brought to Melbourne by his parents, who placed him in 1863 in the Church of England Grammar School. He was there a pupil of the Rev. Dr. Bromby, under whom he developed a taste for mathematics and natural science, and made so much progress with his studies that he very soon won the Foundation Scholarship for boys under fourteen years of age. He became captain of the school in 1866, and at the close of that year matriculated with credit, gaining the entrance exhibitions for classics and mathematics. Next year he passed his first examinations in arts and in engineering at the University with first-class honours, being awarded the exhibition for mathematics. In 1868 he passed the examination for second year of civil engineering with first-class honours, again winning the exhibition for mathematics. In 1869 he passed the final examination for civil engineering with second-class honours, and likewise his second year for arts with first-class honours. In 1870 he obtained to degree of B.A., and in the following year won the University Scholarship for mathematics and physics. In 1873 he took his degree of M.A.

In the same year, 1873, he was appointed Lecturer on Elementary Mathematics and Logic at the University, in which position he remained till the death of the late Professor Wilson, when a re-arrangement of duties among the professorial staff made him Lecturer on Logic and Natural Philosophy.

Mr. Pirani was elected a member of the Royal Society in 1873, and signed the members' book on the 8th of December in that year. He was appointed Secretary to the Society in the following year, and was active and zealous in fulfilling the duties of that position.

On 12th October, 1874, he read a paper entitled, "On some Processes of Scientific Reasoning;" on the 12th April, 1877, another on "Force." In 1878 he read two papers, "Sir William Thomson's Electric Replenisher," and "Sir William Thomson's Form of Daniell's Constant Battery." In 1881 he read two papers, one explanatory of a new form of tangent galvanometer, invented by himself, another on a modification of Mance's method of measuring resistances.

Mr. Pirani was married in the year 1881, but had been only a few weeks married when a fall from his horse at St. Kilda caused the injuries which led to his death some eight or nine days later.

Mr. Pirani was one of the most active and able of the members of this Society; the work he did was of considerable value, and had all the appearance of being only the prelude to a most distinguished career, when the melancholy accident which caused his death took place.

1881.

PROCEEDINGS.

ROYAL SOCIETY OF VICTORIA.

ANNUAL MEETING.

March 16th, 1882.

The Vice-President in the chair, 16 members and 8 associates present.

The Annual Report and Balance-sheet for 1881 were read and adopted, as follow:—

"*Report of the Council of the Royal Society of Victoria, for the Year 1881.*

"In submitting this report for the year 1881, your Council is gratified to be able to record a Session of increased activity, and consequent prosperity to the Society. The papers read during the year have been numerous, and on subjects which evoked considerable interest among the members; while the constant demand made by learned and scientific societies abroad for copies of our Transactions tends to show that the work done by our Society is recognised as of value to scientific labourers all over the world. In exchange for our Transactions we received the publications of societies from every civilised nation; and for the year 1881 the Hon. Librarian announces the receipt of 101 volumes, many of them handsome donations, and in in addition we have received 501 parts, which amount to nearly 100 volumes more.

"So considerable has been of late the additions to our Library that your Council finds it necessary to provide for increased accommodation; and during the ensuing year provision will be made for the erection of new book-shelves, and also for the binding of some of the completed volumes.

"During the past Session there have been elected 15 Members, 9 Associates, and 1 Corresponding Member, which brought our numbers up to the following:—150 Members, 38 Associates, 6 Corresponding Members, 9 Honorary Members.

"The Session of 1881 included one Special and ten Ordinary Meetings.

"On the 10th March a discussion took place on the best means of 'Preventing the Deleterious Effects of the Gases resulting from the Explosion of Nitro-glycerine in Mines.'

"On the 6th April a special meeting was held to consider the proposals of Baron Mikloulo Maclay and Professor M'Coy, with reference to the formation of a Zoological Station and Laboratory at Watson's Bay, near Sydney.

"On the 28th April the Secretary submitted a paper by Dr. Stirton, of Glasgow, on a 'New Genus of Lichens,' which was ordered to be printed; also, a paper by Mr. F. M. Bailey, F.L.S., on a 'New Australian Nipa,' which was ordered to be received.

"On the 19th May Mr. F. J. Pirani, M.A., read a paper on 'A Modification of Mance's Method of Measuring the Internal Resistance of a Battery, with Notes on a Form of Tangent Galvanometer, suitable for Measuring Powerful Currents.' Mr. J. Cosmo Newbery read a paper, prepared by Mr. A. W. Howitt, F.G.S., 'Notes on the Diabase Rocks of the Buchan District.'

"On the 9th June Mr. J. R. Y. Goldstein read a paper on 'Some New Species of Bryozoa from the Marion Islands, with Notes on Bicellaria Grandis.' Mr. A. M. Henderson read a paper on a 'New Scale for the Use of Engineers and Architects,' and exhibited the instrument.

"On the 14th July Mr. Ellery, F.R.S., read a paper on 'Some Trials with Hagemann's Vacuum Anemometer.' Mr. W. C. Kernot, M.A., read some 'Notes on the Storage of Electricity and Faure's Form of Planté's Secondary Battery.'

"On the 11th August Mr. W. Nicholas, F.G.S., read a paper on 'The Origin of Quartz Rocks and Gold.' A paper by Mr. C. M. Maplestone, 'Observations on Living Polyzoa,' also a paper by Mr. W. H. Sutton, a 'Description of a New Vacuum Apparatus,' were received. Mr. J. Cosmo Newbery read some 'Remarks on the Specification of a recent Patent for the Manufacture of Gas.'

"On the 8th September Mr. Joseph read a paper on 'Electric Fire Alarms.' Mr. J. B. Kirkland read a paper on 'Faure's Secondary Battery.'

"On the 13th October Mr. W. W. Culcheth, M.I.C.E., read a paper on 'The Drainage of Melbourne;' and Mr. H. Moors read a paper on 'The Sea-cell as a possible Source of Danger in Torpedo Experiments.'

"On the 10th November a discussion took place on Mr. Culcheth's paper, 'The Drainage of Melbourne.'

"On the 8th December Mr. W. W. Culcheth, M.I.C.E., read a paper on 'The Floods on the River Barwon.' Mr. Ellery, F.R.S., read a paper by Mr. Stirling on 'The Topography of the Australian Alps,' and a paper by Mr. Sutton on a 'New Form of Secondary Cell for Electrical Storage.' Mr. MacGillivray read a paper, 'Descriptions of New Polyzoa,' and exhibited specimens of all the Victorian species of membranipora.

"Volume XVII. of the Transactions of the Society was issued on the 10th May, and forwarded to the Members and to the Societies entitled to receive it. Volume XVIII. is in the hands of the printers, and will be ready for the Members during the course of next month.

"Your Council has with regret to announce the retirement of Mr. P. de Jersey Grut from the office of Hon. Treasurer, which he has held for so long a time, and with so unfailing a devotion to the interests of the Society. The office thus rendered vacant has been filled by the election of Mr. H. Moors.

"Your Council has with regret to record the death of F. J. Pirani, M.A."

BALANCE-SHEET.

The Hon. Treasurer in Account with the Royal Society of Victoria.

Dr.

	£	s.	d.	£	s.	d.
To Government Grant—1880-81				£200	0	0
„ Sale of "Transactions"				1	2	6
„ Sixteen Entrance Fees				33	12	0
„ Subscriptions—						
58 Members	£121	16	0			
10 do. (Half-years) ...	10	10	0			
20 do. (Country)	21	0	0			
26 Associates	27	6	0			
3 do. (Half-years) ...	1	11	6			
Arrears	14	3	6			
Exchange	0	1	6			
				196	8	6
				£431	3	0

Cr.

	£	s.	d.
By Balance from last Balance-Sheet	£26	13	11
„ Printing and Stationery	117	5	0
„ On account of Alterations to Hall	100	0	0
„ Books	2	2	0
„ Freight and Charges of Books and "Transactions"	10	4	4
„ Conversazione and Teas	17	2	10
„ Rates	4	3	4
„ Gas and Fuel	5	13	5
„ Repairs	0	12	0
„ Clerical Assistant	26	0	0
„ Hall-keeper	6	0	0
„ Collector	22	9	5
„ Insurance	3	10	0
„ Postage	21	9	1
„ Petty Cash and Sundries	5	8	8
	£368	14	0
„ Balance in Bank	62	9	0
	£431	3	0

Compared with the Vouchers, Bank Pass-book, and Cash Book, and found correct.

8th March, 1882.

JAMES E. GILBERT } AUDITORS.
ROBERT E. JOSEPH }

H. MOORS, HON. TREASURER.

STATEMENT OF LIABILITIES AND ASSETS.

Dr. LIABILITIES.				ASSETS. Cr.			
To Publishing Fund	£216	11	2	By Estimated Value of Outstanding Subscriptions ...	£20	0	0
,, Three Debentures outstanding	15	0	0	,, do. do. Rents due	5	0	0
,, Interest unclaimed	12	12	0	,, Hall, Library, Furniture	3000	0	0
,, Due to Contractor for Plastering	78	15	0	,, Balance in Bank	62	9	0
	£322	18	2				
,, Balance	2764	10	10				
	£3087	9	0		£3087	9	0

PUBLISHING FUND.

Dr.				Cr.			
To Balance	£216	11	2	By Royal Society of Victoria	£216	11	2

ORDINARY MEETING.

10th March, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 18 members and associates.

A discussion took place on the best means of preventing the deleterious effects of the gases resulting from the explosion of nitro-glycerine in mines, in which Mr. J. Cosmo Newbery, Mr. Blackett, Mr. Kernot, Mr. Ellery, and Dr. Neild took part.

SPECIAL MEETING.

6th April, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 29 members and associates.

Professor M'Coy described what had been done in other countries in providing zoological laboratories, and explained the proposal to establish a similar station at Watson's Bay, near Sydney.

Baron Mikloulo Maclay described the cottages already built on the shores of Port Jackson, and urged the claims of the institution for assistance from the Royal Society of Victoria.

The following resolution was proposed and carried unanimously:—"That the Royal Society of Victoria having heard the proposition of Baron Mikloulo Maclay for the establishment and maintenance of a zoological observing station at Sydney, approves of active steps being taken to provide funds, and by other means to aid the institution."

(Signed) ROBT. L. J. ELLERY.

ORDINARY MEETINGS.

28th April, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 9 members and associates.

A paper by Dr. Stirton, of Glasgow, on a "New Genus of Lichens," was ordered to be printed. A paper by Mr. F. M. Bailey, of Brisbane, on a "New Australian Nipa," was received.

(Signed) ROBT. L. J. ELLERY.

19th May, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 14 members and associates.

Mr. C. A. Chesney was elected a country member of the Society.

Mr. J. Hiscox, Dr. T. P. Lucas, M.R.C.S., and Mr. G. W. Selby were elected as associates.

Mr. Pirani read a paper on a "Modification of Mance's Method of Measuring the Internal Resistance of a Battery," and also "Notes on a Form of Tangent Galvanometer suitable for Measuring Powerful Currents."

Mr. J. Cosmo Newbery read a paper prepared by Mr. A. W. Howitt, F.G.S., "Notes on the Diabase Rocks of the Buchan District."

(Signed) E. J. White.

9th June, 1881.

E. J. White, Esq., F.R.A.S., Senior Vice-President, in the Chair—Present, 21 members and associates.

Mr. G. S. Manns, of Leneva, near Wodonga, and Mr. G. R. B. Steane, of Sandhurst, were elected as country members.

Mr. J. R. Y. Goldstein read a paper on "Some new Species of Bryozoa from the Marion Islands, with Notes on Bicellaria Grandis."

Mr. A. M. Henderson read a paper on a "New Scale for the use of Engineers and Architects," and exhibited the instrument.

(Signed) Robt. L. J. Ellery.

14th July, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 22 members and associates.

Mr. J. S. Gotch was elected a member of the Society, and Mr. F. A. Kernot was elected as an associate.

Mr. R. L. J. Ellery, F.R.S., read a paper on "Some Trials with Hagemann's Vacuum Anemometer."

Mr. W. C. Kernot, M.A., read some notes on the "Storage of Electricity," and "Faure's Form of Plante's Secondary Battery."

Mr. Ellery exhibited a planisphere of the southern sky. Some lamp shades, invented by Emil Hallgren, of Stockholm, were exhibited, representing the northern and austral hemispheres.

(Signed) Robt. L. J. Ellery.

11th August, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 47 members and associates.

Mr. W. W. Culcheth, M.I.C.E., was elected a member of the Society.

Mr. J. Stirling was elected a country member.

Mr. W. Nicholas, F.G.S., read a paper on "The Origin of Quartz Reefs and Gold."

On the motion of Dr. Nield, the Secretary was instructed to write to the widow of the late F. J. Pirani, Esq., M.A., expressing the sympathy of the Society with her in her bereavement, and the regret felt by the Society at the loss of so valuable a member.

Mr. C. M. Maplestone's paper on "Living Polyzoa," and Mr. H. Sutton's paper on a "New Vacuum Apparatus," were received.

Mr. J. Cosmo Newbery read some "Remarks on the Specification of a Recent Patent for the Manufacture of Gas." A discussion followed, in which the following gentlemen took part:—Mr. Blackett, Mr. Sydney Gibbons, Mr. Foord, Mr. MacIvor, Mr. Dunn, Dr. Dobson, and the Rev. Mr. Fraser. The following resolution was put to the meeting and carried unanimously:—"That in the opinion of this meeting there is in the specification in question nothing but kerosene, and its congeners, from which gas for illuminating purposes can be made."

(Signed) ROBT. L. J. ELLERY.

8th September, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 29 members and associates.

Mr. H. Rosales and Mr. Thomas Main were elected members of the Society.

Mr. H. M. Hull, of Hobart, was elected a corresponding member.

Mr. Fred. Walsh and Mr. A. Wills were elected associates.

Mr. Joseph called attention to the fact that an invention placed by Mr. Patching before Section A in the year 1879 had recently been described in a scientific journal as an invention by a gentleman named Seymour.

The following resolution was proposed and carried unanimously:—"That this meeting desires to place on record that a Galvanometer, exhibited by Mr. H. S. Patching on the 29th October, 1879, is identical with one described in the *Telegraph Journal* of 15th January, 1881, and attributed to Mr. Seymour, and that therefore the merit of priority is due to Mr. Patching."

Mr. Joseph read a paper on "Electric Fire Alarms," and a discussion ensued.

Mr. Kirkland, jun., read a paper on "Faure's Secondary Battery;" a discussion followed.

13*th October*, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 33 members and associates.

Mr. T. Hewlett, M.R.C.S., Mr. J. D. Kirkland, M.B., and Mr. C. J. Lucas were elected members of the Society.

Mr. W. W. Culcheth, M.I.C.E., read a paper on "The Drainage of Melbourne."

Mr. H. Moors read a paper on "The Sea-cell as a Possible Source of Danger in Torpedo Experiments."

(Signed) Robt. L. J. Ellery.

10*th November*, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 17 members and associates.

Mr. W. J. Daley and Mr. W. H. H. Lane were elected members of the Society.

Mr. W. H. Finney, Mr. C. Rowan, and Mr. H. A. Slater were elected associates.

A discussion took place on Mr. Culcheth's paper, entitled "The Drainage of Melbourne."

(Signed) Robt. L. J. Ellery.

8*th December*, 1881.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 12 members and associates.

Mr. B. Baker, Mr. F. A. Campbell, Mr. F. A. Dunn, and Mr. S. H. Ridge were elected members of the Society.

Mr. Culcheth, M.I.C.E., read a paper on "Floods on the River Barwon."

Mr. Ellery, F.R.S., read a paper by Mr. Sutton on "A New Form of Secondary Cell for Electrical Storage." Mr. Sutton was requested to forward a cell for examination by a committee, consisting of Mr. Joseph and Mr. Kirkland.

Dr. MacGillivray read a paper, "Descriptions of New Polyzoa," and exhibited some specimens of membranipora.

MEMBERS

OF

The Royal Society of Victoria.

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Allan, Alexander C., Esq., Yorick Club
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Duerdin, James, Esq., LL.B., Eltham-place, Stephen-street
Dunn, Frederick, Esq., Technological Museum
Dunn, F. A., Esq., 181 Bridge-road, Richmond

Ellery, R. L. J., Esq., F.R.S., F.R.A.S., &c., Melbourne Observatory

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Society of Naturalists	Hamburgh
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Mason, Firth & M'Cutcheon, Printers, 51 & 53 Flinders Lane West, Melbourne.

Royal Society of Victoria.

TRANSACTIONS

AND

PROCEEDINGS

OF

Royal Society of Victoria.

VOL. XIX.

Edited under the Authority of the Council of the Society.

ISSUED MAY 10th, 1883.

MELBOURNE:
MASON, FIRTH & M'CUTCHEON, PRINTERS,
FLINDERS LANE WEST.

AGENTS TO THE SOCIETY.
WILLIAMS & NORGATE, 14 HENRIETTA STREET, COVENT GARDEN, LONDON
To whom all communications for transmission to the Royal Society of Victoria, from all parts of Europe, should be sent.

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Royal Society of Victoria.

ANNIVERSARY ADDRESS

OF

The President,

MR. R. L. J. ELLERY, F.R.S., F.R.A.S., Government Astronomer.

(Delivered to the Members of the Royal Society of Victoria, at their Annual Conversazione, held 26th October, 1882.)

GENTLEMEN OF THE ROYAL SOCIETY,

Somewhat more than a year has elapsed since I had last the honour and pleasure of addressing you at a similar meeting. In March last our Society entered upon its twenty-fourth session, which, so far, has been a busy one, and our meetings have all been fully occupied with interesting and important contributions. The affairs of the Society generally are in a satisfactory condition. Our member-roll is steadily increasing, our relations with kindred societies abroad are expanding year by year, the publications of our transactions are almost up to date, and our financial position, although not by any means inflated, is, on the whole, satisfactory.

As we have from time to time expended considerable sums of money in building and improvements to our house, your Council deemed it desirable to obtain the grant of the land on which it stands from the Government; for you doubtless know the land has hitherto been only permanently reserved for Royal Society purposes, and vested in trustees. Application for the grant has been duly made to the Government, and I believe its issue has been approved, and only now awaits the usual formalities.

I am sorry to say that the Council has not yet been able to arrange for a series of lectures in each session on subjects of special scientific interest, as was in contemplation, but, nevertheless, I have reason to believe that the proposition will be carried into effect in our next session, if not earlier.

In addressing you on occasions similar to the present for many years past, I have usually brought under your notice the most noteworthy facts in connection with the year's history and progress of our several science or art departments, and of kindred societies in the colony. Not desiring to depart from this time-honoured custom, and at the same time not to weary you with a long address, I refrain from any detailed reference to the affairs of the Society, the most important of which I have no doubt are familiar to you all.

Our members will be pleased to know that kindred societies in Melbourne are all flourishing, and actively engaged in contributing to the general stock of knowledge in their particular directions. The Medical Society and the Melbourne branch of the British Medical Association, which extends its functions all over the British dominions, show by the results of their meetings and their transactions, that nothing tending to progress of skill and knowledge in the sciences of medicine or surgery is neglected or overlooked by their members. The Microscopical Society continues to fulfil its functions admirably under its able and veteran president, and has done immense good in spreading a sound knowledge of the use of the microscope, and in investigating the Australian forms of minute animal and vegetable life. The good influence of the Pharmaceutical Society and its administration of the Pharmacy Bill is beginning to be felt in our community already, and the efforts of the board and the society to secure a thorough and scientific training for all who are engaged in the sale and dispensing of medicines, drugs, &c., will, I am sure, be commended on all sides.

Looking generally to the progress in our midst of those branches of knowledge which come more immediately within the province of this Society, our members must have noted a growing desire in the community to become more familiar with the sciences and with the arts. New societies and schools have sprung up, and are flourishing, not only in Melbourne, but also in the country towns. The older societies are expanding, and the working classes are evincing a genuine and earnest desire to obtain the teachings of sciences as aids to their handicrafts.

At our last meeting I spoke of the establishment of a Field Naturalists' Club in Melbourne. This continues to thrive, and offers the means, not only of acquiring knowledge in the natural history of our colony, but also of most pleasurable recreation of those members who can join in the periodic excursions in search of specimens of the animal or vegetable kingdom.

A new society has lately been started in Ballarat, under the name of "The Ballarat Field Club Science Society," which already contains about eighty members. Although this society is founded for the purpose of investigation and discussion in the natural sciences, it at present confines its attention chiefly to geological and mineralogical subjects. Lectures are delivered, papers read and discussed, and, like our Melbourne Field Naturalists' Club, excursions are periodically made to elucidate special physiographical points or for the collection of specimens. I hear also of a Philological Society having been formed in Ballarat.

Affiliated to the Sandhurst School of Mines, a "Science Society" was established some two years ago, of which our talented fellow-member, Mr. P. H. MacGillivray, M.A., is president. This society is most effectually fostering study of the natural sciences in that part of the colony by essays, papers, and discussions at the monthly meetings.

I am sure we all join in wishing success and good progress to these young societies. At the same time I may venture to warn them, from my long experience of these matters, that it is only by earnest work and persistent effort on the part of the members that they will make any real progress. Our various training institutions furnish the elementary teaching and much of the most attractive and popular incentives to a little dive into the sciences, but these societies should constitute themselves the arenas for practically applying this teaching to the general advance of science in the community.

As regards our public, scientific and technical institutions, I am able to report satisfactory progress. The Government botanist, our fellow-member, Baron von Mueller, has been busily engaged in elucidating the botany of Australia and adjacent regions, involving continuous and laborious work, for the most part literary. His valuable work on the eucalypts has advanced another stage, and 120 lithographic illustrations have now been completed. A considerable amount of further information and material from the interior regions of Australia will, however, be required before this great undertaking can be completed. The Baron is now engaged on another extensive work, a complete list of the "Vascular Plants of Australia," with literary, chronological, and geographical annotations, which it is expected will be completed by the end of the year. In this work there will be enumerated about 8800 species, and it is intended to devote a second volume to the "Evasculares," containing about 4000 species. The *Fragmenta Phytographiæ Australiæ* was brought to a close last year. Baron von Mueller's work on *Select Plants for Industrial Culture* has been published in German at Cassel, and I am informed arrangements are completed for publishing it in French in Paris.

Our museums are rapidly increasing, and yearly becoming more select and valuable; not only this, but for the last few years they have contributed very largely to museums, collections, and exhibitions in other parts of the world, examples and specimens of the natural productions of Australia. The National Museum at the University continues an object of great attraction. All the collections are in excellent preservation, due largely to the freedom from dust enjoyed by the site in which the building is situated. Specimens stuffed over twenty years still appear fresh and in good preservation. There have been some important additions during the year, among which may be noted specimens illustrating the geology of New Guinea and the adjacent islands, Bleeker's famous collection of fish from the Netherlands and India coasts, and a fine group of adult orangs to compare with the superb specimens of the gorilla formerly obtained.

I am glad also to say that from our Technological and Industrial Museum at the Public Library will be furnished a large suite of specimens to aid in replacing the valuable collection lost by our neighbours in the late Garden Palace fire at Sydney. The classes and lectures at the School of Technology continue to be well attended, and taking chemistry and metallurgy, engineering, mechanical drawing, and telegraphy, we find 142 students on the rolls. As a practical example of the value of this institution, and the soundness of the training given, I may mention that many of the advanced students have been enabled to take responsible positions in factories, mines, workshops, and public offices. Besides actual technical training, a great deal of valuable experimental work is carried on at this school. One interesting item I am able, from information given me by the director of the school (Mr. Newbery) to refer to. It has been found that the steel-wire rope used for the winding gear in mines in some instances passes from a tough and safe to a brittle and unsafe stage in a few weeks—a most serious matter, considering the number of lives at stake and the great cost of the ropes. Mr. Newbery now attributes this to a physical change taking place in the steel through the action of the acidulated saline waters of the mine. The prevention Mr. Newbery suggests is to cover the ropes with a good coating of some elastic waterproof material, such as a mixture of grease and tar. Brittle ropes can be toughened by annealing, but as I believe steel rope is made with hempen core to each strand, this would necessarily be destroyed in the process, and probably render the rope less fit for use. Mr. Newbery also states from results of experiments lately carried out that wood work in buildings, such as flooring, shelving, &c., can be rendered practically fireproof in a very economical way by treating it with a mixture of silicate and sulphate of soda in solution.

The Botanic Gardens, under the curatorship of Mr. Guilfoyle, become more and more attractive every year, not only as a pleasurable resort, but also as a field for botanical study, where by careful and scientific arrangement the botanical student is given access to the vegetation of almost every part of the world, and in many instances under circumstances like those which surround the plants in their native habitat.

In Ballarat and Sandhurst there have been established for many years "Schools of Mines," really technical colleges, where, by lectures and regular training, students are instructed in both scientific and technical subjects. Take, for instance, the School of Mines at Sandhurst, which has lately considerably extended its functions, and made most substantial progress under the direction of its registrar, Mr. Pitman. Mathematics, surveying, engineering, mechanics, drawing, freehand drawing, chemistry, and laboratory practice, are all well taught at this school, free lectures are given in chemistry, students are drawn from all classes, and as a rule take excellent positions at the examinations in nearly all the subjects. The School of Mines, Ballarat, the oldest institution of the kind in the colony, has fulfilled most important functions in its district for many years past. It embraces in its lecture courses and practical teaching, practical and theoretical chemistry, geology, mineralogy, metallurgy, mining and mining engineering, and has also a school of telegraphy, and annual examinations are held in all the subjects. The school generally is well attended and popular, and is a most efficient institution.

Our members will note with satisfaction that through the munificent offer of the Hon. Francis Ormond, the liberal contributions of the merchants and private individuals of Melbourne, and in no less a degree to the most commendable and earnest efforts of the working men themselves, the sum of £10,000 or over has been gathered for the erection and establishing a Working Men's College on a practical and liberal basis. Mr. Ormond offered £5000 if another £5000 could be collected. The working men collected over £3000 chiefly among themselves, and the rest has been contributed by donations from others who sympathise with the object, and the Government have granted a very eligible site near the Supreme Court, facing the north side of the Public Library. Plans are now being prepared, and before very long the Working Men's College will be an accomplished fact in Melbourne.

One of the most interesting items of the year in connection with our Observatory is the apparition of three new comets, the last of which is the most remarkable that has appeared since 1843. The first appeared in September last year, and was called "Schaéberle's Comet;" the next appeared here in June this year, and is known as "Wells' Comet;" the present one, which is of unusual interest, is not yet named. It appears to have been first seen in Australia on 6th September by Captain Baker, an amateur observer at Goldsbrough, who reported its appearance to me on the 8th. It was observed at all the Australian observatories on the 9th, and subsequently. At its first apparition it was of great brilliancy, but of no very great dimensions. It was already near the sun, and visible just before sunrise. It rapidly approached the sun, and increased in brilliancy so much that on the 17th September it was visible to the naked eye at noon within 3 degs. of the sun in a clear sky; it passed its perihelion passage on the morning of the 18th, and so close to the solar surface as to be within the region beyond which the great solar volcanoes of incandescent hydrogen are often seen to extend. The velocity of this body, as it rushed half around the sun at this time, must have been stupendous beyond conception, for, according to our most recent calculation, it must have made this journey in less than six hours. It increased in grandeur after perihelion, and for the last three weeks has been a magnificent spectacle in the morning sky. As it was thought not improbable that the comet of 1812 would again return to perihelion this year, and "searching ephemerides" had actually been prepared and distributed by some French astronomers (Paris Observatory), it was at first thought possible this might be that comet, but an approximate orbit computed by our vice-president, Mr. White, from some of the earliest observations of the present comet, made any futher supposition of this kind altogether untenable. The approximate elements exhibit a remarkable likeness to the great comets of 1843 and 1880. The motions of all three are retrograde, the inclination and longitude of the node very similar, and the perihelion distance of all exceedingly small and nearly like.

The apparitions of two large comets in 1880 and 1882, with elements so very much alike that of the grand comet of 1843, have of course led to some astronomical speculation on the subject. If any celestial bodies appear successively in similar or nearly similar orbits, a supposition that they are one and the same body, or several separate bodies in the same orbit, is quite reasonable. Mr. Tebbutt, our well known astronomer, of Windsor, N.S.W., has therefore suggested it as quite possible that the comets of 1843, 1880, and 1882 are identical, returning to perihelion at rapidly diminishing periods, and that if this be so, its present excursion must be very short, barely taking it out of our sight before it turns back again towards the sun. One incentive to this suggestion was no doubt the fact that the perihelion distance of the rough orbit first computed was less than that of 1880, while that of 1880 was less than that of 1843. More recent calculations, however, show that the perihelion distance of this comet was greater than at first computed, and rather greater than that of 1880. Whether we can possibly entertain this hypothesis will soon be shown by the recession or return of the comet. If it disappear for any considerable time, then we must conclude that there are two or more comets in the same orbit. Numerous critical examinations of the physical appearances of this body have been made both with the great reflector and the 8-in. refractor at the Observatory, and a remarkable character of nucleus has been observed. On the 4th it was first seen to be of a very long oval shape, central in the head, and its long axis parallel with the general length of the tail. On the 6th October it was observed to be inclined by several degrees (5 degs. at least) from this parallelism, and to have a very bright round and distinct planet-like spot in that part of the nucleus nearest the head of the comet. On the 10th this spot had moved nearer to the centre of the elongated oval nucleus. The closeness of the dawn and subsequently strong moonlight were much against spectroscopic observation of its light until the 8th October, when I made a careful examination of the nucleus and other parts of the comet. The spectrum I found to consist of a moderately bright continuous spectrum, crossed by three broad bright bands, the approximate wave lengths of whose centres were 5605, 5070, 4720, respectively. These bands were very bright in the nucleus itself, and could be well seen anywhere near the head of the comet, and traced faintly over a part of the tail for some distance from the head. In the spectrum of Wells' comet of 1881 several observers saw the well-known D line, due to sodium—as far as I know a unique instance in the case of cometic spectra. I examined carefully for any indication of this line in the present comet, but could discover no trace.

A series of observations for the determination of the solar parallax indirectly by Dr. Gallè's method has been made with the 8-in. refractor. These observations consist in very elaborate measures of differences of declination between the small planets Victoria and Sappho and certain selected fixed stars near them, taken each night between 18th July and 18th October. Similar observations have been arranged for in Europe, America, and at the Cape. A combination of the results will furnish means for computing the parallax of both these planetoids. The periodic times of these bodies being known with great exactitude, it follows by Kepler's third law that the solar parallax can thus be indirectly determined. The observations themselves have been carried out on a very elaborate and somewhat novel plan, suggested by Mr. Gill, the astronomer at the Cape. The period of observation terminated last Wednesday. So far as Melbourne is concerned the series has not been very successful, owing to the prevalence of the cloudy weather throughout the early part of the period. Nevertheless, I think a very valuable set of measures has been secured.

The preparations for the transit of Venus, on 6th December, have lately been occupying our attention, and it is now decided that we shall have observing stations at Melbourne, at Sale (in Gippsland), and in or near Hobart. The last phases of the phenomenon occur just after the sun rises in this part of the world; we shall therefore see nothing of the earlier or intermediate phases. In Melbourne the sun will only have risen about 13 degs. above the horizon before the transit is over, and in Hobart only about 15 degs. Nevertheless, the contacts at egress, the last critical phase, should be well seen at any part of Eastern Australia. As this is the last transit of Venus that will occur for more than 120 years, of course the event is looked forward to with considerable interest. The various national observing parties are already on their road to the several observing points, and I have had the pleasure of seeing several of our English observers here within the last fortnight. One British party goes to Brisbane, another to New Zealand, and there will be an American observing party also in New Zealand.

In conjunction with the transit of Venus operations we are arranging with some of the British observers for the determination of the difference of longitude between Greenwich and the Australian cities by telegraph. To do this, Lieutenant Darwin, a member of the Brisbane observing party, will, after the transit, proceed to Singapore; at the same time Australia sends an observer with transit instruments and chronometers to Port Darwin. These gentlemen, after setting up their transit instruments and obtaining correct local time, will commence exchanging a series of time signals between the two places, and thus determine the difference of longitude. The longitude of Singapore having already been determined telegraphically, that of Port Darwin will be found, and hence the longitude of Adelaide, Melbourne, Sydney, Brisbane, &c. A similar series of observations will be made in New Zealand by either the English or American party through the cable to Sydney. We shall, therefore, have the longitudes of all these places from Greenwich ascertained by the most correct and precise method available. The observer for Port Darwin is now training for the work at our Observatory.

Our chain of intercolonial meteorology is now almost complete. Western Australia, Tasmania, and Queensland have practically joined in the work, and our daily weather telegrams now cover the coast line of Australia from Geraldtown, north of Perth, in Western Australia, to nearly Cape York; a line across Australia, from Adelaide to Port Darwin; the north and south parts of Tasmania; and New Zealand generally. The consequence is we are slowly and gradually increasing our knowledge of Australian meteorology, and of the laws which govern the movement of storms along our coast lines, and the distribution of rainfall over the various climatic regions of the continent.

The last few years have forcibly demonstrated the importance of this latter meteorological factor to Australia, and more especially to the southern and central regions. A better knowledge of the laws of deposition of rain, should such exist, would be of incalculable value, as it would show more or less precisely our "assets and liabilities" in moisture. No amount of knowledge will alter the rainfall, but it will show us how far we have to "save up," how much of the water that does fall and now runs into the sea or soaks in the ground must be saved to meet urgent wants. Whether our natural supply will be found sufficient for the purposes of irrigation except to a very limited extent in certain districts, must, in view of recent discussions on the subject at our meetings, be considered very doubtful, as must also the question of the economics of irrigation in the colony, where the cost of labour is comparatively so high as in Australia generally. A mere glance at the rainfall tables for any month shows us that the greatest precipitation takes place at our highest altitudes; our great coast range is the gathering ground of rain-producing clouds, and it is the fall on the tops of our mountains and ranges that keeps our creeks and rivers running, by slowly delivering their stored-up water through numerous and often perennial springs. Wherever destruction of the forest has occurred on the ranges, these springs have all seriously diminished, and in very many instances ceased altogether, lessening the annual flow in the chief arteries of the country. Therefore the reckless denuding of our higher forests is absolutely robbing the country of water. Should this destruction continue, a seriously-diminished flow of our rivers, dry creeks, and scarcity of water over formerly well-watered districts will become inevitable.

Time will scarcely permit of referring to numerous subjects which mark the year's progress in science generally. There are, nevertheless, one or two matters which are of somewhat more than passing interest, which may justly claim our attention for a few moments. It has been estimated that about one-seventh of the human race die of tubercular disease, or consumption as it is called, and, further, that of the deaths in middle life fully one-third are caused by this fatal disease. This dreadful scourge has gone on, and still goes on unhindered, at least to any marked extent, by any human effort, backed up by all the advanced medical science of the day. By hygienic precautions and a more profound knowledge of the disease, there is little doubt that of late years it has been in some small degree more successfully opposed; nevertheless, those who know most of it cannot but acknowledge our comparative helplessness in the face of this enemy. But knowledge is strength. Consumption is now admitted on all hands to be contagious. For the last twenty years the contagiousness or infectiousness of this disease has been suspected, and various experiments have more or less satisfactorily demonstrated its high probability. Creighton, Burdon-Sanderson, Giboux, Martin, and more recently Klebs, Cohnheim, and others, advanced still another step in the same direction, but it has remained for Professor Koch, of Breslau, now chief of the Imperial Medical Department of Berlin, to demonstrate it as a germ disease, transmissible by inoculation, and that its contagiousness is due to a form of bacillus, one of those low orders of germs which appear to be at the bottom of many diseases to which the human, as well as other animals are prone. Now, assuming this to be the case, such knowledge gives great strength, for the modes of resisting contagion offer at once a prospect of, in some degree, stemming the onward course of this destroyer. And, again, if it should be further shown, as we may reasonably hope, that being a contagious germ disease, it is not a hereditary one, then we may cheerfully anticipate that science will find effective weapons to check the spread of this fatal disease.

Speaking of this brings to my memory a *brochure* published six years ago (1876) by Mr. Wm. Thomson, of South Yarra, entitled, *Histo-Chemistry and Pathogeny of Tubercle,* which I referred to in a former address. In this pamphlet he discusses at length the pathogeny of tubercle, and gives his reasons for concluding it to be a purely germ disease. On page 27 he says—"The idea of micrococci being in any way associated with the process of tuberculosis is a recent one; and the explanation of their mode of operation is, at least as far as I am aware, now for the first time in the history of pathology attempted, with what degree of success remains to be seen." What has now been demonstrated by Koch was undoubtedly indicated as of the highest probability in Thomson's pamphlet of 1876, and reiterated at greater length, and with fuller illustrations in another pamphlet in 1879, and afterwards by Cohnheim in his work on the *Contagiousness of Tubercle,* published in 1880, who says:—"We must look forward to the day when the '*tubercle corpuscule*' shall have been discovered in the form of a minute organism."

The immense strides made in the applications of electricity to lighting and other economic purposes during the past year is a subject worthy of note and for congratulation. Not so very long ago I stated that I believed the time when electricity would supersede gas for internal illumination was far distant. I must now recant—the time is here. Electricity has replaced gas in several interiors in Melbourne, and, so far as can yet be seen, with great success. At the Opera House it is pronounced by all a great success and decided improvement; it produces less *heat* and less *headache.* Several public places in Melbourne are lit by electricity, and many establishments are about to adopt it. It has been applied to the illumination of the extensive workings of the Ellenborough Mine at Sandhurst. The Harbour Trust Commissioners have adopted it with great success for carrying on their dredging operations at night, and the trustees of the Public Library have decided to light up the library and reading-room with the incandescent electric lamps. This last instance is one in which the new mode of lighting is peculiarly well adapted, inasmuch as the reading-room in the summer months gets intolerably heated with the gas, and the products of combustion slowly but surely destroy the bindings of the books. It is the small amount of heat developed, and above all the entire absence of the deleterious products of the combustion of gas, that constitutes its great recommendation. I doubt if electric light by the incandescent lamp method will be as cheap as gas; still the advantages referred to are, I think, worth a larger difference than will probably exist. The arc light, of course, is far the most economical, but it is only well adapted for out-of-door lighting or for very large interiors.

The future of electricity as an illuminant, a transferer of mechanical power, or as an agent in metallurgical operations can scarcely be foretold, but already it is shown to be economical and eminently effective in all these directions, and is now used both in England and Germany for depositing metals from their solutions and refining copper and other metals. Dr. Siemens, in his address to the British Association in August, stated that as a transmitter of power for farm work he can, "after two years' experience, speak with confidence of its economy and efficiency." Dr. Siemens also mentions an interesting fact concerning the influence of the electric light on vegetation. He had wheat, barley, and oats planted, some of which was submitted to the influence of the electric arc light of 4000 candles placed about 20 feet above the surface of the ground. No difference was observed till mild weather set in after the end of February, when those cereals over which the electric light shone developed so rapidly that by the "end of May they stood 4 feet high and in full bloom, while the others stood 2 feet high and showed no sign of the ear."

For all the advance of electric lighting, I still believe that "gas" will remain in the ascendant, not altogether as an illuminant, but certainly as a fuel. Already it is extensively used as fuel for steam engines in town, not only for safety and cleanliness, but also for economy; and as time goes on its use in this direction will, I feel sure, greatly increase; and it is devoutly to be desired that it should do so, for not the least good practical result from its universal adoption would be having only one, or at least a few, smoke-producing centres instead of a legion. Hygiene and æsthetics should both clamour for this. Gas, moreover, is fast asserting itself as a fuel for our cooking stoves and kitchens, and although there is still a lurking prejudice against gas-cooked food in some quarters, the exhaustive trials at the Glasgow Gas Fuel Exhibition show conclusively that a properly constructed and ventilated gas stove will cook food better and freer from foreign and undesirable products than nine-tenths of the coal-cooking ranges. As an economical, easily transmitted, and safe fuel, gas has, I think, its greatest future before it.

There is another point, however, which is worthy of note. It has been shown by Dr. Tyndall that coal gas burnt with intensified currents of air, heated by passing over metal surfaces kept at a high temperature by a special and separate burner, can be so increased in illuminating power as to rival the electric arc. Therefore, though gas and electricity are destined to be rivals, the rivalry will spur on to improvement and achievement redounding to the public advantage, and, as a consequence, the prosperity of the several companies.

In conclusion, I would refer to one scientific fact of the year, of great importance—namely, the "Arctic expeditions" which have been fitted out by the various European States for concerted and extensive investigations in terrestrial magnetism, auroras, polar meteorology, natural history, and cognate physical science near both poles. There will be eleven or twelve stations surrounding the North Polar regions, one as far north as Franklin Bay, in latitude about 84 degs. north. These expeditions will be fitted out by various European Governments. In the south the Germans establish a point at South Georgia Island, the French a station at Cape Horn, and the Italians a station in Patagonia, and so on. These, in connection with our fixed meteorological station in Melbourne, it is hoped will furnish a complete and effective chain of observation over the period arranged for the work—namely, from 1st September, 1882, to 1st September, 1883. It was at first hoped by the German Polar Commission that the Australian colonies would probably cooperate by forming observing stations more southerly than Melbourne, but as the intimation of the desirability of such a step reached here too late to take action with any prospect of a practical result, the idea has been abandoned, and the cooperation of the Melbourne Observatory only in this part of the Southern Hemisphere can now possibly be given.

TRANSACTIONS.

ART. I.—*The Phanerogamia of the Mitta Mitta Source Basin and their Habitats.*

BY JAMES STIRLING.

[Read 20th April, 1882.]

IN my recent paper on the topography of the Australian Alps, in outlining proposed physiographical researches in the Omeo district, I intimated my intention to submit a subsequent paper on the geological structure and botany of the Mitta Mitta Source Basin (there topographically described). I regret not having been able to complete observations on the geological structure of this area sufficient to enable me to correctly delineate it, but in the meantime submit the following description of the phanerogamia, or flowering plants, together with a collection of dried specimens representing the different orders most prevalent.

A glance at the map of Victoria will show that the Mitta Mitta Source Basin is bounded by watershed lines ascending to the highest peaks and plateau in the colony. It consequently embraces hypsometrical zones of vegetation, rising from the gigantic eucalypts, prolific amid the shaded slopes of our Victorian Cordillera, through dense masses of arboreous shrubs clothing the moist head of gullies at higher elevations, and again, through undulating uplands covered with patches of heath-like plants, dwarfed arboreous shrubs, and open pasture lands to the grassy moorlands of the highest snow-clad plateaux.

In submitting the following descriptions of native flowering plants, I desire to state that they do not include the whole of the phanerogamia of this portion of our Australian Alps, but simply represent a collection made by me, according as time and circumstances permitted during the past three years. I have also restricted my remarks to species verified by our eminent botanist, Baron von Müeller, to whose kindness, indeed, I am indebted for help in the matter of systematic classification. Among numerous questions of phytological importance, there is perhaps none more interesting than that which relates to the effects of defined geological formations on the growth of plants, and more especially on the evolution of varieties. In order to contribute my quota towards a solution of the question, which may be used for comparisonal purposes by those having a larger experience and more extensive phytochemical knowledge, I have given the geological formation upon which I have found each species to be most prolific. So far as my limited observations would warrant me in forming an opinion, I would suggest meteorological conditions as exercising a more dominating influence over the growth of plants, and in the evolution of varieties, than has hitherto, so far as I am aware, been recognised. Undoubtedly, those soils decomposed from the great rock formations richest in the alkaline salts, also carbonic acid and ammoniacal compounds (from which plants derive a great part of their nourishment), greatly affect the growth of species; but whether such chemical constituents evolve varieties is, I think, quite another question. How far the phenomena of insect cross fertilisation may be assumed as a factor I cannot venture an opinion; but it is extremely probable that insect life is subordinated to climatic influences, so that altitudinal differences and hygrometric conditions are really important factors to be considered in estimating the value of geological or entomological agencies.

However, whether meteorological conditions, geological formation, or entomological considerations are paramount, or whether each are modified by the other, there can be no doubt that the subject is one of great scientific interest, and can only be settled by patient collection, comparison, and analysis. In this paper I have limited my remarks to the dicotyledonous plants only, reserving the monocotyledonæ and the cryptogamia for a subsequent paper.

Taking the area as a whole, it may be said to consist of fine open pasture lands, the more dense arboreous vegetation being confined to the Dividing Range, and the shrubs to its shaded gullies and southern slopes of prominent spurs, and the heath-like plants to open, sunny northern slopes. Out of the included 670,000 acres within the Mitta Mitta Source Basin, fully 400,000 are admirably adapted for pastoral pursuits, and there is every reason to believe that the agricultural and horticultural products of European extra-tropical countries may be successfully and profitably cultivated amid our sub-Alpine elevations; in fact, the only barrier at present existing is that of transit to a market; a good road to the seaboard, distant about sixty miles, being a desideratum.

As settlement progressed in these regions, a number of herbaceous plants were introduced; these, however, I have not included in this list. The principal rock formations within the area under consideration consist of Silurian and altered Silurian—*i.e.*, metamorphic schists, gneiss, &c., including many varieties of quartz porphyry, granite porphyry, &c., basaltic table-lands, numerous igneous dykes intersecting and intruding upon the metamorphic schists; also patches of Middle Devonian sandstone and limestone, with deposits of tertiary gravels along the courses of streams—in fact, what my friend, Mr. A. W. Howitt, has described as the "great paleozoic rock foundations of North Gippsland," intruded upon by subsequent Plutonic masses. The following arrangement is that of Baron von Müeller:—

DICOTYLEDONÆ.

CHORIPETALEÆ-HYPOGYNÆ.

Natural Order—

1. Ranunculaceæ
2. Dillenaceæ
3. Magnoliaceæ
4. Monimieæ
5. Lauraceæ
6. Violaceæ
7. Pittosporeæ
8. Droseraceæ
9. Polygaleæ
10. Rutaceæ
11. Lineæ
12. Geraniaceæ
13. Sterculeaceæ
14. Urticaceæ
15. Casuarineæ
16. Sapindaceæ
17. Stackhousieæ
18. Caryophylleæ

C. PERIGYNÆ.

Natural Order—

19. Leguminoseæ
20. Rosaceæ
21. Onagreæ
22. Halorageæ
23. Myrtaceæ
24. Rhamnaceæ
25. Araliaceæ
26. Umbellifereæ.

SYNPETALEÆ PERIGYNÆ.

Natural Order—
27. Santalaceæ
28. Proteaceæ
29. Thymeleæ
30. Rubiaceæ
31. Compositæ
32. Campanulaceæ
33. Stylideæ, or Candolleaceæ
34. Goodeniaceæ

S. HYPOGYNÆ.

Natural Order—
35. Gentianeæ
36. Scrophularinæ
37. Asperfoleiæ
38. Labiatæ
39. Epacridaceæ
40. Ericaceæ

40 natural orders, embracing 174 species.

I.—CHORIPETALEÆ-HYPOGYNÆ.

No. 1—Ranunculaceæ ( ).

Genera—Clematis and Ranunculus.

1 C. Aristata (R. Br.).—Clothing the tops of the highest trees amid our shaded sub-Alpine slopes with a canopy of snow-white blossoms; in all soils; it is apparently restricted to 4800 feet above sea-level.
2. R. Lappaceus (D. C.), "common buttercup."—Abundant on metamorphic schists around Omeo; it ascends to Alpine heights; all soils.
3. R. Gunnianus (Hask.).—On sub-Alpine slopes and terraces; all soils, up to 5000 feet.
4. R. Millani (F. v. M.).—Along source runnels of Bogong High Plains. Basaltic formation.
5. R. Muelleri (Bent.).—At head of Bundara River, near Mount Cope; 6015 feet; metamorphic soils.
6. R. anemoneus (F. v. M.).—At heads of Big River, on Silurian and granitic soils. I have not seen any species below 6000 feet.

No. 2—Dillenaceæ ( ).

Genus—Hibbertia.

1. H. diffusa (R. Br.).—Lower undulating metamorphic ranges, near Omeo; not ascending above 4000 feet.
2. H. serpillifolia (R. Br.).—On the sub-Alpine slopes, exposed rocky ridges; Silurian and altered Silurian soils; up to 5000 feet.

No. 3—MAGNOLIACEÆ ( ).

Genus—Drimys.

1. D. aromatica (R. et G. F.), "native pepper tree."—Forms amid the shaded slopes of the Dividing Range, on Silurian soils an arboreous shrub attaining a height of 12 feet; on the higher basaltic plateau (5000 feet) it becomes fruiticose, more gregarious, and has more aromatic and pungently acrid properties; it has been used for flavouring preserves with success at Omeo.

No. 4—MONIMIEÆ ( ).

Genera—Hedycaryi and Atherosperma.

1. H. Cunninghami (Tul.).—On the Dividing Range, at the head of Livingstone Creek; on Silurian soil; 4000 feet.
2. A. moschata, "native sassafras" (Lab.).—Forms a dense shrub along the upper courses of the Gibbo River; Silurian formation 3800 feet; frequently attains a height of 40 feet, its bark is laxative, aromatic, and is used by the splitters for flavouring tea.

No. 5—LAURACEÆ ( ).

Genus—Cassytha.

1. C. melantha (R. Br.), "native scrub vine."—Parasitic; on eastern watershed of Livingstone Creek; does not ascend above 5000 feet.

No. 6—VIOLACEÆ (De Candolle).

Genera—Viola and Hymenanthera.

1. V. hederacea (Labill).—Common during early summer on the metamorphic schists around Omeo, up to 4000 feet.
2. V. betonicifolia (S. M.).—On open pasture lands, near Omeo; 3000 feet; metamorphic soils (principally micaceous schists).

1. H. Banksii (F. v. M.).—At head of Victoria River, near Mount Phipps (Dividing Range); altered Silurian formation; 3000 feet.

No. 7—PITTOSPOREÆ (R. Br.).

Genera—Pittosporum and Bursaria.

1. P. bicolor (Banks).—A charming species, with handsome glossy sap-green foliage; bi-valved fruit; shaded gullies; along Dividing Range; Silurian soils; 4000 feet; wood useful for ornamental purposes.

1. B. spinosa (Cav.).—Sparsely distributed within this area, being confined to open rocky spurs of argillaceous schist; at junction of Livingstone Creek and Mitta Mitta River; 1700 feet. At Tongio, in valley of Tambo River; 1500 feet; it is abundant in granitic soils; and at Bindi, Middle Devonian limestone formation in same valley, it attains a height of 20 feet, with trunk 10 inches in diameter. It does not appear to ascend anywhere in the Omeo district above 4000 feet. It is locally known as kangaroo thorn. Crude potash, crude tar, and acetic acid have been obtained from its wood, according to Mr. Guilfoyle curator of the Botanic Gardens. I have also found the charcoal extremely useful for blow-pipe work.

No. 8—DROSERACEÆ (Salisb.).

Genus—Drosera.

D. Arcturi (F. v. M.).—The only species I have met with of this interesting order is confined to the High Plains, near Mount Cope, 6015 feet, on Silurian soils and basaltic detritus; the glandular hairs margining the leaf render it easily distinguishable.

No. 9—POLYGALEÆ (A. & L. de J.).

Genera—Polygala and Comesperma.

1. P. sibirica (L.).—Sparsely distributed on the flats near Hinnomunjie, Mitta Mitta River; 1700 feet; metamorphic schists and alluvium.

1. C. retusum.—Widely distributed within the area; on all paleozoic and basaltic soils up to 5000 feet.

No. 10—RUTACEÆ (A. L. de Jussieu).

Genera—Correa, Zieria, Boronia, and Eriostemon (including Croweæ).

1. C. Lawrenciana ( ).—Forms, with Leptospermun and

Callistemon, the principal shrub vegetation fringing the margin of the Cobungra, Bundara, and Big Rivers; at elevations of from 3000 to 4000 feet; on metamorphic and basaltic soils. Its strong orange odour and fuchsia-like flowers render it easily recognisable.

1. Z. Smithie (And.).—On moist heads of gullies along the Dividing Range, at an elevation of 3000 to 4000 feet, it is most abundant. Its axillary panicles of white scented flowers and trifoliate lanceolar leaves at once distinguish it amid surrounding vegetation; on Silurian soils principally.

1. B. Algida (F.v.M.).—Abundant on the rocky ridges intersecting the Bogong High Plains; 5600 feet; on basaltic formation.
2. B. polygalifolia (Sm.).—Scrubby spurs of Dividing Range, at head of Livingstone Creek and Victoria River; altered Silurian soils. Its palmately compound leaves distinguish it; the small white and light pink flowers are scented. It ascends to 4000 feet.

1. E. Crowea Saligna (F. v. M.).—Abundant on Mount Sisters, near Omeo Plains; metamorphic granite formation. Altitude, 3600 feet.
2. E. myoporoides (D. C.); 3. E. umbellatus (Turc).—Both to be met with on Dividing Range, margining Omeo Plains; on quartz porphyry formation; 3000 to 4000 feet.

No. 11—LINEÆ (De Candolle).

Genus—Linum.

1. L. marginale ( ).—Abundant on all soils (paleozoic and igneous) during January; ascends to 5000 feet. It has a tenacious bark, useful for paper manufacture.

No. 12—GERANIACEÆ (A. L. de J.).

Genera—Geranium and Pelargonium.

1. G. dissectum (L.).—On Dividing Range, margining Omeo Plains; quartz porphyry formation, and near Omeo on metamorphic schist soils; between 2000 and 4000 feet.

1. P. Australe (Wild.).—East of Omeo Plains, near Mount Sisters; quartz porphyry and metamorphic granite formations; 3000 to 4000 feet.

No. 13—STERCULIACEÆ (Vent.).

Genus—Lasiopetalum.

1. L. dasyphyllum (Sieb.).—On the outskirts of other shrubs; Dividing Range, at head of Livingstone Creek; 3600 feet; Silurian soils. Its flowers are peculiar, and hermaphrodite.

No. 14—URTICEÆ (Ventenat).

Genus—Urtica.

1. U. incisa (Poir), "common nettle."—On cultivated ground around Omeo, and densely distributed through moist heads of gullies along Dividing Range; humid soils; up to 5000 feet.

No. 15—CASUARINEÆ (Mirbel).

Genus—Casuarina.

1. C. suberosa (Link).—Limited within the area to the lower undulating ranges margining Omeo Plains, on south side; mica schist formation; 3000 feet.
2. C. distyla (F. v. M.).—Forms dense scrub clothing steep ranges at Tongio (along valley of Tambo River); 1000 to 2000 feet; on granitic and argillaceous schist formation; rare in Mitta Mitta source basin.

No. 16—SAPINDACEÆ (A. L. de J.).

Genus—Dodonæa.

1. D. viscosa.—On Dividing Range, at head of Livingstone Creek and Wentworth River; Silurian formation; ascends to 4500 feet.

No. 17—STACKHOUSIAEÆ (R. Br.).

Genus—Stackhousia.

1. S. linarifolia.—Abundant on metamorphic schists around Omeo; up to 4000 feet.

No. 18—CARYOPHYLLEÆ (Scop.).

Genera—Stellaria, Colobanthus, and Scleranthus.

1. S. pungeus (Brogn.).—Is seen to advantage during the dry season, beginning of March, when the grasses are parched; around Omeo; 2300 feet; metamorphic schists.

1. C. subulatus ( ).—This moss-like plant is abundant on the basaltic plateaux of Bogong High Plains and on the lower shelves of altered Silurian rocks; from 4000 to 6000 feet.

1. Scleranthus biflorus (Hook).—Is abundant on the dry, sunny slopes of the eastern watershed of the Livingstone Creek; mica schist formation, it is frequently mistaken for tufts of moss, so similar is its appearance.

II.—CHORIPETALEÆ-PERIGYNÆ.

No. 19—LEGUMINOSEÆ (Haller).

Sub-order No 1—PAPILIONACEÆ.

Genera—Oxylobium (And.), Mirbelia (Smith), Gompholobium (Smith), Daviesia (Smith), Pultenea (Smith), Dillwynia (Smith), Platylobium (Smith), Bossieæ (Vent.), Hovea (R. Br.) Goodia (Sals.), Lotus (Towns), Acacia (Towns).

1. O. procumbeus ( ).—At head of Livingstone Creek granitic soils and metamorphic schists; also High Plains; basaltic formation; 5000 feet.

1. M. Oxylobium( ).—Open, sunny, northern slopes of Mount Livingstone, near Omeo; gneissose schists; 3500 feet; blooms in January.

1. C. Heuglii (Bentham).—On Dividing Range, margining Omeo Plains; quartz porphyries; 3900 feet. It has large yellow flowers.

1. D. latifolia (R. Br.).—On Silurian soils along Dividing Range, particularly along the margin of Wentworth River; it forms dense scrub, attaining a height of 20 feet; altitude, 3900 feet.

2. D. ulicina (Sm.).—On heathy ranges near Omeo; 3000 feet; metamorphic schists; eastern watershed of Livingstone Creek ("native hop").

3. D. Buxifolia (Bent.).—On Dividing Range, at head of

Victoria River, and along Wentworth eastern watershed; on Silurian formation and quartz conglomerates; altitude, 3500 feet.

1. P. fasiculata (Bent.).—Restricted to the higher tablelands; basaltic and lower Silurian formations; 5000 feet. This is a charming rose-coloured species.
2. P. juniperina (Lat.)—A charming species, abundant at head of Livingstone Creek; orange-coloured flowers.

1. D. ericefolia (Sm.).—On coarse conglomerates, sandy soils; along Dividing Range, at heads of Livingstone Creek. This pretty species flourishes at elevations of 3000 to 4000 feet. It is more abundant on Wentworth River source basin.

1. P. obtusangulum.—Covering the shaded hill sides; up to 5000 feet; all over the area, particularly on the western watershed of the Livingstone Creek. On metamorphic schists this species is abundant.

1. B. riparia (A. C.).—On felsitic rock masses near Omeo this species is most abundant; altitude, 2500 feet. The young plants are edible; stock, especially horses, are fond of it.
2. B. bracteosa (F. v. M.).—Forming a dense underscrub on the higher plateaux; basaltic and Silurian formation; at 4500 feet; 3 to 5 feet high.
3. B. foliosa (Cunng.).—This is the most elegant of the papilionaceous shrubs to be met with in this district. Its spreading, flattened branches take almost the form of fern fronds. It is abundant on the sunny slopes of Mount Livingstone, 3000 feet, and on tertiary gravels *in situ.*

1. H. heterophylla (R. Br.).—Is met with along the banks of the Livingstone Creek; 2200 feet; mica schist formation. Its blue flowers distinguish it.

1. G. lotifolia (Salsb.).—The soft trifoliate leaves and racemes of golden yellow flowers render it easily known. It is sparsely distributed within the area at Tongio Gap, 4000 feet, on altered Silurian soils; south of Dividing Range, on Wentworth River, it is more gregarious and luxuriant.

1. L. corniculatus (L.).—On moist situations along the affluents of Livingstone Creek; up to 3000 feet.
2. L. Australis (And.).—In similar situations with L. corniculatus; ascending to 5000 feet; on metamorphic, Silurian, and basaltic soils; principally along moist margins of watercourses.

Sub-order No. 2—MIMOSEÆ.

Genus—Acacia.

1. A. myrtifolia (Willd).—Flourishes on the northern slopes of Mount Livingstone, in the neighbourhood of granite dykes; along western or southern watershed of Dry Gully; auriferous country; 3000 feet.
2. A. melanoxylon (R. Br.), locally called "lightwood."—Is dispersed among eucalyptus in eastern watershed of Livingstone Creek; ascends to 4000 feet; on metamorphic soils.
3. A. discolor (Willd).—On Dividing Range, at head of Livingstone Creek; 4000 feet; granitic soils; it is sparsely distributed. On Wentworth River it is more gregarious, forming dense underscrub on Silurian soils.
4. A. decurrens (Willd).—Is moderately abundant within the area along the upper flat courses of gullies; metamorphic soils; south of Dividing Range it is abundant.
5. A. pycantha, "golden wattle."—Only occasionally to be met with in the area, on Silurian soils; it is prolific on ranges south of Dividing Range; its gum is very transparent.
6. A. vomeriformis.—This peculiar shrub is abundant on the coarse sandy soils disintegrated from quartz conglomerate in upper courses of Wentworth River at elevations of 3000 feet. On Dry Gully watershed, near Omeo, it is also to be met with on gneissose schists. Another species, similar in appearance to A. vomeriformis, is also to be met with in same habitat.
7. A. silicuformis (A. C.).—Is abundant on the gravels along bed of Livingstone Creek; 2000 feet.
8. A. alpini (F. v. M.).—Is met with on all elevations above 3000 feet up to 5000 feet, principally on altered Silurian soils.
9. A. verticillata (Willd).—In similar habitats to A. vomerformis, particularly in Wentworth River watershed, at elevations of 3000 feet.

No. 20—ROSACEÆ (A. L. de J.).

Genera—Rubus and Alchemilla.

1. R. parvifolius (L.), "native raspberry." —Is abundant on all river margins on rocky bluffs within the area.

1. A. vulgaris, "common lady's mantle."—Is met with on Paw Paw Plains, at head of the Victoria River; 4000 feet; basaltic soils.

No. 21—ONAGREÆ (Adanson).

Genus—Epilobium.

1. E. tetragonium (L.).—On moist, boggy situations along upper courses of Livingstone Creek; 3500 feet, and on higher plateaux up to 5000 feet.

No. 22—SALICARIEÆ (Adanson).

Genus—Lythrum.

1. Salicaria (L.).—Is found growing on the alluvium of principal streams, particularly south of Dividing Range, on Tambo and Dargo Rivers, at elevations of 1000 to 2000 feet.

No. 23—HALORAGEÆ (R. Br.).

Genus—Haloragis.

1. H. tetragyna (R. Br.).—A small, herbaceous species; is abundant on the metamorphic schists around Omeo.

No. 24—MYRTACEÆ (Adanson).

Genera—Bæckea, Leptospermum Kunzea, Callistemon, Eucalyptus.

1. B. gunniana (F. v. M.).—Is abundant on the basaltic tablelands along source runnels, at elevations of 5000 feet.
2. B. Diffusa (Lieb.).—Along upper courses of Benambra Creek, on boggy soils; Silurian formation; altitude, 3700 feet.

1. Leptospermem scoparium (Forst.).—Along margin of Livingstone Creek and Cobungra River; mica schist formation; altitude, 3000 feet.
2. L. lanigerum (Sm.).—In similar habitats to L. scoparium; metamorphic schists.

1. K. parvifolia (Scha.).—Mount Sisters, Dividing Range margin of Omeo Plains; metamorphic granite; on dry slopes.

1. C. salignus, var. Siebierii (D. C.).—On the Paw and Precipice Plains; 4000 feet; basaltic formation; more abundant along source runnels; intersecting the higher plateaux of Dargo High Plains, south of Dividing Range; 5000 feet.

EUCALYPTUS.

1. Genus E. amygdalina, "white gum," is the most prevalent species; distributed all over the area up to 5000 feet, where it gives place to C. alpini —our Alpine species, locally called snow gums.
2. E. obliqua "stringy bark."—Sparsely distributed on granitic and coarse argillaceous schist formation, on the northern sunny slopes of the lower ridges and along the crest of the main Dividing Range.
3. F. melliodora, "honey-eucalypt, or box."—Is hardly represented north of the Dividing Range; along the valley of the Tambo it is the principal species, remarkable for its ash-grey foliage, the durability and hardness of its timber, and its excellent qualities as fuel. It flourishes in hard granitic and gneissic soils in this watershed.
4. E. globulus, "blue gum."—Attains a great height amid the moist southern slopes along the Dividing Range, although not abundant within the area. I have noted trees in the moist gullies, starting from the Tambo Gully, 320 feet high, with leaves lanceolar falcate, fully 2 feet long.
5. E. fissilis, "messmate," is moderately distributed along with
6. E. coriacea, on lower heathy spurs, near the Dividing Range.
7. E. viminalis, "manna gum," is confined to the flats along the Livingstone Creek.
8. E. stuartina, is common towards the Omeo Plains, while close to Omeo a rough-barked, black-stemmed, thick-foliaged species, known as "Black Sally," gives character to the landscape.
9. E. rostrata, "red gum," and 10, C. sideroxylun, "iron bark," are absent from this source basin, unless on the eastern affluents, at lower elevations, as along the Gibbo River.
11. E. pauciflora and 12, E. gunnii, are shrubby Alpine species, which Baron Müeller has been good enough

to inform me are found amid our Alpine regions, although I have not yet identified them; these are probably locally known as snow-gums, ascending to the edge of the highest plateaux at 6000 feet.

13. E. stellulata.—Also a sub-Alpine species. Abundant round Omeo Plains; 3000 feet.

No. 25—RHAMNEÆ.

Genera—Pomaderris and Cryptandra, including Spyridium and Colletia, including Discaria.

1. P. apetala (Labill).—Abundant in heads of gullies with other arboreous shrubs, on south of Dividing Range; all formations; ascends to 4000 feet; its straight stem is said to be used for hop poles in Gippsland.
2. P. phylicifolia (Lod.).—Along margin of Livingstone Creek, near Omeo; 2000 feet; metamorphic schists, sparsely distributed; shrubby.
1. C. omara (Sir S. Small).—At head of Livingstone Creek, on sandy soils; 3800 feet. More abundant on quartz conglomerate in Wentworth River watershed; 3000 feet.
1. S. parirfolium (F.v.M.).—Along margin of Livingstone Creek; on quartzitic schists, near Omeo; 2200 feet. I have not noted any higher than this.
1. D. Australis (Hook.).—Also found growing on metamorphic schists, particularly mica schist, near Omeo; 2000 to 3000 feet. This is a spiney species, easily distinguishable.

No. 26—ARALIACEÆ (Vent.).

Genus—Panax.

1. P. sambucifolias (Lieb.).—This handsome shrub, with its straight, unbranched stem, and tuft of dark, sap-green foliage, is found in shaded rocky sidelings along Livingstone Creek; 2200 feet. At higher elevations, along the Dividing Range, the leaves become thicker and more succulent; ascends to 4000 feet, principally on metamorphosed Silurian soils.

No. 27—UMBELLIFEREÆ (Morison).

Genera—Hydroctyle, Didiscus, and Trachymene.

1. H. laxiflora (Towns).—Is common on pasture lands around Omeo; metamorphic soils; 2000 to 3000 feet.
1. D. homilis (D. C.).—On the detritus of coarse gneissose soils along Victoria River, at altitude of 3500 feet.
1. T. billierdierii (F. v. M.).—On sandy soils at head of Livingstone Creek; 3700 feet; but more abundant on conglomerate detritus along the valley of Wentworth River; 3000 feet.

III.—SYNPETALEÆ-PERIGYNÆ.

No. 28—SANTALACEÆ (R. Br.).

Genera—Leptomoria, Omphacomeria, Exocarpus.

1. L. aphylla (R. Br.).—Common on the open northern slopes of Mount Livingstone; 3000 feet; the fruit is succulent and acrid.
2. O. acerba (A. de C.).—Confined to the Dividing Range, near Mount Sisters; quartz porphyry formation; at elevations of 3000 to 4000 feet.
1. E. cupressiformis (Labill), "cherry-tree."—Is sparsely distributed on undulating ranges near Omeo Plains; more abundant south of Dividing Range.
2. E. stricta (R. Br.).—Common all round Omeo, along eastern slopes of Livingstone Creek, up to 3800 feet; metamorphosed Silurian soils.
3. E. humifusa (R. Br.).—A prostrate bush, abundant at the higher elevations margining Bogong High Plains; granitic and Silurian formation; also on the basaltic plateaux, up to 6000 feet.
4. E. nana (Hook.).—Prostrate shrub, at head of Benambra Creek, and at Mt. Cobberas; 6015 feet, trap form.

No. 29—PROTEACEÆ (A. L. de J.).

Sub-order No. 1—NUMENTACEÆ.

1. Persoonia juniperina.—Is abundant along the valley of the Livingstone Creek, on mica schist formation; up to 4000 feet.

2. P. conteriflora (Bent.).—Similar habitats to P. juniperina.

Sub-order No. 2—TOLLICULARES.

1. Grevillea miquelania (F. v. M.).—On Dividing Range, near Mount Tambo; quartz porphyry formation; on rocky ridges; 3500 feet.
2. G. alpini (L.).—On undulating ranges (metamorphic soils), all round Omeo, and most abundant on south-eastern watershed of Victoria River; ascends to 4000 feet.
3. C. parviflora (R. Br.).—Along the courses of the Livingstone Creek and all eastern afluents of the Mitta Mitta; on altered Silurian soils; up to 4500 feet.
1. Hakea microcarpa (R. Br.).—On margin of Livingstone Creek; ascends to 3600 feet.
2. H. acicularis (R. Br.).—On the shelves of the higher plateaux; basaltic formation; especially on Dargo High Plains, near Mayford; 4800 feet.
1. Lomatia longifolia (R. Br.).—In shaded positions all over ranges near Omeo, both on metamorphic and Silurian soils; ascends to 4000 feet.
2. L. ilicifolia (R. Br.).—On shaded gullies and slopes along Dividing Range, principally on Silurian tracts; altitude, 2000 to 4000 feet.
1. Banksia marginata (Cav.).—Only sparsely distributed, amid junction of streams; a few at junction of Dry Gully and Livingstone Creek; more abundant at lower elevations on rocky ledges of gneissic schists.

No. 30—THYMELEÆ (A. L. de J.).

Genus—Pimelea.

1. P. glauca (R. Br.).—Is abundant all over the open ranges on eastern watershed of Livingstone Creek; blooms during February; metamorphic schists.
2. P. alpina (F.v. M.).—Is also abundant on elevations up to 6000 feet; principally on basaltic soils; Paw Paw and Precipice Plains.
3. P. curviflora ( ).—Similar habitats to P. glauca.
4. P. ligustrina (Lab.).—Is here confined to the lower

source runnels of the higher plateaux; 4000 to 6000 feet; basaltic formation. It is said to contain sudorific and alterative medicinal properties.

5. P. axiflora (F. v. M.).—Along shaded slopes, western watershed of Livingstone Creek. Its bark is said to produce a tenacious bast for paper manufacture.
6. P. pauciflora (R. Br.).—Sparsely distributed along with P. axiflora, but its bark produces a fine brown dye; more abundant along Dividing Range.

No. 31—RUBIACEÆ (A. L. de J.).

Genera—Asperula, Galium, Coprosma.

1. Coprosma hirtella (Lab.).—Along western margin of Livingstone Creek, and on Dividing Range; ascends to 5000 feet; all soils.
2. C. microphylla (F. v. M.).—Confined to Dividing Range, Silurian soils, near Tongro Gap; 3600 to 4000 feet; its small leaves and berries distinguish it.
3. C. pumilla (Hook.)—Bogong Plains, at an elevation of 5000 feet, on basaltic formation.

1. Asperula oleaganta (T. H.).—This small herbaceous plant is abundant on the humid mica schists around Omeo, and ascends to 5000 feet.

1. Galium Australe (D. C.).—Also abundant in moist places near Omeo.

No. 32—COMPOSITEÆ (Vall.).

Genera—Aster, Vittadinea Erigeron, Brachycome, Gnaphalium, Leptorynchus, Helichrysum, Helipterum, Cassina, Cotula, Senecio.

1. Brachycome nivalis (F. v. M.).—During spring this species is abundant all over our sub-Alpine and Alpine elevations.
2. B. ciliaris (Lers.).—Is also abundant, particularly at the heads of the Cobungra and Bundara Rivers; Silurian and basaltic soils.
3. B. radicans (F. v. M.).—In damp situations along Livingstone Creek.

(*Aster* includes Olearia and Celmisia.)

1. A. argophylla ( ), "native musk."—Most abundant on Silurian tracts along Dividing Range, where it frequently forms dense scrubs; does not ascend higher than 5000 feet within this basin.
2. A. myrsinoides (A. Cun.).—At the lower elevations is a robust shrub; on the higher plateaux almost herbaceous and more gregarious.
3. A lepidophylla (Bent.).—Confined to Livingstone Creek near Omeo; 2000 feet; not forming dense underscrub as along the coast-line on sandy soils.

1. Vittadina Australis (A. Rich.).—Abundant on dry slopes of Livingstone Creek near Omeo; 2000 to 3000 feet; quartzitic and gneissose schists.

1. Erigeron pappochromus (Labil).—On the slopes of Mount Cope 6015 feet, and also Mount Hotham 6108 feet. This species when at its greatest luxuriance presents a faded appearance.

1. Gnaphalium alpigenum (F. v. M).—On slopes of Mount Cope this woolly-foliaged plant is abundant.

1. Leptorynchus squammatis (Tess.).—Everywhere abundant during early summer; on all elevations, among open pasture lands; ascends to 5000 feet.

Helichrysum ("everlastings").

14. H. lucidum (Henckel), syn. with H. bracteatum.—Represented by a narrow-leaved variety around Omeo, and by an Alpine variety at elevations of 5000 to 6000 feet, covering those highlands with fields of bright golden-yellow flowers, giving character to the landscape; basaltic formation.
2. H. apiculatum (D. C.).—More abundant on the open ridges near Omeo; up to 3000 feet; mica schists.
3. H. semipapposum (D. C.).—All open northern slopes near Omeo; ascends to 5000 feet; principally on metamorphic soils.
4. H. baccharoides (F. v. M.).—Restricted to the source runnels intersecting the higher plateaux; basaltic soils; covering acres with a dense undergrowth; altitude 5000 to 6300 feet.

1. Helipterum incarum (D. C.).—A variety auriceps; is common on metamorphic schists near Omeo, at elevations of 2000 to 3000 feet, while a white flowered species is restricted to the higher basaltic plateaux, between 5000 and 6000 feet, covering

portion of the open mossy flats with snowy mantle of beautiful blossoms, giving a distinctively Alpine aspect to the localities, and harmonising with the fields of golden Helichrysum lucidum.

2. H. anthemoides (D. C.).—Is more abundant at lower elevations, between 3000 and 6000 feet; on all open grassy flats and hill sides.

1. Cassina aculeata (R. Br.).—Forms an arboreous shrub along the Livingstone Creek near Omeo; 2000 feet; restricted to this habitat apparently—*i.e.*, within the area under consideration.

1. Cotula alpini, "native daisies."—Abundant on the Alpine slopes and terraces; all soils up to 6500 feet; not seen below 2000 feet within this area.

1. Senecio Australis (Wild.); 2. S. vagus (F. v. M.).—Both abundant along southern slopes of Dividing Range in moist gullies; on Silurian formation; sparsely distributed within the area at elevations of 3000 to 4000 feet.

3. S. pertinatus (Towns).—Is to be met with on the higher plateaux.

4. S. bedfordia (Towns), "native flannel plant."—This arboreous shrub is thickly distributed amid our sub-Alpine and Alpine slopes, particularly along the Dividing Range. The leaves have been used by packers and others for fodder for horses during the snowy season. After having been cut for a day, horses will eat them readily. It ascends to 5000 feet; on all soils.

No. 33—CAMPANULACEÆ (A. L. de J.).

Genus—Wahlenbergia.

Wahlenbergia gracilis (A. de C.).—This pretty species is everywhere abundant all over the area. The flowers are purplish blue on the higher plateaux, and the plant more dwarfed.

No. 34—CANDOLLACEÆ (F. v. M.).

Genus—Stylidium.

Stylidium graminifolium (Scharuy).—Equally abundant on the metamorphic schists near Omeo and the higher plateaux. Attains its greatest luxuriance at 4000 feet in basaltic soils.

No. 35—GOODENIACEÆ (R. Br.).

1. Goodenia ovta (Sm.).—This species so common along the coast in Gippsland is here restricted to sub-Alpine heights of 3000 feet, on Silurian soils.
1. Velleia paradoxa (R. Br.).—Common both on the metamorphic schists around Omeo, and on the tablelands up to 6000 feet.

IV.—SYNPETALÆ-HYPOGYNÆ.

No. 36—GENTIANEÆ ( ).

Genera—Erythræa and Gentiana.

1. E. Australis (R. Br.).—Is abundant on ranges around Omeo, and ascends to the basaltic plateaux Bogong High Plains. Its pink flowers arranged in corymbrose panicles render it easily known.
1. G. Saxosa ( ).—More abundant on the higher Alpine slopes and terraces. It differs from Erythræa in not leaving the calyx divided at the base, and the anthers not becoming spirally twisted as they wither.

No. 37—SCHROPULARINÆ (Mistel).

Genera—Gratiola, Veronica, Euphrasia.

1. G. peruviana (L.).—This small succulent plant is found growing along the moist margins of the principal streams, up to 4000 feet, on alluvium principally. It posseses purgative properties.
1. V. gracilis (R. Br.).—On the open sunny slopes near Omeo this blue-flowered species is prevalent; principally on mica schist formation.
2. V. Derwentii (And.).—Abundant on all shaded situations, where moisture aids their growth; ascending to Alpine elevations of 5000 feet.
3. V. perfoliata (R. Br.).—Most abundant on Dividing Range between Mount Sisters and Mount Tambo east of Omeo Plains, particularly on quartz porphyry

formation, where it is found growing from crevices of the rock. Its sessille, opposite, cordate, smooth and entire margined leaves at once distinguish it.

4. V. serpilifolia (L.).—Is to be met with at higher elevations on the western affluence of the Mitta, near Mounts Cope and Wills; 5000 to 6000 feet.

1. E. speciosa (R. Br.).—During spring the fields around Omeo are covered with this pretty puce-flowered species. It ascends to 4000 feet on all soils.
2. E. scabra (R. Br.)—Alike abundant on all soils; between 3000 and 6000 feet. Its yellow flowers distinguish it.
3. E. Brownii (R. Br.).—Is most abundant at the highest elevations near Mount Fainter and Mount Bogong; 5000 to 6500 feet; all soils.

No. 38—ASPERFOLIÆ ( ).

Genera—Mysotes and Cynoglossum.

1. M. sauvcolens (R. Br.).—Along the banks of the Livingstone Creek near Omeo, its scorpoid racemes of yellow flowers render it easily distinguishable. It is most prolific on the detritus of felsitic rocks.

1. C. sauvcolens (R. Br.).—On metamorphic soils along the lower valley of Livingstone Creek. The nuts of this species are muricated and depressed externally.

No. 38—LABIATEÆ (Adam.).

Genera—Mentha, Prostanthera, Azuga.

1. M. Australis (R. Br.), "native mint."—Distributed in moderate patches along the margins of the principal streams; all soils; up to 4000 feet.

1. P. lasianthos (Labill).—Is here confined to the Dividing Range at heads of gullies; on Silurian soils; principally at an elevation of 3800 feet.
2. P. phylicifolia (F. v. M.).—Along the margin of the Cobungra River on gneissose schists; 3500 feet.
3. P. rodundifolia (R. Br.).—On alluvial river flats between 2000 and 3000 feet within the area.

1. A. Australis (R. Br.).—This succulent, herbaceous species, is abundant all over the area on all soils up to 4000 feet. It becomes dwarfed and procumbent at the higher elevations.

No. 39—Epacridaceæ (R. Br.).

Genus—Styphelia (Epacris).

(In arranging the species of this important order, I have adopted Baron von Müeller's generic system, as given in his recently published and valuable work on *Census of the Genera of Plants Hitherto Known as Indigenous to Australia,* 1881.)

1. Styphelia humifusa (Labill).—On metamorphic soils on the undulating ranges east of Omeo; 2200 feet; rather procumbent.
2. S. lanceolatus (R. Br.).—Dividing Range at head of Livingstone Creek on Silurian soils; 4000 feet, and at lower elevations.
3. S. virgatus (R. Br.).—Similar habitats to Lanceolatus; grows, also, on metamorphic soils near Omeo.
4. Styphelia serrulata.—Is equally abundant on the heathy ridges and the lower, more open, and rolling pasture hills; it gives relief to the parched appearance of the latter during the end of summer, giving a variegated verdant aspect to the browned surface. Its principal habitats are the watersheds of the Livingstone Creek and Victoria River, ascending to 4000 feet in all soils.
5. S. scoparia.—This bushy species is met with along the Dividing Range. Most abundant at elevations of 3000 to 4000 feet.
6. S. Frazeri (R. Br.).—On the lower rounded ranges near junction of Livingstone Creek and Mitta Mitta River; on argillaceous mica schists principally.
7. S. montana (R. Br.).—On Dividing Range at head of Livingstone Creek, at contact of granitic and Silurian rock masses.

1. E. impressa (Lab.).—This charming heath-like species with its varying tints of crimson, pink, and white, is here most prolific on sandy soils south of the Dividing Range; within the Mitta Mitta Source Basin it is but sparsely distributed.

E. microphylla (R. Br.).—Is abundant at the heads of the Livingstone Creek, granitic formation, and along the upper courses of Benambra Creek; at elevations of 3000 to 4000 feet; on alluvial flats, Silurian formation.

No. 40—ERICACEÆ.

The order to which the true heaths belong is represented by the genus Gaultheria hispida, a stiff branching Alpine shrub, luxuriant amid the basaltic soils on the higher plateaux, blooming during December and January.

QUANTITY OF WATER CONSUMED IN IRRIGATION.

By W. W. CULCHETH, M. Inst. C.E.

ART. II.—*Quantity of Water Consumed in Irrigation.*

BY W. W. CULCHETH, M. Inst. C. E.

[Read 20th April, 1882.]

I.—INTRODUCTORY REMARKS.

1. IN a country like Australia, where so little in the way of irrigation has been accomplished, the experience of other countries must be depended on. The author at first intended giving the results of his own experience and observations (extending over a period of more than twenty years) on irrigation generally in India, thinking the information would be useful to many at the present time; but the limits prescribed for this paper would not permit of much more than one branch of the subject—the quantity of water required for irrigation—being treated in sufficient detail to be really of any practical use.

2. The quantity of water required for irrigation is a most important point in connection with the probable success of any proposed scheme; nevertheless, opinions of engineers are much divided on the subject. Numerous experiments and measurements of water actually consumed have been made, often giving under various forms widely differing results. In many cases, however, the differences are more apparent than real, being in the conditions of the cases rather than in the results themselves. Shortly before leaving India, the author made several notes from the official report (the latest he has seen) on the irrigation of the North-western Provinces (India) for the year 1875-76. At the time, the author had not arrived at the conclusions about to be noticed, hence there will appear an incompleteness of information on certain points, which cannot at present be remedied. From these and other notes, some useful results may be deduced, which the author will endeavour to give in a convenient form for use in Australia.

3. It is sometimes assumed that because a given supply of water has been made to irrigate so many acres, or, expressed in the usual way, because a "duty" of so many acres per cubic foot per second of canal discharge has been

obtained in one locality, the same duty may be estimated for elsewhere, notwithstanding differences of climate, of soil, in the quantity of water available, in the length of canal the water has to traverse before reaching the fields, in the mode of using the water, in the crops grown, in the number of waterings they require, and in several other respects. The number of acres irrigated per cubic foot per second of discharge may be sufficient information to base calculations on when one country only is concerned, and there are certain points of resemblance in the schemes, though not always even then; but when the information is required for application in another country, and under wholly different conditions, it is too vague to be of much use. The following instances of the actual duty obtained on certain canals in various countries may be taken in illustration of this:—

Countries and Canals.	Acres irrigated per cubic foot per second of supply.		Authorities.
	Extremes.	Average.	
India { Eastern Jumna Canal..	184 to 291	216	Official Report*—Results of ten years, 1866 to 1876.
India { Ganges Canal	154 to 239	190	
Spain—Canals from River Turia	38 to 114	78	Major Scott Moncrieff, R.E.†
Italy { Canals in Lombardy ..	62 to 104	70	Col. Baird Smith, R.E.‡
Italy { ,, Piedmont ..	43 to 106	55	

Even in one canal there are differences; thus in one division of the Ganges Canal a duty of 97 acres only was obtained in 1875-76, while in another the duty was 290 acres; in the cold season only, one division gave 41 acres and another 204 acres (see par. 6).

4. The volume of any stream, which is to be turned wholly into a canal for irrigation, will be consumed as follows:—

(1) By loss at the head itself.

(2) By loss from escapes provided at convenient places to insure the safety of the works.

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* Irrigation Revenue Report of the North-western Provinces (India) for the year 1875-76, page 13, par. 23.

† Irrigation in Southern Europe (1868), page 168.

‡ Italian Irrigation (1855), Vol. I., pages 116 to 298.

(3) By loss from evaporation and percolation—
- (*a*) In the canal itself.
- (*b*) In the distributaries, called in Northern India *rájbahas.*
- (*c*) In the village watercourses, called *gúls.*
- (*d*) In the small field channels, for the supply of one field only at a time.

(*N.B.*—*c* and *d* might be noticed under one head, but a division is convenient for the purpose of this paper.)

(4) Lost by accidental breaches of banks and by carelessness of cultivators.

(5) Utilised in irrigating the fields.

5. The consumption under these several heads may be more fully explained as follows :—Head (1) represents the difference between the volume of water flowing down the stream and that entering the canal. Head (2) explains the difference between the supply entering the canal and that available for irrigation. The consumption under these two heads may be neglected in this paper, since the results adopted are based on the net supply of water available. The loss under (3) is an item of the greatest uncertainty; it is affected by the lengths of the several portions of the works along which the water has to travel, and by the nature of the soil. A village watercourse is here supposed to be one for the supply of a whole village or a large portion of a village, situated at a distance from a distributary; on the average such may be a mile in length, or, perhaps, a little more. The field channels—for the supply of one field only at a time—may be on the average, perhaps, 200 yards in length. Head (4) is an uncertain quantity; the best way of providing for the loss of water by breaching of banks is, perhaps, to consider it as part of the loss (under 3*b*, 3*c*) from the distributaries, &c., breached, and for the rest (waste by cultivators) to increase the allowance per acre irrigated. By this arrangement this item of loss need not be further considered separately. Head (5) represents the useful employment of the water; every effort should evidently be made to increase the proportion of water under this head by reducing that under the other heads. For practical purposes, the quantity of water consumed may be divided into two parts—(1) that usefully employed in the field, and (2) that lost in the canal and watercourses, large and small.

II.—RESULTS OBTAINED IN INDIA.

6. In 1875-76 the Ganges canal had been in operation over twenty years, but irrigation was not considered to be fully developed. The "duty" obtained from the water, or the area irrigated per cubic foot per second, passing down four of the divisions of the canal (there were altogether seven divisions), and the average duty of the whole canal, in 1875-6 (an average year), were* :—

Divisions of the Ganges Canal.	During the monsoon.	During the cold season.	For the whole year.†	
	Acres.	Acres.	Acres.	
Northern ..	60	41	97	Least duty during the cold season.
Anupshahr ..	46	72	117	,, ,, ,, monsoon.
Cawnpore ..	70	149	220	
Etawah ..	83	204	290	Highest duty each harvest.
Average for the whole canal	65	129	192	

There are two harvests in the year, each ordinary crop being on the ground and requiring water from three to five months. Sugar-cane and garden-produce are exceptional, belonging to both harvests. Cold season crops are chiefly wheat, barley, and other grains (except maize, which is a monsoon crop). Grasses and fodder are seldom irrigated to any great extent in India, particularly during the cold season.

7. It is not quite clear from the author's notes whether the duty of each division refers to the water entering the distributaries of the division, or whether it includes the loss in the canal as well. The author believes the former view is correct, as he is not aware that the canal discharge is gauged elsewhere than near the head and at escapes. Moreover, the duty for the year given in the official report, when comparing several years and the results of two canals together, is 187 acres‡; but when comparing the results obtained in the various divisions, and for the two seasons,

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*Irrigation Revenue Report of the North-western Provinces (India) for the year 1875-76, page 9A, table IX.

†The duty for the year is not the sum of the areas for the two harvests, the yearly duty being separately calculated.

‡ Irrigation Revenue Report of the North-western Provinces (India) for the year 1875-76, page 13, par. 23.

separately, the duty is given at 192 acres.* The former would apparently include the loss in the canal, and the latter exclude it; though to avoid error the author has made calculations on each supposition (see App. B).

8. The small duty obtained in the two first divisions in the cold season is explained in the report to be due to the smallness of the area of cold weather crops irrigated, while the high duty in the Etawah division is said to be due to a large area having received only one watering late in the season. So far as the author's notes go, he fails to find any notice taken of the great difference of soil in the various divisions, though it is too important a factor to have been entirely overlooked. The author's notes are, doubtless, incomplete on this point. The low duty year after year in the upper part of the canal, where the soil is light and sandy, and the high duty also year after year in the lower parts of the canal, where much of the soil is heavy and clayey, coupled with other facts to be presently noticed, lead the author to look to the soil as the chief cause of this constant difference. But, in order to allow due weight to the difference in the watering of crops, the author proposes to take (instead of the extreme results shown above) the Anupshahr division as the type of a light soil, and the Cawnpore division as the type of a soil partly sand and partly clay. Fortunately, these are the two divisions with which the author is best acquainted.

9. Taking these two divisions as types of the two soils, and confining further attention to results obtained during the cold season only, since the crops then grown in India more nearly correspond with those grown in the southern portions, at least, of Australia, while the monsoon as a season has no counterpart here, the following figures are obtained :—

——	Area irrigated per cubic foot per second.	Quantity of water used per acre.	Depth of water over area irrigated.	——
	acres.	cubic feet.	feet.	
Light sandy soil ..	72	183,000	4·19	See Appendix D.
Mixed sand and clay soil	149	88,000	2·02	
Average for the whole canal	129	102,000	2·34	See *a* and *q*, Appendix B.

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* Irrigation Revenue Report of the North-western Provinces (India) for the year 1875-76, page 17, par. 38

The figures, as regards the soils, can only be considered as approximations. The average for the whole canal also does not represent the average consumption in fully irrigated fields, since some fields are said to have received only one watering.

10. Results obtained in two other cases may be here briefly noted, leaving till later (see pars. 25 to 27) remarks on their connection with this paper. In 1868-69, a year of great scarcity in the North-western Provinces of India, when the irrigation from the Ganges and Eastern Jumna canals was greater than in any previous year and for several years afterwards, the area irrigated by the Ganges canal, with an average supply of 4668 cubic feet of water per second during the cold season, was 794,794 acres, the duty obtained being 170 acres per cubic foot per second.* In the second case, the author found by measurements of discharge and irrigation from a reservoir in Rajputana during two years, that in five months of the cold season (November to March) an average of 65,000 cubic feet of water was consumed per acre (a depth of nearly 18 inches) in three waterings of about 6 inches each in depth. With a supply of 12 cubic feet per second, gauged at the tank sluices, running for ten hours, an average area of 20 acres was watered daily.

III.—CONSUMPTION OF WATER IN THE FIELDS.

11. The author, a few years ago, carefully measured the quantity of water actually used in irrigating cold weather crops from certain wells. It was found in one case that 29,579 cubic feet per acre (a depth of 8·15 inches) had been used, and in another 36,357 cubic feet per acre (a depth of 10·02 inches).† The soil was a light loam, of considerable depth, corresponding, perhaps, with the average land irrigated from the Ganges canal. But since well irrigation is more economical than that from canals, an increase must be made before applying these results to canal irrigation. The author is of opinion that, including the waste of cultivators, an increase of about one-third on the average of the above

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*Professional Papers on Indian Engineering, Vol. VII. (Roorkee, 1870), page 306.

† Professional Papers on Indian Engineering, Vol. II., new series (Roorkee, 1873), page 150.

two quantities would suffice, making the depth, say, 12 inches, and the quantity of water per acre about 44,000 cubic feet, given in four waterings, averaging 3 inches each in depth. This represents the consumption under heads 3*d*, 5, and a portion of 4 (see pars. 4 and 5), and is in the main supported by some results obtained a few years ago on the Bari Doab canal, in the Punjab.* Colonel Baird Smith, R.E., mentions that the result of several experiments made in Italy, in the irrigation of meadows, gave a depth of 3¼ inches for each watering; other experiments gave as much as 6 inches, but some of the water was available for other land at a lower level.† Major Scott Moncrieff, R.E., records that 2·36 inches (·06 metre) was found by experiment to be an ample depth for watering in Castile.‡ Many other instances could by given, more or less in support of the author's figures, and some showing higher results; but since it is seldom stated at what distances the fields were from the point of measurement, what was the nature of the soil, and other important particulars, it is fair to conclude that the higher results include considerable loss in the channels leading to the fields; this loss the author is endeavouring to arrive at separately.

12. In a light sandy soil more water would be consumed; but the author is decidedly of opinion that most of the increased consumption above shown to occur in certain divisions of the Ganges canal, is in the canal and distributaries, where they pass through light soil, rather than in the fields. If beds be similarly formed in two different soils, the extra consumption in the lighter soil is an increase of the quantity absorbed during the time each bed takes to fill.§ Thus, supposing a depth of 2 inches of water required in the bed, and that 1 inch is absorbed in average soil before this depth is attained, making 3 inches consumed; then the increase in a light sandy soil would be on the 1 inch, which might become, say, 2 inches, making the consumption in the light soil 4 inches. These figures represent, in the opinion of the author, the depths of the waterings respec-

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* Professional Papers on Indian Engineering, Vol. I., new series (Roorkee, 1872), page 368.

† Italian Irrigation (1855), Vol. II., pages 84, 85.

‡ Irrigation in Southern Europe (1868), page 105.

§ There are 400 or 500 beds to an acre in well irrigation, but fewer in canal irrigation. Evaporation may be neglected for the short time (some three to five minutes only) each of these takes to fill.

tively necessary in the two soils mentioned. In a similar way the author estimates the depth absorbed in a mixed sand and clay soil at half an inch, making the depth of each watering 2½ inches.

13. To make, however, every reasonable allowance for wasteful consumption on the Ganges canal, let a further increase be made to the above estimated depths of waterings. The average consumption per acre being 102,000 cubic feet (see *q*, Appendix B), suppose half be taken as having been used in the fields in four waterings; this would make the depth of each watering in average soil 3½ inches, or one-sixth more than above stated to be necessary; the extra half-inch may be considered as avoidable waste. For very light soil, a depth of 5 inches may be taken (one inch of which is avoidable waste), making the consumpton for the season 20 inches, or, say, 72,000 cubic feet per acre. For a mixed sand and clay soil a depth of 3 inches may be allowed for a watering, and 12 inches for the season, or say 44,000 cubic feet per acre. These quantities are at best approximations, but it is necessary to make some estimate of the kind before the results obtained in India can be put in a form applicable to any other country. The allowance for single waterings will, in the opinion of the author, be found generally applicable to other countries, under a system similar to that adopted in India, whereby water is flowing on to any plot of land for a short time only. Unless in very light soil, or in exceptional circumstances, a depth of 3 to 4 inches seems to be sufficient in European countries as well as in India.

14. The year 1875-76 has been taken as an average year; the duty of the water (either 192 acres or 187 acres—see par. 7) at least corresponds sufficiently with the average duty (190 acres—see par. 3) of the ten years 1866-76 to make it appear such. The quantities of water given in the last paragraph, based on the returns of that year, will, the author believes, be found ample to cover the average consumption in the fields. It must not be overlooked by any one wishing to verify the figures by further experiments that, besides the consumption in the fields, it includes only the loss in the small field-channels, or those for the supply of one field only at a time; loss in village water-courses, or such as are intended to supply several fields at one time, is not included. Probably it would seldom be convenient to gauge the discharge so as to include field-channels only. To allow, therefore, of results obtained in different places

being compared, the points suggested further on (see par. 32) should be noted in every case. And, further, when the field-channels are unusually long, it would be better to consider them separately.

IV.—LOSS BY EVAPORATION AND PERCOLATION.

15. The remainder of the consumption (averaging, in the case of the Ganges canal for the year 1875-76, 51,000 cubic feet per acre) represents loss by evaporation and percolation in the various channels from the point where the discharge was gauged to the point where the water was issued for individual fields. The total quantity lost daily over the various channels included on this occasion was 192 million cubic feet (see App. B), which will probably be found a near approximation to the loss each year on this canal. The author particularly wishes to urge that this loss, instead of being referred to as so much per cent. of the supply or so many cubic feet per second per mile, as usual hitherto, should be expressed by the depth spread over the whole wetted area of the bed and slopes of the various watercourses. In this form, results obtained on one canal could be applied, as the author will endeavour to show, to other canals, not only in the same country, but also to canals in other countries. The chief points for consideration are noted further on (see pars. 29 and 33).

16. The author has calculated that the loss daily by percolation from the Ganges canal and its distributaries in the cold season of 1875-76 was from $4\frac{1}{3}$ inches to $7\frac{1}{4}$ inches in depth over the whole wetted surface (see App. B). The lesser depth supposes the loss from the canal itself to be included in the 102,000 cubic feet of water consumed per acre; the greater depth supposes the measurements of discharge to have been made at the distributary heads, thus taking no account of the loss in the canal itself. The latter supposition appears to the author more likely to be correct than the former (see par. 7). Assuming, then, the greater depth as correct, and that the loss in the canal was equal in *depth* to that in the distributaries and minor watercourses, the total loss during the season would suffice to fill a trench having a width equal to that of the wetted perimeter and an average depth of over 90 feet, extending the whole length of canal and dis-

tributaries. Further calculations by the author, to ascertain the loss in various soils (see App. D), show that a depth of 1½ feet would probably be lost daily in very sandy soil; in which case the loss in one part of the canal (the Northern division) during this season would be sufficient to fill a trench nearly 170 feet in width by over 200 feet in depth, for the whole length of the division (about 50 miles). In the first fifteen miles or so, the loss might be double this, or even more (see App. D).

17. The quantity of water lost, when expressed in this form, may appear enormous; but further considerations will perhaps convince those acquainted with the facts to be presently noticed, that it is not more than there is good reason for believing actually takes place. The above quantity, large as it may appear, is, however, small compared with the average volume of water carried by the canal; and special measures to prevent the loss are not worth undertaking. The average loss in the Northern division of the canal was, in fact, only 15·58 cubic feet per second per lineal mile, out of a mean discharge in the season of 4447 cubic feet per second—about one-third (·35) per cent. only. In this form the loss appears insignificant. Where, however, the canal is smaller, and particularly in the distributaries, the proportion lost is much greater. In a small watercourse the loss in a mile may be one-fourth of the discharge at its head (see instance given in next paragraph); here the advantage of puddle in sandy soil is apparent.

18. A Ganges canal officer (Mr. Beresford) some time since gave instances of the loss of water in portions of his (the Anupshahr) division,* which the author, from his recollection of it, would consider not uncommon in that division. Mr. Beresford mentioned a loss of 1·25 cubic feet per second in the first mile of a distributary, having a discharge at the head of 50 cubic feet per second; allowing a wetted perimeter of 16 feet, the depth percolating in 24 hours would be 1·28 feet. In the case of a small watercourse having a head discharge of one cubic foot per second, the loss was ·03 cubic foot in a furlong (·24 cubic foot in a mile); with a wetted perimeter of 4 feet, the depth lost would be ·98 foot per diem; with 3 feet wetted perimeter, the loss would be 1·31 feet in depth. Mr. Login, who was some years ago in

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*Professional Papers on Indian Engineering, Vol. V., new series (Roorkee, 1876), page 416.

charge of the Northern division of the canal, has recorded the results of some measurements of the volume of water passing down it in December, 1860, from which the author has calculated that the average daily loss in the first 15 miles was 2·66 feet in depth, and in 31 miles a little further down it was probably $1\frac{1}{2}$ feet (see App. C).

19. The following are some results calculated by the author from data given by Colonel Baïrd Smith, R.E., for three canals in Italy :—*

	Total discharge per second.	Loss in whole length per second.	Length of canal.	Mean wetted perimeter, estimated by the author.	Average loss.	
					Per mile of canal per second.	Depth over wetted surface in 24 hours.
	c. ft.	c. ft.	miles.	feet.	c. ft.	feet.
Naviglio Grande ..	1851	158	31	100	5	·835
Canal Muzza ..	2652	477	35	150	$13\frac{1}{2}$	1·487
,, Martesana..	843	105	28	60	$3\frac{3}{4}$	1·023

These results are merely approximations, as the data are incomplete; but even allowing a considerable margin for errors, the results support the views of the author regarding the excessive loss in certain soils. Some experiments made by the author some years ago, to ascertain what proportion of rainfall might be expected to flow off the ground, showed that about a quarter-inch per hour (6 inches a day) was absorbed. The soil was a light sandy one, in which, by the way, a very fair garden was formed, and the subsoil to a depth of 3 or 4 feet was very similar in appearance to the surface soil. More water would doubtless have been absorbed had a constant head been maintained; all that was done in the experiment was to prevent the ground drying up.

20. In the disposal of sewage there is a system called "intermittent downward filtration," in which sewage is poured in large quantities on land, with a view to its being purified in its passage through the soil. The land must be thoroughly underdrained. At Kendal, England, on one occasion, sewage was flowing on to the land "at the rate of 2,000,000 gallons per diem, equivalent to a depth of 19 inches. . . . The average quantity of sewage flowing out of the land was at least 1,000,000 gallons per diem, equivalent

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*Italian Irrigation, Second Edition, Vol. I., pages 219-225, 250-254, and 270-276.

to a depth of 9½ inches over the filtration area. So that, after allowing for the 35 days in each year when the sewage was applied to other land, the enormous depth of 261 feet per annum was purified by the filtration areas, and had been so purified for the last three years."* Such an instance is perhaps exceptional for sewage filtration, but it shows what certain soil can do when the subsoil is thoroughly drained. In the filtration of water for the supply of towns, a very large quantity of water is passed through layers of sand and other material. In London, a depth of from 4½ feet to 18 feet is filtered in 24 hours. The filters are usually formed of 2 feet or 3 feet of sand over 3 feet to 5 feet of gravel and other porous material. This shows what sand, over a porous substratum, can carry off.

21. The canal officer before mentioned, Mr. Beresford, stated that he had seen water just reach an outlet or a field, and no more, and "there are places where a fairly large *kulába*" (outlet) "in a whole week only irrigates two or three fields."† The author recollects that some years ago, when one distributary in the Anupshahr (then called the Fatehgarh branch) division of the Ganges canal was first opened, and for months afterwards, a discharge of something like 80 cubic feet per second in the upper part, was with difficulty able to supply a fourth of this quantity 20 or 25 miles further down; all outlets between had to be closed in order to obtain enough water in the lower part of the distributary to irrigate from it. The author has known several small tanks, where the subsoil was non-retentive, to fill after a heavy fall of rain, and in a couple of days or so, a depth of 6 or 7 feet to soak away. The great facility for the percolation of water offered by very sandy soil, with a porous substratum, is shown by certain rivers in many parts of the world, which are lost in sandy plains—in some cases during the drier portions of the year only, in other cases all the year round. Instances are to be found in parts of Australia.

22. In nearly all these cases a portion of the loss was unquestionably due to evaporation. In canals, evaporation would take place not only from the surface of the water, but also from the moist part of the banks, where water is absorbed and rises above the water-line in the canal. This addition to

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*Proceedings of the Institution of Civil Engineers, Vol. XLVIII., page 207.

†Professional Papers on Indian Engineering, Vol. V., new series (Roorkee, 1876), page 416.

the loss may be unimportant in a large canal, but it may add very materially to the loss from a small watercourse, where it would in similar soil be as much as in the canal, and, consequently, bear a larger proportion to the water surface. Till more is known on the point, it will be convenient to take the wetted perimeter for both evaporation and percolation. The author is of opinion that a quarter-inch per diem may be taken as the average loss from a canal and its distributaries. This might be too much to allow from a large area of deep water, except, perhaps, on very hot, dry, and windy days but it is not too much to allow in hot and dry weather, when irrigation is most needed, as an average for streams, some a few feet deep, and others a few inches only. In a moist and cool climate, and in damp weather also, evaporation would generally be much less than a quarter-inch a day, but under such conditions, irrigation would scarcely be a necessity, unless for what would in India be monsoon crops, which are not considered in this paper, with the exception of rice. In Appendix A, less loss by evaporation has been allowed for rice cultivation, owing to the conditions attending it. Whether evaporation be estimated at a quarter-inch or a little more, since the loss from percolation has been shown to be very great, that by evaporation from water flowing in channels may generally be neglected, except in very clayey soils, where percolation is comparatively little.

23. The depth of water in the canal has not been taken into consideration in the foregoing remarks, because the author's observations on the loss of water from tanks has led him to the conclusion that where the variations of water level are regular, the loss is practically independent of the depth of water in the tank. Doubtless the comparatively great thickness of soil through which the water usually has to pass, is one reason why the effect of a varying depth of water in a tank on percolation is not perceptible. The author sees no reasons for supposing that percolation from any channel, in which water is constantly flowing, would be materially different from percolation from a tank. The author's contention is, that in any given case (tank or canal) the loss in depth would, under ordinary conditions, be practically the same, whatever the depth of water. If the depth of water is one factor, the thickness of soil through which percolation takes place is another factor.

24. The fact of water being often stored in open and unlined reservoirs, formed on the surface of the ground or in

slight excavation, might at first sight be taken as opposed to the foregoing deductions regarding the extent of percolation; but the conditions under which tanks can be successfully formed are essentially different from those pertaining to an ordinary canal. It will suffice here to remark that generally those conditions which are favourable to the construction of a tank restrict the escape of subsoil water, while those favourable to a canal facilitate its escape; and on the free escape or otherwise of the subsoil water, it depends whether percolation is much or little.

V.—APPLICATION OF RESULTS TO OTHER COUNTRIES THAN INDIA.

25. Before showing how to apply the foregoing deductions to canals in other countries than India, it will be well to examine the two cases briefly noticed above (see par. 10) and their bearing on the conclusions drawn by the author. In the first instance, with a larger supply in the Ganges canal in the cold season of 1868-69 by 5 per cent. than that in the cold season of 1875-76, the area irrigated was 39 per cent. larger. It is clear that either there was less waste or the crops received less water in 1868-69—probably both. That the crops received less than the usual quantity of water in 1868-69 is evident from the remark by the Superintending Engineer (Colonel Brownlow, R.E.)—"I have no hesitation in saying that, but for the timely and providential fall of rain in the end of January, there would have been failure of crops, and consequent bitter distress over considerable areas."* There was an unusually large supply of water (6000 cubic feet per second in October, 1868) at the commencement of the season, allowing a larger area than in any previous year being watered; but when, in January, 1870, the supply fell to 4200 cubic feet per second, the canal could not have supplied the wants of the irrigators had not rain fallen. It is thus clear that the crops received less than their normal supply of water—probably an average of three waterings was given instead of four, the usual number.

26. Taking the number of days in the season for convenience of comparison, the same as in 1875-76 (there may

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* Professional Papers on Indian Engineering, Vol. VII. (Roorkee, 1870), page 303.

have been more, but this will not be found materially to affect the result), and using the same symbols as in Appendix B, the following results are obtained :—

$$\left.\begin{array}{l} D = 4668 \text{ c. ft. per second} \\ A = 794{,}794 \text{ acres} \end{array}\right\} a = \frac{794{,}794}{4668} = 170 \text{ acres}$$

$Q = 4668 \times 86{,}400 = 403$ million c. ft.

$q = 152\ Q \div A = 77{,}132$ c. ft. per acre.

The area of wetted surface (M) over which the loss took place may have been less in 1868-69 than in 1875-76, since there was a less length (by nearly 300 miles) of distributaries in the former year; but probably the larger area irrigated necessitated more village watercourses being in operation, while many of these, doubtless, having been quickly and carelessly formed on an emergency, and used for the first time, the loss in them would be greater than in ordinary years. On the whole, then, perhaps it will be safe to estimate the loss (Q_a) as in both years the same, that is, 192 million cubic feet daily. Then $q_a = 152\ Q_a \div A = 36{,}740$ cubic feet per acre, leaving $q_c = 40{,}392$ cubic feet per acre, which would represent a depth of about 11 inches. Allowing 3½ inches per watering (see par. 13), it would appear that a little over three waterings, on the average, were given, which is probably correct. Taking a greater number of days (than 152) for the season would increase the values of q and q_c; but, if irrigation went on for a longer period, it would be only fair to assume that more waterings would be given to some of the fields; this would increase the average number of waterings as well as the consumption of water per acre without altering the "duty." It is evident from Colonel Brownlow's remarks that fewer waterings were given at the ordinary time; the above calculation gives corresponding results, and so far supports the author's previous deductions.

27. In the second instance the result—65,000 cubic feet per acre (q)—may be distributed in the following manner: —$D = 12$ cubic feet per second $= 432{,}000$ cubic feet in 10 hours, the consumption daily. Mean distance of the fields from the tank was two miles; though as much as two miles of distributary and ten village watercourses, each say half a mile long, would be running at one time to irrigate 20 acres daily, on the average. Then the area over which loss has to be distributed was :—

		π	Sq. feet.	Total.
Distributary ...	2 × 5280 ×	7 =	73,920	153,120 sq. ft.
Village channels	10 × 2640 ×	3 =	79,200	

Then, taking for one trial a depth of 4 inches for a watering, and in another $4\frac{1}{2}$ inches (supposing half the land to be excessively sandy, as much of it was), the depth lost in channels would be 11 inches in the first case and $8\frac{1}{4}$ inches in the second, thus :—

—	First Supposition.		Second Supposition.	
	Depth.	Quantity.	Depth.	Quantity.
	inches.	cubic feet.	inches.	cubic feet.
Utilised in 20 acres	4	290,400	$4\frac{1}{2}$	326,700
Lost over 153,000 sq. ft. ..	11	141,600	$8\frac{1}{4}$	105,300
Total consumption	—	432,000	—	432,000

28. For the application of the foregoing results to Australia or to other countries than India, certain local information is necessary. First, in order to estimate the quantity of water required for actual irrigation (excluding loss by percolation) it is necessary to ascertain, besides the nature of the soil, what crops are to be irrigated, the number of waterings to be given to each, the intervals between the waterings and at what season water will be required. The author would then allow for each watering a depth of from 3 to 5 inches, according to the soil, as shown in Appendix A. If excess of water is to be used to save labour without any compensation in other ways, a larger supply would have to be allowed, according to the extra time the water would be flowing on any plot of ground (see column 7 of Appendix A). The result arrived at by multiplying the quantity consumed per acre each time by the number of waterings and by the area, will give the total quantity of water required for irrigation, including only loss in the field-channels up to a length, say, of 150 yards. More water might be used for the first watering of a crop (called in N. India *paleo*), but less would generally suffice afterwards, unless the ground were continually stirred up, or the upper crust repeatedly broken by hoeing. For the first few years the consumption of water might, and probably would, be in excess of this estimate, but good management should bring it down.

29. To estimate the loss by percolation from a canal and distributaries, the nature of the soil passed through

by the various channels, the approximate depth of soil and the nature of the subsoil, must be ascertained. Then, take the mean wetted perimeter of the canal and each distributary and multiply it by the respective length of each and by the number of days water would be flowing during the irrigating season. Allow a loss according to the scale given in Appendix A (cols. 2 and 3) over the whole wetted surface of bed and slopes of all channels.* If the soil or subsoil in which the canal is carried is an open or loose gravel or is much fissured and of considerable depth, a much larger loss than given by the scale may be expected; such places should be avoided if possible. In a narrow valley, or where an impervious substratum lies a little below the canal bed, or at a greater depth but rising on both sides so as to confine the subterranean current, or where the subsoil is less pervious than the surface soil, the loss would probably be less. Where, however, canals of any size are likely to be made, the country would be more or less open and the underground current practically unrestricted. After a few years the loss might be expected to decrease, owing to the pores of the subsoil becoming clogged.

VI.—CONCLUDING REMARKS.

30. The author has for several years watched carefully the working of various irrigation projects, and made inquiry into the causes of failure in certain cases. As a contribution to a subject on which but little is accurately known, loose generalisations being usually accepted, he thinks it right to make public the results of his observations, imperfect as they are; others can then make use of them or not as they please. Much difference of opinion may be expressed regarding the real value of the data accepted by the author, and the conclusions he has arrived at—(he will be glad to see these fully criticised), but he would urge on those having better knowledge of the subject, that the results of their observations should at the same time be given in a form suitable for the object of this paper—to serve as a guide for engineers in other countries than their own, epsecially in countries like Australia, where irrigation is in its infancy. Appendix A

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* Where experiments on the absorbing power of the soil can be made in the manner described a little further on (see par. 33), it would perhaps be more satisfactory to base calculations of loss on the results so obtained.

should be considered as merely tentative—to be replaced by a better scale when fuller information is available.

31. However vague and imperfect the results given in this paper may be considered, it should not be forgotten that the same points have been hitherto not less vaguely dealt with (see par. 3), and that, moreover, irrigation is not singular in this respect. In many engineering calculations there is often very great latitude allowed in the shape of co-efficients, the value of which depends on the judgment of the one using them ; as, for instance, in calculating discharges of an irregular channel, of a channel when partially obstructed and, generally, whenever the conditions are complicated, as in practice they often are. Many other points, especially in hydraulic engineering, might be mentioned, such as the proportion of rainfall flowing off the surface of the ground for the supply of a reservoir, the volume of sewage it is necessary to provide for in any case, and others which will readily occur to an engineer.

32. Further investigation being very desirable, or rather essentially necessary, a few remarks on the point may be useful. When measuring the quantity of water used in irrigation, in order that results obtained in different localities may be compared, the author would suggest that the following particulars be noted :—Volume of water supplied, length of channel from the point of gauging the discharge to the field, mean wetted perimeter of channel, whether the channel is old or newly formed, and whether puddled in any way or not, average size of the beds in the fields, or the approximate number per acre, how long one bed takes to fill, how many previous waterings have been given to the same crop, at what intervals and how long since the last, whether or not the watercourse has been used just before for another field or otherwise, if the field has been hoed or the surface of the ground disturbed since the last watering, height of the crop or the extent to which it shelters the ground, nature of the soil, state of the weather at and just before the time of watering, date of measurement, and such other information as the observer may deem likely to affect the result. For want of full particulars, results hitherto obtained in different places are often not comparable. If, moreover, the observer would endeavour to apportion the total consumption between the fields and the watercourses in each case, somewhat after the example given above (see par. 27), it is probable that correct information would be obtained

quickly, since errors would be detected at once, and unusual results would lead to further inquiry.

33. The author's experiments on absorption before alluded to (see par. 19) were conducted as follows:—Several beds, formed by little ridges of clay, and measuring inside 4·8 feet square, were kept supplied with water; five gallons were poured on at a time, each gallon over the area enclosed giving a depth of one-twelfth inch. The object was to ascertain how long it would take for the soil to absorb given quantities of water. A somewhat similar arrangement might be adopted to ascertain the absorbing powers of any soil; but a measurable depth of water should be maintained, say not less than one inch; in the author's experiments this was not done. It would be well to note the quantities poured on in given periods, in order that it might be seen when, the absorption having assumed its normal rate, the experiment might be discontinued. At first, absorption would be very rapid, but it would soon decrease. Evaporation during the day, especially in hot weather, would be found to affect the result. In these experiments the following points should be noted:—Nature of soil, nature and depth of subsoil, and the general formation of the substratum in the neighbourhood, with any other points affecting the escape or retention of subsoil water; a natural drainage channel or other depression in the ground close by would be likely to assist very materially the escape of subsoil water. The results of these observations would, as a rule, apply only to the case of a canal, and not to a site likely to be selected as suitable for a tank (see pars. 24 and 29).

33. In conclusion, the author will offer a few remarks on the importance of the results brought to notice in this paper with reference to contemplated irrigation works in Australia. A canal may of course be constructed, and water supplied for irrigation, notwithstanding very erroneous notions as to the quantity of water required for various crops, the area likely to be irrigated, and on other similar points; but as all such works partake more or less of a commercial nature—a fair return for the outlay being in some form or other expected—it is important that a trustworthy estimate should be formed, or disappointment is likely to result. It is very unpleasant to find, after constructing a long canal, that water will not reach the end of it, that the supply is sufficient for only one-half or one-third of the area it was hoped to irrigate, and that in consequence of

various mistakes, instead of a profit of 5 or 10 per cent, only ½ per cent. is realised, or, perhaps, the working expenses not even covered. These things have happened in India and elsewhere. It is not much consolation to be told that in 20 years' time the estimate may be fulfilled; and yet it is on results given by old canals, without proper correction, that estimates for new ones are often based, forgetting that usually it takes several years for irrigation to become fully developed.

APPENDIX A—*Empirical Scale for estimating the depths and quantities of water lost by percolation, and consumed in the irrigation of fields, in certain specified soils, where better information is not available.**

Class and nature of soil.	Loss by absorption or percolation daily.†		Loss by evaporation (see par. 22).	Consumption of water in the irrigation of fields.‡					Remarks.
				When flowing for a few minutes only into each separate division of field (see pars. 12 and 13).		Extra quantity per acre, when flowing for a considerable time, including evaporation.			
							For a continuous flow.		
	Depth (see par. 16).	Quantity per mile for each foot in width of wetted perimeter.		Depth of watering.	Quantity per acre each time.	For each hour *after* ground is saturated.	First 24 hours.	Each succeeding 24 hours.	
	Inches.	Cubic feet.		Inches.	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.	
1—Pure sand. Nothing grows on it, except where a little soil may have collected on the surface or just below it	36	15,840 or, say, 16,000	This may ordinarily be estimated at about ¼-inch, or, say, 100 c. ft. per mile for each foot in width, daily. The wetted perimeter of channels, as for percolation, should be taken. In rice irrigation the loss would probably be less than ¼-inch daily.	—	—	—	—	—	No cultivation possible unless other materials be mixed with it, when the soil would become that classed as 2.
2—Excessively sandy soil. Very poor; in its natural state, a long coarse grass or some sort of scrub may be found on it; when manured and cultivated, light crops may be produced. This is known as *bhoor* land in N. India	18	8,000		5	18,150	2,760	84,398	66,248	On these soils a continuous flow of water should be avoided, if possible, owing to great percolation.
3—Light-sandy soil. No mixture of clay perceptible; when cultivated, fair crops may be grown	9	4,000		4	14,520	1,399	48,098	33,578	
4—Soils containing a mixture of sand and clay—									
a—Sand largely predominating, forming, with manure, a light loam, and producing very good crops	4½	2,000		3	10,890	719	28,132	17,242	
b—Sand and clay in about equal parts, forming, with manure, a rich loam—perhaps the best for general farming	2¼	1,000		3	10,890	378	19,965	9,075	These soils, with the next (5), crack when dry, allowing water to run to waste; hence extra allowance made for irrigation.
c—Clay largely predominating, forming under cultivation a heavy loam	1⅛	500		4	14,520	208	19,511	4,991	
5—Almost pure clay. Found in low, marshy localities, and unsuited, as a rule, for any culture but that of rice§	½	220		5	18,150	100	20,550	2,400	Loss by evaporation assumed to be less than for other crops (see par. 22).

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[*] See par. 30 and App. D. [†] See pars. 29 and 33. [‡] See pars. 28 and 32.

[§] After this ground has been flooded for rice, a depth of ·66 inch daily flowing on to it has been allowed to keep up the supply, giving a "duty" of 36 acres per cubic foot per second; Col. Baird Smith estimated that a depth of ·62 to ·68 inch was consumed. See *Italian Irrigation*, Vol. II., pages 101 and 106.

APPENDIX B.

CALCULATION OF THE AVERAGE LOSS OF WATER BY PERCOLATION FROM THE GANGES CANAL DURING THE COLD SEASON OF 1875-76.

Let D = mean discharge flowing during the season (152 days) = 4447 c. ft. per second. This may have been gauged in the main canal, thus including loss in the canal itself (case A), or more probably (case B), the gauging may have taken place at the distributary heads, thus excluding loss in the canal (see par. 7).

A = area irrigated during the season = 571,907 acres.

a = ,, ,, per c. ft. per sec. of discharge = $A \div D$ = 128·6 acres.

Q = average quantity of water consumed daily on the whole canal = $4447 \times 86{,}400$ = 384 million c. ft.

q = quantity consumed per acre = $152\,Q \div A$ = 102,000 c. ft.

q_c = quantity used in the fields per acre (51,000 c. ft.—see par 13) = $q \div 2$.

q_a = quantity per acre lost before reaching the fields (51,000 c. ft. —see par. 15) = $q \div 2$.

Q_a = quantity lost daily on the canal, bearing the same proportion to Q that q_a does to q $\therefore Q_a = Q \div 2$ = 192 million c. ft.

Q_c = quantity used daily in the fields = $Q - Q_a$ = 192 million c. ft.

l = average length in miles of channels (large and small) traversed by the water from the point where it is gauged to the fields, after allowing for closures (*tátils*) during the season.

π = wetted perimeter of various channels in feet.

M = miles of wetted surface of channels one foot in width = $l \times \pi$.

w = wetted surface in sq. feet = $5280\,M$.

d = depth in feet lost by percolation daily.

Then—

——	Total lengths in operation.	l	π	$M = l \times \pi$. Case A.	$M = l \times \pi$. Case B.
	miles.	miles.	feet.		
Canal	579	400	100	40,000	..
Distributaries ..	3386	2500	12	30,000	30,000
Village watercourses .	(See	below.)		30,000	30,000
Totals				100,000	60,000

The length of village watercourses has been assumed at 3 or 4 miles per mile of distributary, and π = 3 or 4 feet; then, area is about the same as that of distributaries. Field-channels (see 3*d*, par. 4) are not included.

From the foregoing the following average depths are obtained:—

——	Q_a	M.	Loss per M per diem = $Q_a \div$ M.	Depth lost per diem (d) = $Q_a \div 5280$ M.
	mill. c. ft.		c ft.	feet. inches.
Case A	192	100,000	1921	·3638 = 4·366
Case B	192	60,000	3202	·6064 = 7·277

These are the average depths over the whole wetted surface in cases A and B respectively, lost by percolation (see par. 16).

APPENDIX C.

Calculation of the Loss of Water by Percolation in the first part of the Ganges Canal.

(*For Symbols, see Appendix B.*)

The volume of water (D) passing down the canal in December, 1860 (see "Pro. Inst. Civil Engineers," vol. 27, p. 509), was found to be —— at the head, Hardwar, 6710 c. ft. per second, and at Roorkee, 6283 c. ft. per second, giving a loss of 427 c. ft. per second in this length of about 18 miles. The loss really took place in 15 miles, or probably less, where beds of sand and boulders are crossed. The depth of water in the canal was from 8¼ ft. to 9 ft., making $\pi = 175$ ft. Then $w = 15 \times 5280 \times 175 = 13{\cdot}86$ mill. sq. ft., and $Q_a = 427 \times 86{,}400 = 37$ mill. c. ft. $\therefore d = Q_a \div w = 37 \div 13{\cdot}86 = 2{\cdot}66$ ft. At the Ratmu river it must have been much more—probably over 3 feet.

At the same time, 31 miles below Roorkee, D = 5279 c. ft. per second, showing a further loss of 1004 c. ft. per second. A portion of this was used for irrigation, though probably not more than 400, or, say, 500 c. ft. per second. The larger quantity would leave 500 c. ft. per second as the loss by percolation in the 31 miles, giving an average depth (d) of a little over 1½ ft. daily; though, owing to the consumption for irrigation being uncertain, this result is open to question. Between the 30th and 40th miles, where a sandy tract of country is crossed, the depth would be in excess of the average, and doubtless fully 1½ ft.

APPENDIX D.

Calculation of the Probable Depths of Water Lost by Percolation in Various Soils.

Taking the figures given in App. B, the average depth lost over the whole wetted surface of canal, distributaries and watercourses (case A) was ·3638 ft.—or, more probably, the canal not being included (case B), ·6064 ft.—over wetted surface of distributaries and watercourses only.

In light sandy soil the duty obtained from the water (see par. 9) was 72 acres, making the consumption per acre $= aq \div 72 = 183{,}000$ c. ft. Since the quantity used in the fields in sandy soil has been taken at 72,000 c. ft. per acre (see par. 13), that lost by percolation would be $183{,}000 - 72{,}000 = 111{,}000$ c. ft. per acre. It may be assumed that the depth percolating through a light sandy soil would bear the same ratio to the average depth lost in the canal as the loss per acre in the light soil (111,000 c. ft.) bears to the average loss per acre (51,000 c. ft.—see q_a, App. B). Then—

$$\text{As } \overset{\text{c. ft.}}{51{,}000} \;:\; \overset{\text{c. ft.}}{111{,}000} \;::\; \left\{ \begin{array}{l} \cdot3638 \text{ ft.} \;:\; \cdot792 \text{ ft.—case A.} \\ \cdot6064 \text{ ft.} \;:\; 1\cdot320 \text{ ft.—case B.} \end{array} \right.$$

Now, since the loss per acre in light soil is based on the results obtained in the Anupshahr division of the Ganges canal, in which sandy soil largely predominates, though there is also some clayey soil, it is fair to assume that, had the soil been entirely sandy, the loss would have been greater. Assuming case B as the correct one (see par. 7), it will probably not be thought too much, after reading the instances of loss mentioned in the paper (pars. 18 to 21) and in Appendix C, to take the loss, in what in App. A (class 2) is termed an excessively sandy soil, at $1\frac{1}{2}$ feet per diem. This result may be considered as of general application in India or elsewhere.

The loss in clayey soil is not so easily estimated. The Cawnpore division of the Ganges canal, as a type of a mixed sand and clay soil, shows a duty of 149 acres per c. ft. per second (see par. 9), making the consumption per acre $= aq \div 149 = 88{,}000$ c. ft. Calculating as above (in the case of a sandy soil), the depth would be ·523 ft. in case B; but, as far as present information goes, this is too vague to be of much use. The loss in pure clay is practically nil; but a slight admixture of clay reduces materially the percolation through a sandy soil. On the whole, perhaps, the empirical scale given in App. A is as near an approach to a correct estimate as is possible at present (see par. 30). It will at any rate be better than taking one depth for any mixture of sand and clay, irrespective of the proportions. If further inquiries are carried on as recommended in the paper (par. 33), more definite results may be obtained in time.

ART. III.—*Australian Mosses, enumerated by*

WILLIAM MITTEN, ESQ.

[Contributed 20th April, 1882.]

LESS than two years ago the great bryologist, Dr. Edward Hampe, then at the venerable age of eighty-five years, responded most kindly to a wish of mine, to place together systematically the names of all mosses of continental Australia, which had become known to him either from large material out of my own collections for nearly thirty years, or from any other bryologic sources accessible to him. Death soon subsequently closed the researches of this Nestor in botanic science, and the list above referred to was therefore his last contribution to that branch of knowledge, which he had leadingly advanced since more than half a century. Dr. Hampe's record having been published in the eleventh volume of the *Fragmenta Phytographicæ Australiæ*, along with enumerations of different Australian evascular Acotyledoneæ by other masterly specialists, I was eager to supplement the bryologic index also with those Tasmanian species, which are not known to occur in continental Australia, and also with any other mosses, which would be additional to those of Dr. Hampe's record. A request made for this purpose to the foremost of bryologists in Britain, William Mitten, Esq., who already twenty years ago had aided much in the elaboration of the mosses for Sir Joseph Hooker's *Flora Tasmaniæ*, met with a most ready response. Accordingly, he has now enumerated all the Australian species known to him, either from literary works or from collections accessible in Britain. Meanwhile, to close the eleventh volume of the *Fragmenta* in 1881, a supplement to Hampe's list, compiled by myself, had passed through the press; and it devolves therefore on me to see otherwise early publication given to Mr. Mitten's fuller writings, particularly as the manuscripts were placed by him unreservedly at my disposal. I beg therefore, to submit these pages to the Royal Society of Victoria, the mosses of our own colony being dealt with in these writings also, and some additional notes of localities given by myself. I may still add, that Mr. Mitten has evolved a special and very excellent system of bryology from his most extensive study of mosses, obtained from all parts of the globe, which systematic arrangement of his own he has applied already to a most ample descriptive elaboration of the moss-flora of South America.

FERD. VON MUELLER.

I. DICRANEÆ.

Bruchia, Schwaegrichen.—(Sporledera, Hampe).

B. exigua, Hook. & Wils. in Hook. icon. pl. rar. 737 A. (Phascum); C. Muell. in Bot. Zeit., 1847 (Bruchia); Krauseana, Hampe, C. Muell., Syn. I. 16.
Swan River, Drummond; St. Vincent Gulf, Dr. Behr.

B. minuta, Mitt. in J. Hook., Fl. Tasm. II., 165, t. 171.
Tasmania, Archer.

Pleuridium, Bridel.

P. gracilentum, Mitt. in J. Hook. Fl. Tasm. II., 164.
King George's Sound, Menzies; Tasmania, Archer.

P. curvulum, Tayl.; P. nervosum, Mitt. in Kew Journ. Bot. VIII., 257 (Phascum); pulchellum, Hook. and Wils. (Eccremidium).
Swan River, Drummond; Gippsland, F. v. Mueller.

P. tenuissimum, Tayl. in Lond. Journ. of Bot., 1846 (Bryum); arcuatum, Hook. and Wils. in Hook. icon. pl. rar. 738 A. (Eccremidium).
Swan River, Drummond.

P. tenellum, Mitt. in J. Hook. Fl. Tasm. II., 164.
Tasmania, Archer.

Ditrichium, Timm.—(Leptotrichum, Hampe).

D. Muelleri, Hampe in Linnæa, 1855, 206.
Grampians, F. v. M.

D. scabrifolium, Mitt.
Tasmania, Archer.

D. Oldfieldi, Mitt. in J. Hook. Fl. Tasm. II., 177 (Leptotrichum).
Tasmania, Oldfield.

D. laxifolium, J. Hook. & Wils. in Fl. Tasm. II., 177; D. flexifolium, Mitt. in Kew Journ. Bot. VIII., 257.
Victoria, F. v. M.; Tasmania, J. Hooker, Oldfield.

D. australe, Mitt. in J. Hook. Fl. Tasm. II., 177.
Tasmania, Archer.

D. affine, C. Muell.
Victoria, F. v. M.

D. cylindrocarpum, C. Muell. in Bot. Zeit., 1851, 351.
Tasmania, Mossman.

D. elongatum, J. Hook. & Wils. in Fl. Tasm. II., 176.
Tasmania, Fraser, J. Hooker, Archer.

Dicranella, C. Mueller.

D. rufo-aurea, Hampe in Linnæa, 1859, 60 (Angstrœmia).
Australian Alps, F. v. M.

D. Dietrichiæ, C. Muell. in Linnæa XXXV., 617.
Queensland, A. Dietrich.

D. trichodontoidea, C. Muell. in Revue Bryol., 1876, 3.
Near Sydney, Kayser.

D. tricruris, C. Muell. (Angstrœmia, Diobelon) in Linnæa XXXV., 616.

Anisothecium, Mitten.

A. ferrugineum, Mitt. in J. Hook. Fl. Tasm. II., 171 (Leptotrichum); brachycarpum, Hampe in Linnæa, 1872.
Blue Mountains, Rev. Dr. Woolls; Tasmania, Archer.

Trematodon, Cl. Richard.

T. longescens, C. Mueller in Rev. Bryol., 1876, 3.
Near Sydney, Kayser.

T. flexipes, Mitt. in J. Hook. Fl. Tasm. II., 173, t. 172.
Tasmania, Archer.

Rhabdoweisia, Bruch & Schimper.

R. cyathocarpa, Mont. (Zygodon).
Tasmania, Archer, Oldfield.

Leptodontium, Hampe.

L. papillatum, J. Hook. & Wils. in Fl. N. Zeal., t. 85; Leskea rubicaulis, Tayl.; Zygodon Preissianus, Hampe in Linnæa, 1860, 633.
West. Austr., Preiss; Victoria, Adamson; Tasmania, J. Hooker, Archer, Oldfield.

Blindia, Bruch & Schimper.

B. robusta, Hampe in Linnæa, 1860, 627; F. v. M., Austr. Mosses, pl. VII.
Australian Alps, F. v. M.

B. arcuata, Mitten.
Tasmania, Archer.

Holomitrium, Bridel.

H. Dietrichiæ, C. Muell. in Linnæa, 1871, 147.
Brisbane River, Dietrich; Severn River, Hartmann.

H. Muelleri, Hampe & C. Muell. in Linnæa, 1870, 513.
Victoria, F. v. M.

H. perichætiale, Brid. Bryol. univ. I, 227.
Sealers' Cove, F. v. M.; Tasmania, Gunn.

H. Novæ Valesiæ, C. Muell. in Rev. Bryol., 1876, 3.
Near Sydney, Kayser.

Mesotus, Mitten.

M. acutus, Mitten, M. alato similis, sed foliis densius areolatis margine magis serrulatis distinguendus.
Australia, inter Sphærophoron, from Borrer's Collect.

Dicranum, Hedwig.

1. * Isocarpus.

D. microcarpum, J. Hook. & Wils. in Fl. Tasm. II., 166; D. cirrhatum (Holomitrium), Mitt. in Kew Journ. of Bot. VIII., 257.
Tasmania, Archer.

2. ** Hemicampylus.

D. Menziesii, Taylor; D. brachypelma, C. Mueller.
Tarwin, Grampians, F. v. M.

D. chlorocladum, C. Muell. in Rev. Bryol., 1876, 3.
Near Sydney, Kayser.

D. subviride, C. Muell. in Linnæa, 1872, 515.
Near Sydney, Sieber.

D. dicarpum, Hornschuch; D. leucolomoides, C. Mueller in Bot. Zeit., 1851, 54.
Near Sydney, Sieber; Maitland, Vicary; Gippsland, F. v. M.; Brisbane-River, Bailey; Tasmania, Archer.

D. polychaetum, Hampe in Linnæa, 1859 p. 60.
Yarra and Grampians, F. v. M.

D. suberectum, Hampe in Linnæa, 1860, 629.
Tarwin, F. v. M.
D. Walteri, Hampe.
Victoria, C. Walter.
D. angustinervis, Mitten.
Victoria, F. v. M.; Tasmania, Archer.
D. diaphanoneuron, Hampe & C. Muell. in Linnæa, 1870, 515.
Stirling's Range, F. v. M.
D. Billardieri, Schwaegrichen suppl. II, 70, t. 121.
Victoria, F. v. M.; Tasmania, Gunn.
D. pungens, J. Hook. & Wils. in Flora Antarct., 17, t. 59; subpungens, Hampe in Linnæa, 1860, 629.
Grampians, F. v. M.; Tasmania, Archer.
D. punctulatum, Hampe in Linnæa, 1860, 628.
Australian Alps, F. v. M.

3. *** Eudicranum.

D. austrinum, Mitten; D. Sphagni varietas, J. Hook., Fl. Tasm. II., 171.
King George's Sound, Cunningham; interior of subtropical Australia, Sir Thomas Mitchell; Tasmania.
D. argutum, Hampe in Linnæa, 1870, 516.
New South Wales, Hooker's Collection.

Eucamptodon, Montagne.

E. Muelleri, Hampe & C. Muell. in Linnæa XXXVI., 513.
Victoria, F. v. M.

Dicnemon, Bridel.

D. rugosum, Hooker (Leucodon).
Australia, Dickson.
D. calycinum, Hooker (Leucodon).
Australia, Dickson.
D. enerve, C. Mueller in Revue Bryol., 1876, 3.
Near Sydney, Kayser.

Ceratodon, Bridel.

C. purpureus, Bridel; convolutus, Reichardt.
Snowy River, Tarwin, Gippsland, F. v. M.; King George's Sound, Cunningham; Ash Island, Hunter River and Newcastle, Mrs. Forde.

C. stenocarpus, Montagne.
Tasmania, Oldfield.

Tridontium, J. Hooker.

T. Tasmanicum, J. Hook. in Hook. Icon. Plant. rar. 248.
Tasmania, Gunn.

Pœcilophyllum, Mitten.

P. Leichhardti, Hampe & C. Muell. (Leucoloma) in Linnæa, 1870, 514.
New South Wales, Leichhardt; Victoria, F. v. M.; Brisbane River, Bailey.

Sclerodontium, Schwægrichen.—(Dicnemonella, Hampe and C. Mueller).

S. pallidum, Hook., Musci exot., 172 (Leucodon); Dicranum Sieberianum, Schw.
Victoria, F. v. M.; Port Jackson, Gaudichaud; Tasmania, Gunn.

S. Fraseri, Mitten, S. pallido simillimum, sed foliis nervo lato crassiore, cellulis lævioribus, limbo marginis nullo.
New South Wales, Fraser; Parramatta, Woolls.

Campylopus, Bridel.

C. introflexus, Hedw. (Dicranum); leptocephalum, C. Muell. in Linnæa, 1855, 206 (Dicranum).
Sealers' Cove, Gippsland; Goulbourne Ranges and Mt. Gambier, F. v. M.; King George's Sound, Cunningham; near Port Jackson, Sieber; Maitland, Vicary; Ash Island, Hunter River, Mrs. Forde.

C. pudicus, Hornschuch.
Near Port Jackson, Sieber.

C. bicolor, Hornschuch.
King George's Sound, Cunningham; Swan River, Drummond; Tasmania, Gunn.

C. clavatus, R. Brown in Schwgr. Suppl., 255.
Tasmania, R. Brown, Oldfield; near Sydney, Jupp.

C. appressifolius, Mitt. in J. Hook. Handb. Fl. N. Zeal., 414.
New South Wales, Cunningham.

C. torquatus, Mitt. in J. Hook. Fl. Tasm. II., 173; flexuosus, Hampe in Linnæa, 1855, 206; pallidus, J. Hook. & Wils. in Fl. N. Zeal. II., 68, t. 84.

Tarwin, Victoria, F. v. M.; Richmond River, Camara; Tasmania, Archer; Bellenden Ker Range, Karsten.

C. nudus, Hampe in Linnæa, 1860, 630.
Tarwin, F. v. M.

C. capillatus, J. Hook. & Wils. in Fl. Tasm. II., 172.
Tasmania, Oldfield, Stuart.

C. insidiosus, J. Hook. & Wils. in Fl. Tasm. II., 172.
Tasmania, Oldfield, Stuart.

C. densifolius, Angstr., Oefvers, 1872, 4, 18.
Wollongong, Professor Andersson.

C. Australiensis, Duby in Mem. de la Soc. de Phys. et d'Hist. Nat. de Genève, 1869.
Locality unrecorded.

C. Erythropoma, Duby in Mem. Soc. Phys. Hist. Nat., 1869.
Victoria, F. v. M.

C. subtorquatus, C. Muell. in Rev. Bryol., 1876, 3.
Sydney, Kayser.

II. GRIMMIEÆ.

Grimmia, Ehrhart.

1. * Schistidium.

G. apocarpa, Hedwig.
Australian Alps, F. v. M.; Tasmania, Archer.

G. mutica, Hampe in Linnæa, 1860, 631; apocarpa var. foliis muticis, in J. Hook. Fl. Tasm. II., 180.
Mount Wellington, Sealers' Cove, F. v. M.; Parramatta, Woolls.

G. cyathocarpa, Hampe in Linnæa, 1872, 516.
Gippsland, F. v. M.; Blue Mountains, Mrs. Calvert.

G. flexifolia, Hampe in Linnæa, 1860, 632.
Snowy River, F. v. M.

2. ** Eugrimmia.

G. trichophylla, Greville.
Tasmania, Hooker; Oldfield, Archer.

G. crispata, C. Muell. & Hampe in Linnæa, 1853, 498.
Flinders Range.

G. funalis, B. & S.; J. Hook. Fl. Tasm. II., 180.
Tasmania, Gunn.

G. pulvinata, Hook. & Taylor, var. obtusa; G. cygnicolla, Tayl.
Swan River, Drummond; Australian Alps, Gippsland, F. v. M.; Tasmania, J. Hooker, Oldfield, Archer.

3. *** Guembelia.

Mitten, Musci Austr. Americ, 101.

G. leucophæa, Grev.; G. leiocarpa, Taylor.
Swan River, Drummond; Brisbane River, Bailey; Tasmania, Hooker, Archer.

G. callosa, C. Muell. & Hampe in Linnæa, 1853, 498.
Barossa Range and Brown's Hill, F. v. M.

G. procumbens, Mitten; dioica, humilis, gracilis; folia patentia, lanceolata, nervo carinata, cellulis superioribus rotundis minutis inferioribus oblongis prædita; perichætialia longiora, erecta, dimidio inferiore amplexante pallidiore, dimidio superiore angusta, apice pilo brevi denticulato terminata; theca ovalis, lævis, in pedunculo ea duplo longiore exserta, operculum acuminatum; peristomii dentes perforati; annulus compositus.
Gippsland, Snowy River, F. v. M.

G. montanæ similis.

4. **** Dryptodon.

G. chlorocarpa, Mitten.
Tasmania, Archer.

G. symphyodon, C. Mueller; G. emersa ejusd. in Bot. Zeit., 1851, 562.
Tasmania, Hooker, Archer, Mossmann.

G. crispula, J. Hook. & Wils. in Fl. Antarct, 124.
Tasmania, Gunn, J. Hooker, Archer.

5. ***** Rhacomitrium.

G. lanuginosa (Dill.), C. Mueller, Synops. I., 806.
Australian Alps, F. v. M.
Var. pruinosa, in J. Hook. Fl. Tasm. II., 182.
Tasmania.

G. Sundaica, C. Mueller.
Queensland.

G. pseudo-patens, C. Mueller in Rev. Bryol, 1878, 3.
Near Sydney, Kayser.

G. heterosticha, Hedwig, J. Hook. Fl. Tasm. II., 182.
Tasmania.

Glyphomitrium, Bridel.

G. Muelleri, Mitt. in Journ. of Proceed. Linn. Soc., 1859; Brachystelium Howeanum, Hampe.
Glasshouse Mountains, Moreton Bay, F. v. M.; Lord Howe's Island, Milne.

G. Adamsoni, Mitt. in Journ. Linn. Soc., 1859.
Near Melbourne, Adamson.

G. acutifolium, J. Hook. & Wils. in Fl. Tasm. II., 180.
South Australia, Prentice; Tasmania, J. Hooker, Archer.

G. Australe, Hampe in Linnæa, 1855, 208.
Buchan River, F. v. M.

G. Mittenii, Jæger; G. serratum, Mitt. in J. Hook. Fl. Tasm. II., 181.
Tasmania, Archer.

III. LEUCOBRYEÆ.

Octoblepharum, Hedwig.

O. albidum (L.), Hedwig.
Locality unrecorded.

Leucobryum, Hampe—(Sect. Pegophyllum, Mitt.).

L. brachyphyllum, Hampe.
Newcastle, Mrs. Forde; Parramatta, Woolls.; Sealers' Cove, F. v. M.; Moreton Bay, Bailey; Richmond River, Camara; Bellenden Ker Ranges, Karsten.

L. subchlorophyllosum, Hampe in Linnæa, 1876, 304.
Mount Warning, Guilfoyle.

L. spirostichum, C. Muell.; L. Teysmanni, fide Hampe.
Near Sydney, Kayser.

L. candidum, Schwægr, t. 187 (Dicranum).
Tasmania, Archer.

IV. SYRRHOPODONTEÆ.

Syrrhopodon, Schwægrichen.

S. platycerii, Mitten.
Lord Howe's Island, Milne, also M'Gillivray.

S. Novæ Valesiæ, C. Muell. in Revue Bryol., 1876, 3.
Near Sydney, Kayser.

S. fimbriatum, C. Mueller in Linnæa, 1872, 151.
Brisbane River, A. Dietrich.

Thyridium, Mitten.

T. fasciculatum, Hook. & Grev. (Syrrhopodon); clavatus Schw.
N. S. Wales, G. Sieber.

Calymperes, Bridel.

C. latifolium, Hampe in Pl. Preiss, 1846, 116.
Perth, Preiss; N. S. Wales.
C. Kennedyanum, Hampe in Linnæa, 1876, 303.
Rockingham Bay, Kennedy; Goode Island, Queensland, Powell.

V. TORTULEÆ.

Acaulon, C. Mueller.

A. Brisbanicum, C. Muell. in Linnæa, 1871, 144.
Brisbane River, Dietrich.
A. integrifolium, C. Muell. in Bot. Zeit., 1855, 745.
Yarra River, F. v. M.
A. turgidum, Mitt. in J. Hook. Fl. Tasm.
Tasmania, Archer.

Phascum, Linné.

P. perpusillum, C. Muell. in Linnæa, 1871, 145.
Brisbane River, Dietrich.
P. Drummondii, Wilson in Lond. Journ. Bot., 1848, 26, t. 1.
Melbourne, Adamson.
P. cylindricum, Tayl. in Lond. Journ. Bot., 1846, 42.
Swan River, Drummond.

Pottia, Ehrhart.

P. cæspitulosa, C. Muell. & Hampe (Anacalypta) in Linnæa, 1853, 491.
Near Mt. Lofty, also Yarra River, F. v. M.
P. brevicaulis, Tayl. (Gymnostomum).
Swan River, Drummond.
P. brachyodus, Hampe in Linnæa, 1860, 624.
Yarra River, F. v. M.

Weisia, Hedwig.

W. inflexa, Tayl. (Gymnostomum).
Swan River, Drummond.

W. nuda, Mitt.; humilis; folia a basi erectiora, subquadrata, pellucide areolata, patentia, oblongo-ligulata, acuta apiculatave, canaliculata planiusculave, nervo obscure flavo excurrente prædita, integerrima, cellulis rotundis densis obscuris areolata; perichætialia conformia; theca in pedunculo pallido ovalis, gymnostoma; operculum subulatum, theca brevius.

Trichostomo mutabili similis.

Moreton Bay, F. v. M.

W. bicolor, Hampe (Gymnostomum) in J. Hook. Fl. Tasm. II., 165.

Tasmania.

W. nudiflora, C. Muell. & Hampe in Linnæa, 1853, 496.

Bugle Range, F. v. M.; Yarra and Mount Abrupt, F. v. M.

W. riparia, Hampe in Linnæa 1860, 626.

Gawler River, F. v. M.

W. flavipes, J. Hook. & Wils. in Fl. N. Zeal., 57,

Gippsland, F. v. M.; Tasmania, Gunn, Archer, Oldfield.

W. controversa, Hedwig.

Tasmania, Archer.

Trichostomum, Hedwig.

T. cirrhatum, Hampe, Icones, 28.

Swan River, Preiss.

T. leptotheca, C. Muell. in Linnæa XXXV., 625.

Gippsland, F. v. M.

Tortula, Hedwig.

1. * Trichostomum.

T. Knightii, Mitt. in J. Hook. Fl. Tasm. II., 174.

Tasmania, Mossman.

2. ** Helicopogon.

T. pseudopilifera, Hampe in Linnæa, 1853, 493; T. luteola, Mitt. in Kew Journ. Bot. VIII., 258; T. pungens, J. Hook. & Wils. in Fl. Tasm. II., 175.

Darebin Creek and Gippsland, F. v. M.; Tasmania, Oldfield, Archer, Gunn.

3. *** Pachynoma.

T. torquata, Taylor in Lond. Journ. Bot., 1846, 50.

Swan River, Drummond; New South Wales, Woolls; Tasmania, Oldfield, Archer.

T. adusta, Mitt. in Kew Journ. Bot. VIII., 258 (Desmatodon).
Gippsland, F. v. M.

T. calcicola, Hampe, Icones, 29.
Fremantle, Preiss.

T. Australasica, Hook. & Grev.; T. rufiseta, Tayl.; T. fuscescens, J. Hook & Wils. (Trichostomum).
Swan River, Drummond.

T. rubiginosa, C. Muell. in Linnæa XXXV., 625 (Eutrichostomum).
Yarra River, F. v. M.

4. **** Leptopogon.

T. calycina, Schw. (Barbula).
Swan River, Drummond; King George's Sound, Cunningham; Queensland, Miss Gore; Arthur's Seat, F. v M.; Tasmania, Hummock Island, Bass' Straits, Milne.
Var. brevicaulis, Hampe; Sealers' Cove, F. v. M.

T. subcalycina, C. Muell. in Linnæa XXXV., 617.
Brisbane River.

T. subtorquata, C. Muell. & Hampe in Linnæa, 1853, 492.
Mount Gambier, F. v. M.; Australian Mosses, pl. III.

T. Tasmanica, Hampe in Linnæa, 1852.
Tasmania, Stuart.

T. brachyphylla, Hampe in Linnæa, 1860, 625.
Victoria, F. v. M.

T. Parramattana, Mitten; caulis humilis, innovans; folia sparsa, a basi erecta, subquadrata, pellucide areolata, oblongo-ligulata, patentia, canaliculata, nervo flavo obscuro in mucronem brevissimum excurrente prædita, integerrima, cellulis minutis densis obscuris areolata; perichætialia longiora, arcte convoluta, apice obtusa, pellucide areolata; theca in pedunculo longo flavo elliptica, erecta subarcuatave, operculo subulato subæquilonga; peristomium rubrum, elongatum; annulus compositus.
Parramatta, Woolls.

Caulis 2 to 3 mm. altus. Folia obscure viridia, parte patente 1 mm. longa, sicca incurva. Pedunculus 2 cm. longus. Statura T. convolutæ, foliis autem T. calycinæ.

5. ***** Desmatodon.

T. nervosa, Bridel.
Avon River, F. v. M.; Melbourne, Adamson; Tasmania.

T. recurvata, Hooker.
Tasmania, Oldfield.
T. crassinervia, Taylor. (Desmatodon); reflexidens, Hampe (Trichostomum) in Linnæa, 1860, 625.
Swan River, Drummond; Yarra and Avon Rivers, F. v. M.

6. ****** Syntrichia.

T. fleximarginata, C. Muell. & Hampe in Linnæa, 1853, 493.
Victoria, F. v. M.; Australian Mosses, pl. VI.
T. rubra, Mitten; T. serrulata, Mitt. in Kew Journ. Bot. VIII., 258.
Australian Alps, F. v. M.
T. papillosa, Wilson.
Sealers' Cove, F. v. M.
T. breviseta, C. Muell. & Hampe in Linnæa, 1853, 492.
Mt. Gambier, F. v. M.; Australian Mosses, pl. IV.
T. princeps (Syntrichia), De Notaris; T. antarctica, Hampe in J. Hook. Fl. Tasm. II., 175; T. cuspidata et rubella, J. Hook. & Wils., l. c.; T. panduræfolia, C. Muell. & Hampe in Linnæa, 1853, 493.
Victoria, F. v. M.; Australian Mosses, pl. V.
T. Latrobeana, C. Muell. & Hampe in Bot. Zeit., 1864, 358.
Latrobe and Axe-River, F. v. M.; Tasmania, Archer.

Streptopogon, Wilson.

S. mnioides, Schw., t. 310 (Barbula); crispata, Hampe in Linnæa, 1876, 304.
Mount Macedon; Tasmania, Archer, Mossman.

Encalypta, Schreber.

E. Tasmanica, Hampe & C. Muell. in Linnæa, 1853, 491; australis, Mitt. et. vulgaris, var. in J. Hook. Fl. Tasm. II., 182; ciliata, Hedw. Mitt. in Kew Journ. Bot. VIII., 259.
Tasmania; Archer.

Pyramitrium, Hampe.

P. cristatum, Hampe in Linnæa, 1872, 513.
Blue Mountains, Mrs. Calvert.
P. Novæ Valesiæ, Hampe in Linnæa, 1872, 513.
Blue Mountains, Mrs. Calvert.

VI. ORTHOTRICHEÆ.

Orthotrichum, Hedwig.

O. laterale, Hampe in Linnæa, 1876, 309.
Hume River, F. v. M.

O. Tasmanicum, J. Hook. & Wils. in Lond. Journ. Bot. VII., 27, t. 1.
Tasmania, Gunn, Oldfield, Archer, Mossman.

O. Lawrencei, Mitt. in J. Hook. Fl. Tasm. II., 188.
Tasmania, Lawrence.

Ulota, Mohr.

U. lutea, Mitt. in J. Hook. Fl. Tasm. II., 184; crispa var., l. c.; crocea, Hampe (Orthotrichum).
Tasmania; Gunn, Hooker, Archer.

Macromitrium, Bridel.

1. * Macrocoma.

M. Eucalyptorum, C. Muell. & Hampe in Linnæa, 1853, 500; microphyllum, Hooker & Greville.
Victoria, F. v. M.; Toowoomba, Hartmann; Tasmania, Archer.

M. Novæ Valesiæ, C. Mueller in Rev. Bryol., 1876, 3.
Near Sydney, Kayser.

M. Dæmelii, C. Mueller in Rev. Bryol., 1877, 43.
Queensland, Daemel; Toowoomba, Hartmann.

M. Geheebii, C. Mueller; Hampe in Linnæa, 1876, 308.
Illawarra, Johnson.

2. ** Goniostoma.

M. pusillum, Mitten; J. Hook., Fl. Tasm. II., 183.
Tasmania, Archer.

M. microstomum, Hook. & Grev.
Sealers' Cove, F. v. M.; Brisbane River, Bailey; Toowoomba, Hartmann.

M. Scottiæ, C. Muell. in Linnæa XXXV.
Ash Island, Hunter River, Miss Scott; Tasmania, Gunn.

M. asperulum, Mitt. in J. Hook. Fl. Tasm. II., 376.
Tasmania, Lawrence.

M. Muelleri, Hampe (Macromitrium).
Sealers' Cove, F. v. M.

M. Archeri, Mitt. in J. Hook. Fl. Tasm. II., 183; M. linearifolium, C. Mueller.
Maitland, Vicary; Tasmania, Archer, Oldfield.

M. hemitrichodes, Schwægrichen, spec. musc. t. 136; G. amœnum et Sieberi, Hornschuch.
Botany Bay, Dickson, Sieber; Ranges between the Burnett and Brisbane Rivers, F. v. M.; Ash Island, Mrs. Forde.

M. intermedium, Mitt.; rami humiles; folia humiditate patenti-incurva, siccitate compacte contorta, sublanceolato-linearia, acuta, nervo carinata; cellulæ eorum ubique rotundatæ, parvæ, carnosulæ, distinctæ, fere læves; folia perichætialia breviora, lanceolata, acuta, erecta; theca in pedunculo 2-3 lineari ovalis; operculum subulatum; calyptra infra thecam descendens, multifida, appresse ramentosa.
Brisbane River, Bailey.

Very similar to G. hemitrichodes, but areolation different.

M. diaphanum, C. Mueller in Linnæa, 1871, 151.
Brisbane River, Dietrich, Bailey.

M. Baileyi, Mitten; rami breves; folia humiditate erecto-patentia, siccitate convoluta, oblongo-ligulata, nervo carinata, inferne cellulis oblongis pellucidis superne densis rotundatis obscuris formata; perichætialia breviora, erecta, ovata, acuta; calyptra ramentis paucis appressis pilosa.
Brisbane River, Bailey.

M. aurescens, Hampe in Linnæa, 1860, 633.
Dawson River, F. v. M.

M. spirale, Hampe.
Locality unrecorded.

M. Reinwardtii, Schw., t. 173; J. Hook. Fl. Tasm. II., 183.
Tasmania, Gunn.

M. lingulare, Mitt. in Journ. Linn. Soc. IV., 78; G. weissioides, C. Muell. in Linnæa, 1871.
Ranges between the Burnett and Brisbane Rivers, F. v. M.; Brisbane, Bailey.

M. prorepens, Hook., Musci exot. 120.
Norfolk Island, Bauer.

3. *** Leiostoma.

M. involutifolium, Hook.
Ranges between the Rivers Burnett and Brisbane, F. v. M.; Toowoomba, Hartmann.

M. carinatum, Mitten; M. involutifolio simillimum sed paululum majus; folia magis carinata, basi cellulis paucis elongatis prædita, apice magis subcucullato-incurva; perichætialia conformia; theca infra os plicata, in pedunculo brevi exserta.

In M. involutifolium the capsule is smooth, the perichætial leaves are shorter than the cauline leaves and more acuminated.

M. viridissimum, Mitten; M. involutifolio simile, sed elatius et ob folia longiora crassius; folia perichætialia superne angustiora, apicibus basin thecæ oblongo-cylindraceæ basi plicatæ fere attingentia; calyptra ramentis appressis obtecta.

Ranges between the Burnett and Brisbane Rivers, F. v. M.; Toowoomba, Hartmann.

M. subulatum, Mitten; longe repens; rami curvati, ascendentes; folia humiditate patentia, arcuato-incurva, siccitate torta crispataque, rigidula, subnitentia, a basi elongate lanceolata, sensim longe subulato-angustata, acuta, nervo percurrente carinata, basi cellulis angustis elongatis inde ad apicem rotundatis prædita; perichætialia ovata, longius angustata; theca in pedunculo 2-3 lineari parva, ovalis, plicata; peristomii dentes lati pallidi.

Bass' Straits, Milne.

Habitus M. cirrhosi et a reliquis speciebus Australibus diversissimum.

M. sordido-virens, C. Muell. in Linnæa, 1871, 153.

Brisbane River, Dietrich.

M. Tongense, Sullivant in American Expl. Exped., t. 5.

Lord Howe's Island, Fullagar and Lind.

M. adstrictum, Angstroem, Œfvers, 1872, 4, 19; M. Owhaiense, C. Mueller, fide Jæger.

Wollongong, Prof. Andersson.

M. brevisetaceum, Hampe in Linnæa XXXVIII., 633.

Lord Howe's Island, Fullagar and Lind.

Powellia, Mitten.

P. involutifolia, Mitt. in the Journ. Linn. Soc. X., 187; Australis, Hampe in Linnæa, 1870, 524 (Helicophyllum).

Rockinghan Bay, Dallachy.

Zygodon, Hooker and Taylor.

Z. intermedius, Bruch and Shimper.

Tasmania, Archer, Mossman.

Z. brachypodus, Hampe & C. Muell. in Linnæa, 1855, 210.
Sealers' Cove, F. v. M.
Z. Brownii, Schw., t. 317.
Sealers' Cove, F. v. M.; Tasmania, Archer,
Z. Hookeri, Hampe in Linnæa, 1859, 60.
Grampians, F. v. M.
Z. minutus, C. Muell. & Hampe in Linnæa, 1855, 209.
Sealers' Cove, F. v. M.
Z. anomalus, Dozy & Molkenbœr; Z. Reinwardtii, Mitt. in J. Hook., Fl. Tasm. II., 185.
Tasmania, Oldfield.
Z. Menziesii, Schw., t. 137 (Codonoblepharum); Drummondii, Taylor.
Swan River, Drummond; Melbourne, Adamson; Port Albert and Tarwin, F. v. M.; Tasmania Gunn, Archer, Oldfield.

Gymnocybe, R. Brown.

G. palustris, Mitten; Aulacomnion, Schwægrichen, J. Hook., Fl. Tasm. II., 192.
Tasmania, Gunn.

Apalodium, Mitten.

A. lanceolatum, Mitt. in Kew Journ. Bot. VIII., 761 (Orthodontium).
Mount Wellington, Gippsland, F. v. M.; Tasmania, Archer.
A. lineare, Taylor (Zygodon), Weissia pallens, Wilson.
Swan River, Drummond.
A. australe, J. Hook. et Wils. in Fl. Antarct., t. 153.
Tasmania, J. Hooker, Archer, Oldfield.
A. sulcatum, Hook. & Wils.
Grampians, F. v. M.

VII. SPLACHNEÆ.

Tayloria, Hooker.

T. calophylla, C. Muell. in Bot. Zeit., 1851, 564 (Dissodon); robusta (Eremodon), J. Hook. et Wils.
Tasmania, Mossman.
T. octoblepharis, Hooker; cuspidata (Dissodon), C. Mueller.
Tarwin, Sealers' Cove, F. v. M.; Tasmania, Archer, Oldfield.

Splachnum, Linné.

S. Gunnii, J. Hook. & Wils. in London Journ. of Bot. VII., 26, t. 1; Tetraplodon Tasmanicus, Hampe in Linnæa, 1876, 302.
Tasmania, Gunn, Schuster.

VIII. FUNARIEÆ.

Ephemerum, Hampe.

E. cristatum, Hook. & Wils. in Hook. Icon. pl. rar., t. 737 A.
Tasmania, Archer.

E. fimbriatum, C. Muell. in Linnæa, 1871, 145.
Brisbane River, Dietrich.

Pleurophascum, Lindberg.

P. grandiglobum, Lindberg, in Journ. of Bot., 1875.
Alps of Tasmania, Picton River, R. Johnston.

Leptangium, Montagne.

L. repens, Hook., Musci. exot., 106 (Anictangium).
Tasmania, Archer.

L. tumidum, Mitt.; folia oblongo-ovalia, cochleariformi-concava, margine late recurva, apice acuta vel apiculo brevi angusto terminata, enervia, cellulis oblongis carnosulis areolata.
Tasmania, Archer.

Caules 2 centim. alti, fusci. Folia 3 mm. longa, flavo-fusca. Quoad genus, fructu absente, dubium.

Physcomitrium, Bridel.

P. firmum, Mitt. in Kew Journ. Bot. VIII., 259.
Delatite, F. v. M.

P. Brisbanicum, C. Muell. in Linnæa, 1871, 146.
Brisbane River, Dietrich.

P. subserratum, C. Muell. in Linnæa, 1860, 623.
Dargo River, F. v. M.

P. minutulum, C. Muell. in Linnæa, 1871, 147.
Brisbane River, A. Dietrich.

P. conicum, Mitt. in J. Hook. Fl. Tasm. II., 197.
Tasmania, Archer.

P. nodulifolium, Mitten; monoicum; caulis semiuncialis uncialisve; folia sparsa, erecto-patentia appressaque, comalia patentia, oblongo-obovata, breviter apiculata, margine a medio ad apicem serrulata; nervus in apiculo evanescens; cellulæ oblongæ, limitibus nodulosæ; theca in pedunculo circiter 3 lineari erecta; theca subglobosa, collo æquilonga, ore paululum coarctata, satis magna sed non dilatata.

Near Moreton Bay, F. v. M. (1856).

Primo adspectu P. firmo simile, sed foliis serrulatis et areolatione diversissimum.

P. flaccidum, Mitten; caulis gracilis; folia patentia, flaccida, obovata, acuta, margine superne serrulata, nervo sub apice evanido prædita, cellulis teneris areolata; pedunculus gracilis; theca globosa, collo æquilongo attenuata, demum cyathiformis.

Ash Island, Hunter River, Newcastle, Mrs. E. Forde.

Caulis 1 centim. altus. Folia 1 mm. longa. Pedunculus 5 mm. metiens.

P. integrifolium, Hampe & C. Mueller in Linnæa, 1853, 490.

Delatite, F. v. M.

Goniomitrium, Hooker and Wilson.

G. acuminatum, Hook. & Wils. in Lond. Journ. Bot., 1846, t. 3 B.

Swan River, Drummond; Clermont, Queensland, Miss Gore.

G. enerve, Hook. & Wils. in Lond. Journ. Bot., 1846.

Swan River, Drummond.

Entosthodon, Schwægrichen.

E. clavæformis, C. Muell. & Hampe in Linnæa, 1853, 490.

Torrens River, F. v. M.

E. laxus, J. Hook. & Wils. in Fl. Antarct., t. 151 (Physcomitrium).

Australian Alps, F. v. M.; Tasmania, Archer, Oldfield.

E. apophysatus, Tayl. in Lond. Journ. Bot., 1846, 42; E. Taylori, C. Muell., Syn. I., 122.

Swan River, Drummond; Queensland, Miss Gore; Yarra River and Gippsland, F. v. M.; Tasmania, Archer.

E. productus, Mitten in J. Hook. Fl. Tasm. II., 197.

Tasmania, Archer.

E. varius, Mitten; caulis brevissimus; folia in comam congesta, ovali-rotundata, breviter apiculata, immar-

ginata, integerrima, nervo infra apicem evanido prædita; theca in pedunculo subunciali clavata, subinæqualis; operculum fere planum, gymnostomum.
Victoria, Adamson.

Species ambigua, foliis Funariæ hygrometricæ, thecis Entosthodonti apophysato similior.

Funaria, Schreber.

1. * Plagiodus.

F. subnuda, Tayl. in Lond. Journ. Bot., 1846, 57.
Swan River, Drummond.

F. glabra, Tayl. in Lond. Journ. Bot., 1846, 57.; F. acaulis, Hampe in Linnæa, 1860, 624; F. radians, Mitt., in Kew Journ. Bot. VIII., 259.
Swan River, Drummond; Gippsland, F. v. M.; Tasmania, Archer.

F. Tasmanica, C. Muell. & Hampe in Linnæa, 1853, 490; F. v. M., Austr. Mosses, pl. 1.
Tasmania, Stuart.

F. crispula, J. Hook. & Wils. in Fl. Tasm. II., 198.
Tasmania, Oldfield, Archer.

2. ** Eufunaria.

F. hygrometrica, Linné.
Maitland, Vicary; Brisbane River, Bailey; Ash Island, Hunter River, Mrs. E. Forde; Bellenden Ker Range, Karsten.

F. papillata, Hampe in Linnæa, 1876, 302.
Brisbane River, Slater.

IX. BARTRAMIEÆ.

Bartramidula, Bruch & Schimper.

B. pusilla, J. Hook. & Wils. in Lond. Journ. Bot., 1844, 545 (Glyphocarpa).
Tasmania, Lyall, Archer, Oldfield.

B. Hampei, Mitt.; Bartramia erecta, Hampe in Linnæa, 1876, 305.
Mount William, Sullivan.

Philonotis, Bridel.

P. appressa, J. Hook. & Wils.
Australian Alps, F. v. M.; Tasmania, Archer, Oldfield.

P. uncinatula, C. Muell. in Revue Bryol., 1876, 4.
Near Sydney, Kayser.
P. atro-lutea, C. Muell. in Rev. Bryol., 1876, 4.
Near Sydney, Kayser.
P. Slateri, Hampe in Linnæa, 1876, 306.
Brisbane River, Slater.
P. pallida, Hampe in Linnæa, 1876, 307.
Sub-tropical East Australia, Eaves.
P. pseudo-mollis, C. Muell. in Linnæa, 1871, 150.
Brisbane River, Dietrich.
P. tenuis, Tayl. in J. Hook. Fl. Tasm. II., 193.
Tasmania, Oldfield.
P. fertilis, Mitt. in Kew Journ. Bot. VIII., 260.
Mount Hotham, Australian Alps, F. v. M.

Breutelia, Schimper.

B. Sieberi, Hornschuch (Bartramia).
Near Port Jackson, Sieber 13; Mount Tomah, Cunningham; Tasmania, Archer, Oldfield.
B. pendula, Hook., Musci exot. 21 (Bartramia).
Near Port Jackson, Sieber 15; Tasmania, J. Hooker, Oldfield.
B. elongata, J. Hook. and Wils. (Bartramia).
Tasmania, Archer.
B. comosa, Mitt. in J. Hook. Fl. Tasm. II., 195 (Bartramia).
Mt. Dromedary, N.S.W., Reader; Tasmania, Archer, Mossman.
B. crassa, J. Hook. & Wils. in Fl. Tasm. II., 194 (Bartramia).
Tasmania, Mossman, Archer.
B. affinis, Hook., Musci exot. 176 (Bartramia).
Victoria, Robertson; Snowy River and Buffalo Range, F. v. M.; Tasmania, Mossman, Archer, Oldfield.
B. divaricata, Mitt. in J. Hook. Fl. Tasm. II., 195 (Bartramia).
Tasmania, Archer.
B. commutata, Hampe in Linnæa, 1876, 307 (Bartramia).
Grampians, F. v. M.; Tasmania,
B. luteola, C. Muell. in Rev. Bryol., 1876, 4.
Sydney, Kayser.

Conostomum, Swartz.

C. Australe, Swartz in Schrad., Neu. Journ. für Bot., 134.
Tasmania, Archer.
C. curvirostre, Mitt. in Kew Journ. Bot. VIII., 260 (Bartramidula).
Munyang Mounts., Australian Alps, F. v. M.

C. pusillum, J. Hook. & Wils. in Fl. Antarct., t. 86; C. parvulum, Hampe in Linnæa, 1855, 207.
Grampians, Victoria, F. v. M.; Tasmania, Archer, Oldfield.

Bartramia, Hedwig.

B. papillata, J. Hook. & Wils. in Fl. N. Zeal., t. 86; B. acerosa, Hampe in Linnæa, 1855, 207.
Snowy River, F. v. M.; Mount Dromedary, Reader; Tasmania, Archer.

B. fragilis, Mitt. in J. Hook. Fl. Tasm. II., 196.
Tasmania, Archer.

B. strictifolia, Tayl. in Lond. Journ. Bot. V., 451 (1846).
Swan River, Drummond.

B. Halleriana, Hedwig; B. Mossmaniana, C. Muell. in Bot. Zeit., 1851, 552.
Tasmania, Archer.

Meesia, Hedwig.

M. Muelleri, C. Muell. & Hampe in Linnæa, 1865, 208.; M. macrantha, Mitten.
Cobberas Mountains, Australian Alps, F. v. M.

X. BRYEÆ.

Bryum, Linné.

1. * Dicranobryum.

B. Preissianum, Hampe, Icones, 25.
Swan River, Drummond, Preiss.; Victoria, F. v. M.

2. ** Webera.

B. nutans, Schreber; B. longifolium, Hampe in Linnæa, 1855, 205.
Grampians, Cobberas and Snowy River, F. v. M.; Tasmania, Archer, Oldfield, Gunn.

B. nudiflorum, C. Muell. & Hampe in Linnæa, 1855, 205.
Yarra River, F. v. M.

B. clavæforme, Hampe & C. Muell. (Pohlia) in Linnæa, 1870, 519.
Mount Disappointment, F. v. M., Taylor.

B. erythrocaule, Hampe in Linnæa, 1872, 516.
Blue Mountains, Mrs. Calvert.

B. albicans, Wahlenberg.
Locality not recorded.

3. *** Leptobryum.

B. pyriforme, Hedwig.
Maitland, Vicary.

B. sericeum, Hampe in Linnæa, 1853, 494.
Tasmania, Stuart.

**** Brachymenium.

B. lanceolatum, J. Hook. & Wils. in Fl. Tasm. II., t. 173.
Tasmania, Gunn.

***** Eccremothecium.

B. dichotomum, Hedwig; B. balanoides, Tayl.; B. pachytheca, C. Muell.
Swan River, Drummond; Yarra River, F. v. M.; Tasmania, Gunn, Oldfield.

B. Gambierense, C. Muell. in Linnæa, 1871, 148.
Mount Gambier, also in Victoria, F. v. M.

B. cupulatum, C. Muell. in Linnæa, 1871, 149.
Victoria, also Brown's Hill Creek on St. Vincent's Gulf, F. v. M.

B. pachypomatoides, Hampe.
Locality unrecorded.

B. brevicaule, Hampe et C. Muell. in Linnæa XXXVI., 518.
Locality unrecorded.

B. suberythrocarpum, C. Muell. in Bot. Zeit., 1856, 417.
Rottnest, West Australia, Preiss.

B. subæneum, C. Muell. & Hampe in Linnæa, 1853, 494.
Victoria, F. v. M.

B. macropelma, C. Muell. in Linnæa, 1871, 149.
South-West Australia, Preiss; Porongerup, F. v. M.

B. erythrocarpoides, C. Muell. & Hampe in Linnæa, 1853, 495.
Mt. Lofty Range, F. v. M.

B. subpachypoma, Hampe & C. Muell. in Linnæa, 1870, 518.
Rockingham Bay, Dallachy.

B. pyrothecium, Hampe in Linnæa, 1855, 205.
Sealers' Cove, Thomson River, Avon; Glenelg River, F. v. M.

B. inæquale, Tayl. in Lond. Journ. Bot., 1848, 53.
Swan River, Drummond.

B. multicaule, Tayl. in Lond. Journ. Bot., 1848, 53.
Swan River, Drummond.

B. creberrimum, Tayl. in Lond. Journ. Bot., 1848, 53.
Swan River, Drummond.

B. argenteum, Linné, var. nivea.
Victoria, F. v. M.; Tasmania, Gunn.
B. subrotundifolium, Hampe in Linnæa, 1876, 512.
Mt. Ararat, Sullivan.
B. subatropurpureum, C. Muell. in Linnæa, 1871, 147.
Brisbane River, Dietrich.
B. chrysoneuron, C. Muell. in Bot. Zeit., 1851, 549; B. duriusculum, J. Hook. & Wils.
Cobberas Mts., Austral. Alps, F. v. M., Tasmania.
B. curvicollum, Mitten; B. clavatum, J. Hook. & Wils., Fl. N. Zeal. 84, t. 85.
Tasmania, Archer, Gunn.
B. viridulum, C. Muell. in Rev. Bryol., 1876, 3.
Australia.
B. torquescens, Bruch & Schimper.
Australia, F. v. M.
B. intermedium, W. & M.; J. Hook. Fl. Tasm. II., 189.
Tasmania, J. Hooker.
B. pseudo-pallescens, Hampe & C. Muell.
Locality unrecorded.
B. camptothecium, Taylor.
Swan River, Drummond; Mount William, F. v. M.
B. Australe, Hampe, Icones 26.
Swan River, Preiss.
Var. minor; Victoria, F. v. M.
B. rubiginosum, J. Hook. & Wils. in Fl. Tasm. II., 190.
Tasmania, Gunn.
B. crassum, J. Hook. & Wils. in Fl. N. Zeal., t. 86.
Mount Hotham, Australian Alps, F. v. M.; Tasmania, Archer, Gunn.
B. crassinerve, J. Hook. & Wils.
Munyang Mountains, F. v. M.
B. blandum, J. Hook. & Wils. in Fl. Antarct., t. 60; var. luridum.
Tasmania, Gunn.
B. Tasmanicum, Hampe in Linnæa, 1852.
Tasmania, R. Brown, Archer, Mossman.
B. bimum, Schreber; J. Hook. Fl. Tasm. II., 190.
Tasmania, Archer.
B. lævigatum, J. Hook. & Wils. in Fl. Antarct., t. 154.
Tasmania, Lawrence, Archer, Gunn.
B. capillare, Hedwig.
Tasmania, Gunn.
B. obconicum, Hornschuch.
Tasmania, Gunn.

B. cæspiticium, L. var. crinitum, J. Hook., Fl. Tasm. II., 191.
Tasmania, Gunn, Archer.

B. leucacanthum, Hampe.
Lord Howe's Island, Fullagar.

B. subtomentosum, Hampe & C. Muell. in Linnæa, 1870, 516.
Victoria, F. v. M.; near Melbourne, Adamson; Richmond River, Camara; Brisbane River, Bailey.

B. brachyaris, C. Mueller.
Locality unrecorded.

B. albo-limbatum, Hampe & C. Muell. in Linnæa, 1870, 517.
Porongerup, West Australia, F. v. M.

B. robustum, Hampe in Linnæa, 1860, 627.
Tarwin River, F. v. M.; Mt. Dromedary, Reader.

B. crispatum, Hampe in Linnæa, 1876, 310.
Between Cape Otway and Cape Patten, Walter.

B. olivaceum, Hampe in Linnæa, 1876, 311.
Sub-tropical East Australia, Eaves.

B. leptothecium, Taylor; B. truncorum, Wilson in J. Hook. Fl. Tasm. II., 192.
Sealers' Cove, Gippsland, F. v. M.; Tasmania, Archer, Gunn, Mossman.

B. Billardieri, Schwægrichen.
Australian Alps, F. v. M.; Tomah, Cunningham; Tasmania, Archer, J. Hooker; Lord Howe's Island, Milne.

B. breviramulosum, Hampe in Linnæa, 1876, 311.
Mount Ararat, Sullivan.

B. subfasciculatum, Hampe in Linnæa, 1876, 312.
Sub-tropical East Australia, Eaves.

B. rufescens, J. Hook. & Wilson in Fl. Tasm. II., 192.
Victoria, F. v. M.; Tasmania, Hooker, Gunn.

B. roseodens, C. Muell., Rev. Bryol., 1876, 3.
Near Sydney, Kayser.

B. Commersonii, Bridel, mant. musc., 119.
Logan River, Scortechini; Lord Howe's Island, Milne.

Mielichhoferia, Hornschuch.

1. * Leptochlæna.

M. microdonta, Mitten.
Gippsland, F. v. M.; Tasmania, Archer, Oldfield

2. ** Haplodontium.

M. Eckloni, Hornschuch; J. Hook. Fl. Tasm. II., 189.
Tasmania, Gunn, Archer.

M. Australis, Hampe in Linnæa, 1855, 204, et 1860, 626.
Gippsland and Grampians, F. v. M.

Leptostomum, R. Brown.

L. macrocarpum, R. Br. in Transact. Linn. Soc. X., 322.
Norfolk Island, Cunningham.

L. inclinans, R. Br., l. c. 320, t. 23; L. flexipile, C. Mueller.
Sealers' Cove and Grampians, F. v. M.; Mount Wellington, Tasm., R. Brown; Western Mountains, Archer.

Var. longiseta, Hampe in Linnæa, 1855, 206.
Sealers' Cove, F. v. M.

Leptotheca, Schwægrichen.

L. Gaudichaudi, Schw., t. 186.
Grampians and Avon River, F. v. M.; Tasmania, J. Hooker, Oldfield, Archer.

Mnium, Dillenius.

M. rostratum, Schwægrichen; M. Novæ Valesiæ, C. Muell. in Rev. Bryol., 1876, 4.
Near Sydney, Kayser.

Mittenia, Lindberg.

M. plumula, Lindberg; Mitten in J. Hook. Fl. Tasm. II., 187, t. 173 (Mniopsis).
Tasmania, Archer.

Hymenodon, J. Hooker et Wilson.

H. piliferum, J. Hook. & Wils. in Fl. N. Zeal., t. 92.
Victoria, F. v. M.; Tasmania, Sir J. Hooker, Archer.

Rhizogonium, Bridel.

1. * Pyrrhobryum.

R. spiniforme, Bruch in Regensb. flora, 1846, p. 134.
Australian Alps, F. v. M.; Tasmania, Archer, Mossman; Bellenden Ker Range, Karsten; Ash Island, Mrs. Forde.

R. Parramattense, C. Muell., Synops. II., 255.
Parramatta (herb. Kunze).

R. Hookeri, C. Mueller; R. mnioides, Wils. var. contortum et var. lutescens, J. Hook. Fl. Tasm. II., 216; Mossmanianum, C. Muell. in Bot. Zeit., 1851, 547.
Mt. William and Sealers' Cove, F. v. M.; Tasmania, Mossman, Archer.

2 ** Eurhizogonium.

R. distichum, Bridel, Bryol. univ. II., 665.
Victoria, F. v. M.; Tasmania, Archer, Mossman.
R. Geheebii, C. Muell. in Rev. Bryol., 1876, 3.
Sydney, Kayser.
R. Novæ Hollandiæ, Bridel, Bryol. univ. II., 664.
Victoria, F. v. M.; Tasmania, Archer.
R. aristatum, Hampe in Linnæa, 1876, 714.
Tasmania, Schuster.
R. gracillimum, Hampe in Linnæa, 1876, 314.
Buchan River, F. v. M.; between Cape Otway and Cape Patten, Walter.
R. Muelleri, Hampe in Linnæa, 1855, 211.
Mt. William and Sealers' Cove, F. v. M.
R. bifarium, Schimper in der Bot. Zeitung, 1844, p. 125.
Tasmania, Oldfield.
R. undulatum, Lindberg, Œfvers af F. Vet. Soc. Foerh., 1869.
Parramatta, Woolls; Sydney, F. v. M.; Twofold Bay, Mossman; Ash Island, Hunter River, Mrs. Forde; Brisbane River, Bailey.
R. taxiforme, Hampe in Linnæa, 1876, 313.
Johnston River, Fitzalan.

3. *** Goniobryum.

Lindberg in der Hedwigia, 1863, p. 21—Photinophyllum, Mitten.
R. pellucidum, Mitten; reticulatum, Hampe in Linnæa, 1860.
Apollo Bay, F. v. M.; Tasmania, Archer.
R. subbasilare, Hook., Musci. exot. 10 (Hypnum).
Tasmania, Gunn, Archer.

XI. HYPOPTERYGIEÆ.

Cyathophorum, Beauvois.

C. pteridioides, Beauvois; C. pennatum, Bridel.
Victoria, F. v. M.; Tasmania, Archer, Gunn, Oldfield.

Hypopterygium, Bridel.

1. * Lopidium.

H. concinnum, Hooker.
Sealers' Cove, F. v. M.

H. nematosum, C. Muell. in Journ. Mus. Godefr. Heft. VI., 30.
Mount Elliot, Kayser.

H. pallens, J. Hook. & Wils. in Fl. N. Zeal., 119.
Victoria, F. v. M.; Tasmania, R. Brown, Gunn, Oldfield, Archer, Stuart.

H. planatum, Hampe in Linnæa, 1874, 672.
Mount Elliot, Kayser.

2. ** Catharomnion.

H. ciliatum, Hedw. (Pterygynandrium).
Tasmania, Gunn.

3. *** Euhypopterygium.

H. Muelleri; Hampe in Linnæa, 1855, 215.
Buchan River, F. v. M.; Brisbane River, Bailey.

H. discolor, Mitten; H. Scottiæ, C. Muell. in Linnæa XXXV., 619.
Parramatta, Woolls; Ash. Isl., Hunter River, Mrs. Forde; Moreton Bay and Mt. Gambier, F. v. M.

H. Novæ Zealandiæ, C. Mueller in Bot. Zeit., 1851, 367; H. Smithianum, J. Hook. & Wils. in Fl. N. Zeal. II., 118.
Sealers' Cove, F. v. M.; Tasmania, Hooker, Archer, Oldfield.

H. glaucum, Sullivant in Amer. Expl. Exp., 26; H. Smithianum var., J. Hook. & Wils. in Fl. N. Zeal. II., 118.
Tasmania, Archer.

H. viridulum, Mitt. in J. Hook. Handb. Fl. N. Zeal. II., 487.
Ash Island and Hunter River, Mrs. Forde; Brisbane River, Bailey.

H. oceanicum, Mitt. in J. Hook. Handb. Fl. N. Zeal. II., 487; H. Norfolkianum, C. Muell.
Norfolk Island, Cunningham, Thompson, Milne.

XII. RHACOPILEÆ.

Rhacopilum, Bridel.

R. strumiferum, C. Mueller in Bot. Zeitung, 1851, 563; R australe, J. Hook. and Wils. in Fl. N. Zeal., 121.
Tasmania, Archer.

R. crinitum, Hampe & C. Muell. in Linnæa, 1870, 526.
Porongerup, West Australia, F. v. M.

R. convolutaceum, C. Mueller, Synops. II., 13; R. cristatum, J. Hook. & Wils. in Fl. N. Zeal., 121.
Ranges between the Burnett and Brisbane Rivers, F. v. M.; Richmond River, Camara; Norfolk Island, Thompson; Ash Island, Mrs. Forde.

R. purpurascens, Hampe in Linnæa, 1876, 326.
Near Melbourne and on Mt. Elephant, F. v. M.

R. æruginosum, C. Mueller in Rev. Bryol., 1877, 43.
Toowoomba, Hartmann.

XIII. HOOKERIEÆ.

Daltonia; Hooker and Taylor.

D. pusilla, J. Hook. and Wils. in Fl. Tasm. II., 221.
Tasmania, Oldfield.

Distichophyllum, Dozy & Molkenboer.

1. * Mniadelphus.

D. apiculatum, J. Hook. & Wils. in Fl. N. Zeal., t. 93 (Hookeria).
Tasmania, Gunn.

D. complanatum, Hampe in Linnæa, 1876, 320.
Johanna River, near Cape Otway, F. v. M.

D. subrotundum, Hampe in Linnæa, 1876, 320.
Mt. Disappointment, F. v. M.

D. microcarpum, Hedw. (Hypnum).
Tasmania, Archer, Gunn.

D. sinuosum, J. Hook. & Wils. in Fl. Tasm. II., 219.
Tasmania, Gunn, Oldfield.

2. ** Discophyllum.

D. pulchellum, J. Hook. & Wils. in Fl. Antarct., t. 62.
Tasmania, Gunn, Archer.

D. crispulum, J. Hook. & Wils. in Fl. N. Zeal., t. 93.
Tasmania, Archer.

D. amblyphyllum, J. Hook. & Wils. in Fl. N. Zeal., t. 93.
Tasmania, Gunn.

D. Zetterstedtii, C. Muell. in Linnæa, 1871, 158.
Victoria, F. v. M.

Hookeria, Smith.

(Cyclodictyon, Mitten.)

H. lepida, Mitten; folia lateralia obovata ovaliave obtusa, apiculo brevi terminata; intermedia late ovalia, acuta; omnia binervia, limbo angusto integerrimo marginata, cellulis hexagonis limpidis areolata.

Bellenden Ker's Range, Karsten.

Folia pallide viridia, 1 mm. longa; Fructus ignotus, genus igitur dubium.

Sauloma, J. Hooker & Wilson.

S. tenellum, J. Hook. & Wils. in Fl. N. Zeal., t. 92 (Hookeria).

Bunyip Creek, F. v. M.; Tasmania, Hooker, Archer, Gunn, Oldfield.

Pterygophyllum, Bridel.

P. Hookeri, Jæger II., 247; Pt. obscurum, Mitt. in J. Hook. Fl. Tasm. II., 220, t. 177.

Tasmania, Archer.

P. denticulatum, J. Hook. & Wils.

Tasmania, Gunn.

P. nigellum, J. Hook. & Wils. in Fl. N. Zeal., t. 93 (Hookeria); H. hepaticifolia, C. Muell. & Hampe in Linnæa, 1853, 503.

Tasmania, Sir J. Hooker; Dandenong Ranges, Steep Bank River, Bunyip Creek, and many other places in ferntree-gullies, F. v. M.

XIV. ERPODIEÆ.

Erpodium, Bridel.

E. Hodgkinsonianum, Hampe & C. Mueller.

Richmond River, Mrs. Hodgkinson.

XV. NECKEREÆ.

Hedwigia, Ehrhart.

1. * Euhedwigia.

H. ciliata, Ehrhart in Hannov. Magaz., 1781, p. 109; H. microcyathea, C. Muell. in Bot. Zeit., 1851, 564 et forsan H. Jaratzkæ, C. Muell., Rev. Bryol., 1876, 3.

Ingogobbi, Australian Alps, F. v. M.; near Sydney, Kayser; Tasmania, Hooker, Mossman.

2. ** Hedwigidium.

H. imberbis, Sm. (Gymnostomum); H. Drummondi, Tayl. (Schistidium); J. Hook. Fl. Tasm. II., 179 et forsan H. emersa, Hampe & C. Mueller.
Swan River, Drummond; Tasmania, Archer.

Rhacocarpus, Lindberg.

R. Humboldti, J. Hook. & Wils. in Fl. Tasm. II., 179 (Hedwigia); H. Australis, Hampe in Linnæa, 1860, 636.
Swan River, Drummond; Grampians, F. v. M.; Tasmania, Archer, Hooker, Gunn.

Lasia, Bridel.

L. subproducta, C. Muell. in Rev. Bryol., 1877, 43.
Parramatta, Woolls; Toowoomba, Hartmann.

L. Australis, C. Muell. in Linnæa, 620.
Ash Island, Hunter River, Mrs. E. Forde; Toowoomba, Hartmann; Brisbane River, F. v. M.

Cryphæa, Bridel.

1. * Eucryphæa.

C. brevidens, C. Muell. in Rev. Bryol., 1876, 4.
Near Sydney, Kayser.

C. tenella, Hornschuch.
New South Wales, Sieber.

C. crenulata, Mitt. in Journ. Linn. Soc., 1859.
Tarwin, Gippsland, F. v. M.; Tasmania, Archer.

2. ** Philudora.

C. ovalifolia, C. Muell. in Bot. Zeit., 1851.
Twofold Bay, Mossman; Parramatta, Woolls; Brisbane River, Bailey.

C. squarrulosa, Hampe in Linnæa, 1860, 636.
Gippsland, Tarwin, F. v. M., Australian Mosses, pl. XI.

C. Muelleri, Hampe in Linnæa, 1851, 212 (Dendropogon); C. dilatata, Mitt. in Kew Journ. Bot. VIII., 263.
Buchan River and Moreton Bay, F. v. M.

C. Tasmanica, Mitt. in J. Hook. Fl. Tasm. II., 204.
Tasmania, Archer.

C. imbricata, J. Hook. & Wils. in Fl. Tasm. II., 202 (Leskea).
Tasmania, Oldfield.

Bescherellia, Duby.

B. brevifolia, Hampe in Linnæa, 1876, 317.
Toowoomba, Slater; Brisbane, Bailey; Riverina, Dangar.
B. cyrtopus, F. v. Mueller; Cyrtopus bescherellioides, C. Mueller in Rev. Bryol., 1876, 4.
Near Sydney, Kayser.

Spiridens, Nees ab Esenbeck.

S. Muelleri, Hampe in Rev. Bryol. 1875, 118; perhaps S. capilliferus, Mitten.
Mt. Lidgbird, Lord Howe's Island, C. Moore.

Lepyrodon, Hampe.

L. Lagurus, Hook., Musci. exot., t. 126 (Leucodon).
Mt. Latrobe, Australian Alps; Tasmania, Hooker, Archer, Oldfield.

Garovaglia, Endlicher.

1. * Euptychium.

G. cuspidata, Mitt. in Kew Journ. Bot. VIII., 263 (Esenbeckia); Euptychium Neo-Caledonicum, Schimper.
Moreton Bay, F. v. M.; Brisbane River, A. Dietrich.
G. mucronata, Hampe in Linnæa, 1874, 666.
Lord Howe's Island, Fullagar and Lind.
G. robusta, Hampe in Linnæa, 1874, 667.
Lord Howe's Island, Fullagar and Lind.
G. Muelleri, Hampe in Linnæa, 1876, 318 (Endotrichum).
Tropical East Australia, Eaves.

2. ** Endotrichella.

G. lepida, C. Muell. in Linnæa, 1871, 157.
Herbert's River, Dallachy.
G. Dietrichiæ, C. Muell. in Linnæa, 1871, 155.
Brisbane River, A. Dietrich.

3. *** Cladomnion, (J. Hooker & Wilson; Ptychothecium, Hampe; stereodon, Mitten).

G. sciuroides, Hook., Musci. exot. 175 (Leskea); G. glyphotheca, C. Muell. in Linnæa, 1855, 212 (Neckera); G.

Muelleriana, Hampe in Linnæa, 1860, 637 (Glyphothecium).
Tasmania, Sir J. Hooker; Tarwin, Gippsland, F. v. M.

Ptychomnion, J. Hook. and Wils.

P. aciculare, Labill (Hypnum), Brid.
New South Wales, Capt. Cartwright; Victoria, F. v. M.; Tasmania, Lyall, Gunn, Archer, Oldfield.

Pterobryum, Hornschuch.

1. * Calyptothecium.

P. Australinum, Mitten; rami pinnati, frondiformes, stipitati; folia (e medio frondis) complanata, patentia; media ovata, apice late acuta; lateralia complicata, infra apicem parum excavata, omnia nervo tenui ultra medium evanido prædita, margine, integerrima, cellulis oblongis pellucidis areolata.
Islands of Moreton Bay, F. v. M.

Fronds 3 inches high, about 2 millimetres wide, where the foliage is most fully developed. In colour pale-green, scarcely shining.

P. humile, Mitt.; P. Australino simillimum, sed folia (e medio frondis) oblonga, obtusa; lateralia complicata; omnia nervo tenui, supra medium evanido prædita, margine apicem versus subserrulata, cellulis oblongis areolata.
Richmond River, Henderson.

P. acutum, Mitt.; folia (e medio frondis) ovata, apice obtuse acuminata, lateralia breviter acutata et complicata, omnia basi cordato-auriculata, nervo tenui supra medium evanido instructa, apice serrulata, cellulis elongatis areolata.
Richmond River, Henderson.

P. duplicato similior.

2. ** Trachyloma.

P. planifolium, Hook. (Neckera).
Parramatta, Woolls; Tasmania, Mossman.

P. Muelleri, Hampe.
Apollo Bay, F. v. M.

P. diversinerve, Hampe.
Yarra River, F. v. M.

3. *** Braithwaitea (Lindberg; Dendro-Leskea, Hampe).

P. sulcatum, Hook. Musc. exot., t. 164 (Leskea); Pt. nematosum, C. Muell. in Linnæa XXXV., 615 (Pilotrichum).
Near Port Jackson, R. Brown; Ranges between the Burnett and Brisbane Rivers, F. v. M.; Brisbane River, Bailey.

Meteorium, Bridel.

M. Kermadecensis, C. Muell. in Bot. Zeit., 1857, 779; M. Hornschuchii, Mitt. (Trachypus); M. cuspidiferum, Taylor in J. Hook., Fl. Tasm. II., 203.
Tasmania, Hooker, Gunn, Oldfield, Archer.

M. Eavesianum, Hampe in Linnæa, 1876, 219 (Neckera, Pilotrichella).
Sub-tropical East Australia, Eaves.

M. limbatum, C. Muell. & Hampe in Linnæa, 1853, p. 502; M. cerinum, J. Hook. et Wils. in Fl. Tasm. II., 203.
Victoria, F. v. M.; Ash Island, Hunter River, Mrs. E. Forde; Maitland, Vicary; Tasmania, Archer.

M. filipendulum, J. Hook. et Wils. in Fl. Tasm. II., 203; Neckera Scottiæ, C. Muell. in Linnæa XXXV., 621 (Papillaria).
Ash Island, Hunter River, Mrs. E. Forde; Brisbane, Bailey; Tasmania, Gunn.

M. amblyacis, C. Muell. in Linnæa XXXVI., 521.
New South Wales, Leichhardt; Brisbane River, Bailey.

M. flexicaule, Tayl. in J. Hook. Fl. N. Zeal., 101.; M. squamatum, C. Muell. & Hampe in adnot. ad M. amblyacem, in Linnæa XXXVI., 522, probably also.
Australia, Tasmania, Archer.

M. Reginæ, Hampe in Linnæa, 1876, 319 (Neckera, Pilotrichella).
Toowoomba, Hartmann.

M. dimorphum, C. Muell. in Linnæa, 1873, 516.
Blue Mountains, New South Wales, Mrs. Calvert.

M. fulvum, Mitt. in Journ. Linn. Soc., 1859.
Tarwin, F. v. M.

M. molle, Hedwig (Leskea).
Tarwin, F. v. M.

M. Billardieri, Hampe.
Gippsland, F. v. M.

M. trichophoroides, Hampe in Linnæa, 1874, 668.
Lord Howe's Island, Fullagar and Lind.

M. compressum, Mitten; rami elongati, flexuosi, ramulis irregularibus remotis pinnati, saepe attenuati: folia appressa, a basi amplexante subcordata oblongo-lanceolata, in ramulis longius et tenuissime flexuoso-angustata, remote denticulata, inferne crenulata, cellulis angustis unipapillatis areolata, enervia.
Brisbane River, Bailey.

Neckera, Hedwig.

N. aurescens, Hampe in Linnæa, 1855, 212; N. leptotheca, Mitt. in Hook. Kew Journ. VIII., 263.
Tarwin and Brodribb Rivers, F. v. M.

N. hymenodonta, C. Muell. in Bot. Zeit., 1851, 564; N. pennata, var. Tasmanica, Hampe in Linnæa, 1852; N. pennata, Wilson in J. Hook. Fl. Tasm. II., 204.
Tasmania, Mossman, Archer.

N. Leichhardti, Hampe & C. Muell. in Linnæa, 1870, 520.
New South Wales, Leichhardt.

Homalia, Bridel.

H. falcifolia, J. Hook. et Wils. in Fl. N. Zeal., t. 92.
Tasmania, Gunn.

Porotrichum, Bridel.

(Camptochæte, Reichardt; Lembophyllum, Lindberg; Cœlidium et Isothecium, J. Hook. et Wils.; Thamniella, Bescherelle.)

P. arbusculum, Hook. (Neckera).
Tasmania, Archer, Gunn, Oldfield.

P. fruticosum, Mitten; P. arbusculo simillimum, sed foliis ovalibus acutioribus et theca in pedunculo elongato pendula dignoscendum.
Tasmania, Gunn.

P. divulsum, J. Hook. and Wils. in Fl. N. Zeal., t. 90.
Tarwin, F. v. M.; Tasmania, Lawrence, Gunn, Archer, Oldfield.

P. deflexum, Mitten in Muscis Stephensonii; Dendro-Hypnum Leichhardti, Hampe in Linnæa, 1876, 523 (probably).
Sealers' Cove, F. v. M.; New South Wales, Leichhardt.

P. vagum, Hornsch. (Hypnum); P. assimile, Hampe; P. Schlosseri, Sendtner.
Richmond River, Henderson; Parramatta, Woolls; Brisbane River, Bailey; Tasmania, Archer.

P. ramulosum, Mitt. in Kew Journ. of Bot. VIII., 253; P. chlorocladium, C. Muell. in Linnæa XXXV., 622.
Steep Bank and Tarwin River, Apollo Bay, F. v. M.; Brisbane River, Bailey; Bellenden Ker's Range, Karsten.

P. clandestinum, J. Hook. et Wils. in Fl. N. Zeal., t. 90.
Sealers' Cove, F. v. M.

P. cochlearifolium, Schw., t. 88 (Hypnum).
Tasmania, Archer, J. Hooker.

P. gracile, J. Hook. et Wils. in Fl. Antarct., t. 61.
Tasmania, Archer.

P. decurvatum, Hampe.
Locality unrecorded.

P. pseudo-pilaceum, Hampe.
Locality unrecorded.

P. orbiculare, Hampe.
Locality unrecorded.

P. Novæ Cambriæ, Hampe.
Locality unrecorded.

Thamnium, Schimper.

T. pandum, J. Hook. et Wils.
Parramatta, Woolls.

T. flagellare, Angstrœm in der Hedwigia, 1875, p. 66.
Australia.

T. eflagellare, Angstrœm in der Hedwigia, 1875, p. 66.
Sydney.

T. pumilum, J. Hook. et Wils. in Fl. Tasm. II., 206 (Isothecium); T. rivale, Mitten.
Tasmania, Archer.

T. perpusillum, C. Mueller.
Australia.

XVI. SEMATOPHYLLEÆ.

Rhaphidorrhynchum, Schimper.

R. Joliffii, Mitt. in J. Hook. Fl. Tasm. II., 213.
Tasmania, Archer.

P. homomallum, Hampe, Icon., 6; Leskea Drummondii, Taylor.
Swan River, Drummond, Preiss; King George's Sound, Cunningham; St. Vincent's Gulf and Sealers' Cove, F. v. M.; Tasmania, Gunn, Oldfield, Hooker.

R. contiguum, J. Hook. et Wils. in Fl. Tasm. II., 213; R. subhomomallum, C. Muell. in Bot. Zeit., 1857, 781.
New South Wales, R. Brown; Brisbane River, Bailey; Lord Howe's Island, M'Gillivray.

R. cerviculatum, J. Hook. et Wils. in Fl. N. Zeal., t. 91.
Tasmania, Archer, Gunn.

R. limatum, J. Hook et Wils. in Fl. Tasm. II., 213.
Tasmania, Lyall, Archer, Oldfield; Gippsland, F. v. M.

R. calidioides, C. Muell. in Linnæa, 1856, 213.
Sealers' Cove, F. v. M., Australian Mosses, pl. XIV.

R. tenuirostre, Hook., Musci exot. 111 (Hypnum).
Tasmania, Gunn, Oldfield.

R. splendidula, Hampe (Leskea).
Locality unrecorded.

Acanthocladium, Mitten.

(Acanthodium, Mitten olim.)

A. extenuatum, Bridel (Hypnum); H. crinitum, J. Hook. et Wils.; Leskea amblyocarpa, Hampe in Linnæa, 1860 (probably).
Bunyip Creek, F. v. M.; Macquarie River, Ball; Tasmania, Archer, Gunn.

XVII. STEREODONTEÆ.

Entodon, C. Mueller.

E. pallidus, Mitt. in Seem. Fl. Vit., 398.
Brisbane River, Bailey; Queensland, Miss Gore.

E. Tasmanicus, Mitten; robustus; caulis quadriuncialis; folia compressa, ovata, acuta, apice serrulata.
Hobarton.

E. Hartmanni, C. Muell. in Rev. Bryol., 1877, p. 4.
Toowoomba, Queensland, Hartmann.

E. Novæ Valesiæ, Hampe.
New South Wales.

E. Myosurella, C. Muell. in Rev. Bryol., 1876, p. 4.
Near Sydney, Kayser.

E. Mackayensis, C. Muell. in Linnæa XXXVII., 155.
Port Mackay, A. Dietrich.

E. Dæmelii, C. Mueller.
Gayndah, Queensland, Dæmel.

Plagiothecium, Bruch & Schimper.

P. denticulatum, Linn. (Hypnum).
Tarwin River and Australian Alps, F. v. M.; Tasmania, Oldfield.

P. lamprostachys, Hampe in Linnæa, 1859, 60 (Platyhypnum).

P. Howeanum, C. Mueller (Hypnum).
Lord Howe's Island, Fullagar and Lind.

Acroceratium, Mitten.

A. auriculatum, Montagne; Hypnum chlamydophyllum, J. Hook. et Wils. in Fl. Antarct., t. 61.
Tarwin River, F. v. M.; Tasmania, Archer.

A. politum, J. Hook. et Wils. in Fl. Antarct., t. 154 (Hypnum); callichroum, Mont. (Phyllogonium); elegans, Hampe (Phyllogonium) in Linnæa, 1855, 212; Mitt. in Kew Journ. Bot. VIII.; Hampeanum, C. Muell. in Linnæa, 1869, 29 (Orthorhynchium).
Sealers' Cove, F. v. M.; Tasmania, Gunn, Mossman, Oldfield.

Isopterygium, Mitten.

I. molliculum, Sullivant in U. S. Explor. Exp., t. 11; C. Muell. in Linnæa, 1871, 160; Hypnum Norfolkianum; H. nitidulum, Hampe et C. Muell. in Linnæa, 1870, 524 (Platyhypnum).
Norfolk Island, Thompson; Lord Howe's Island, M'Gillivray.

I. umbilicatulum, C. Muell. in Rev. Bryol., 1876, 4.
Near Sydney, Kayser.

I. candidum, C. Muell. in Rev. Bryol., 1876, 4.
Near Sydney, Kayser.

I. Walterianum, Hampe in Linnæa, 1876, 322.
Mt. Macedon, Walter.

I. austro-pusillum, C. Mueller in Linnæa, 1872, 159 (Platyhypnum, Hampe).
Brisbane River, A. Dietrich.

Amblystegium, Schimper.

A. riparium, Linné (Hypnum); H. Muelleri, C. Muell. & Hampe in Linnæa, 1853, 504.
Latrobe River and Lake Wellington, F. v. M.

A. uncinatum, Hedwig; Hypnum pseudo-uncinatum, Hampe in Linnæa, 1860, 639.
King George's Sound, Cunningham.
A. decussatum, J. Hook. et Wils. in Fl. N. Zeal., t. 90. (Hypnum).
Tasmania, Gunn.
A. oblongifolium, Hampe in Linnæa, 1860, 641.
South Esk River, Tasmania, F. v. M.
A. fluitans, L. (Hypnum); Hypnum pseudo-fluitans, Hampe.
Tasmania, Gunn.
A. convolutifolium, Hampe in Linnæa, 1859, 641 (Serpenti-Hypnum).
Dargo, F. v. M.
A. fontinaloides, Hampe in Linnæa XXXVII., 518.
Blue Mountains, Mrs. Calvert.

Stereodon, Bridel.

S. chrysogaster, C. Mueller; Hypnum patale, J. Hook. and Wils. in Fl. N. Zeal., t. 90.
Tasmania, Archer.
S. cupressiforme, L. var. minor, J. Hook., Fl. Tasm. II., 212; H. Mossmanianum, C. Muell. in Bot. Zeit., 1851, 565.
Sealers' Cove, F. v. M.; Tasmania, Archer, Gunn.
S. leucochlorum, Hampe in Linnæa XXXVIII., 669.
Lord Howe's Island, Fullagar and Lind.
S. Walterianum, Hampe.
Victoria, Walter.

Ectropothecium, Mitten.

E. Slateri, Hampe in Linnæa, 1876, 321 (Hypnum).
Brisbane River, Slater.
E. Hillianum, Hampe in Linnæa, 1876, 322 (Hypnum).
Queensland, W. Hill.
E. cygnisetum, C. Mueller.
Locality unrecorded.

XVIII. HYPNEÆ.

Fabronia, Raddi.

F. Hampeana, Sonder; Hampe, Icon., 13; F. incana, Taylor.
Swan River, Drummond, Preiss.
F. Australis, Hook., Musc. Exot., 160.
King George's Sound, Menzies.

F. Scottiæ, C. Muell. in Linnæa XXXV., 620.
Ash Island, Hunter River, Mrs. E. Forde.
F. Tayloriana, Hampe in Linnæa, 1870, 522.
Mt. Disappointment, Taylor; M'Arthur's Creek, on Casuarina, F. v. M.

Stereophyllum, Mitten.

S. lepturum, Tayl. (Hypnum).
Swan River, Drummond; King George's Sound, Cunningham.

Rhynchostegium, Schimper.

R. tenuifolium, Hedwig; Hypnum collatum, J. Hook. and Wils. in Fl. Tasm. II., 209; H. Megapolitanum, Hampe in Linnæa, 1855, 213.
Sealers' Cove, F. v. M.
R. subclavatum, Hampe.
Sealers' Cove.
R. antipodum, Hampe.
Locality unrecorded.
R. dentiferum, Hampe in Linnæa, 1859, 60.
Gippsland, F. v. M.
R. patulum, Hampe in Linnæa, 1872, 162.
Gippsland, Walter.
R. laevisetum, Geheeb in Rev. Bryol., 1876, p. 4.
Sydney, Kayser.
R. obtusum, Geheeb in Rev. Bryol., 1876, p. 4.
Sydney, Kayser.
R. latifolium, Geheeb in Rev. Bryol., 1876, 4.
Sydney, Kayser.
R. distractum, Hampe in Linnæa, 1860, 642.
Sealers' Cove, F. v. M.
R. luxatum, Mitt. in Kew Journ. Bot. VIII., 264.
Gippsland, F. v. M.
R. pseudo-stramineum, Hampe in Linnæa, 1872, 518.
Blue Mountains, Mrs. Calvert.
R. cucullatum, Mitt. in Kew Journ. Bot. VIII., 265.
Dargo River, F. v. M.
R. incurvum, Hampe in F. v. M. fragm. XI., suppl. 51 (Hypnum).
Locality unrecorded.
R. Parramattense, Hampe & C. Mueller (Hypnum).
New South Wales.

R. erythropodium, Hampe in Linnæa XXXVII., 161 (Hypnum).
Rockingham's Bay, Dallachy.

R. strumiferum, Hampe in F. v. M., fragm. XI., suppl. 51.
Locality unrecorded.

R. congruens, Hampe in Linnæa, 1858, 643; F. v. M., Austr. Mosses, pl. XIII.
Victoria Ranges, Steep-bank River, F. v. M.

R. glauco-viride, Hampe in Linnæa, 1876, 325.
Rockingham Bay, Dallachy.

R. austro-montanum, Hampe in F. v. M. fragm. XI., suppl. 51 (Hypnum).
Locality unrecorded.

R. pseudo-murale, Hampe in Linnæa, 1859-60 (Hypnum).
Gippsland, Moe Swamp, F. v. M.

R. Pseudo-Teesdalii, Hampe in Linnæa, 1859-60 (Rhyncho-Hypnum).
Gippsland, Broadrib River, F. v. M.

R. muriculatum, J. Hook. et Wils.
Tasmania, J. Hooker, Gunn.

R. trachychaetum, F. v. Mueller, Australian Mosses, pl. XV.,
Victoria, F. v. M.

R. subpungens, Hampe et C. Mueller.
Locality unrecorded.

R. glaucescens, Hornschuch.
Locality unrecorded.

Brachythecium, Schimper.

B. aristatum, J. Hook. et Wils. in Fl. Tasm. II., 210 (Hypnum)
Tasmania, Archer, Gunn.

B. Kayseri, Geheeb in Rev. Bryol., 1876, 4.
Near Sydney, Kayser.

B. Novæ Valesiæ, Geheeb in Rev. Bryol., 1876, 4.
Near Sydney, Kayser.

B. paradoxum, J. Hook. et Wils. in Fl. Antarct., t. 155 (Hypnum).
Gippsland, F. v. M.; Tasmania, Archer.

B. salebrosum, Mitten; B. campestre, Mitten in J. Hook., Fl. Tasm, II., 210, non Bruch.
Tasmania, Archer.

P. rutabulum, L. (Hypnum).
Tasmania, Archer, Gunn, Oldfield.

B. austro-alpinum, Hampe in Linnæa, 1859-60 (Sciuro-Hypnum).
Australian Alps, F. v. M.

Sciaromium, Mitten.

S. glauco-virens, Mitt. in Seem. Fl. Vit., 400.
Norfolk Island.

Hypnodendron, C. Mueller.

(Mniodendron, Lindberg).

H. comosum, Labillardière (Hypnum).
Tasmania, Labillardière; Gippsland, F. v. M.

H. Sieberi, C. Muell., Syn. II., 504.
New South Wales, Sieber; Tasmania, J. Hooker, Gunn, Archer.

H. Colensoi, J. Hook. et Wils. in Fl. Tasm. II., t. 176.
Tasmania, Gunn.

H. Archeri, Mitt. in J. Hook. Fl. Tasm. II., 206.
Tasmania, Archer.

H. arcuatum, Hedwig; H. spininervium, Hook., Musci exot. 29.
Victoria, F. v. M.; Bellenden Ker Range, Karsten.

H. prænitens, Hampe in Linnæa, 1874, 671.
Lord Howe's Island.

Thuidium, Schimper.

T. furfurosum, J. Hook. & Wils. in Fl. N. Zeal. 107 (Hypnum); H. unguiculatum, J. Hook. and Wils. in Fl. Tasm. II., t. 176; H. hastatum, C. Muell.; H. Stuartii, C. Muell. in Linnæa, 1856, 459; H. amblystegioides, C. Muell. in Rev. Bryol. 1876, 4.
Tasmania, Archer; Ash Island, Mrs. Forde; Victoria, F. v. M.

T. sparsum, J. Hook and Wils.
Bellenden Ker Range, Karsten; Logan River, Scortechini; perhaps var. of the preceding.

T. ramentosum, Mitten.
Toowoomba, Hartmann; Brisbane River, Bailey, Logan River, Scortechini; Parramatta, Woolls; Norfolk Island, Thompson; Bellenden Ker Range, Karsten.

T. læviusculum, Mitt. in J. Hook. Fl. Tasm. II., 207.
Parramatta, Woolls.

T. nano-delicatulum, Hampe in Linnæa, 1876, 324.
Illawarra, Johnson; sub-tropical East Australia, Eaves.

T. erectum, Hampe.
Locality unrecorded.

T. suberectum, Hampe in Linnæa, 1860, 638; F. v. M., Austr. Mosses, pl. XII.
Tarwin River, F. v. M.

T. rubens, Hampe & C. Muell.
Locality unrecorded.

T. plumuliforme, Hampe, in Linnæa, 1876, 324.
Illawarra, Johnson.

XIX. SKITOPHYLLEÆ.

Fissidens, Bridel.

F. Muelleri, Hampe in Linnæa 1855, 214 (Conomitrium), et 1860, 644; F. Dillenii, Mitt. in Kew Journ. Bot. VIII., 262.
Murray River, F. v. M.

F. rigidulus, J. Hook. & Wils. in Fl. N. Zeal., t. 83.
Australian Alps, F. v. M., Tasmania, Archer, Gunn, Oldfield.

F. pungens, C. Muell. & Hampe in Linnæa, 1853, 502; F. v. Mosses Austr. M. pl. XVII.; incurvus var., Wilson, in J. Hook. Fl. Tasm. II., 167.
Barossa Range, F. v. M.

F. vittatus, J. Hook. & Wils. in Fl. Tasm. II., 167.
Swan River, Drummond; Tasmania, Gunn; Gippsland, F. v. M.

F. maceratus, Mitten; humilis, flaccidus; folia laxe inserta, ligulato-lanceolata, acuta, integerrima, nervo tenui supra medium laminæ apicalis evanescente prædita; lamina vera æqualis; cellulæ ovali-hexagonæ, pellucidæ; margo limbi angustissimus, fere obsoletus; theca in pedunculo elongato erecta, obovata.
Brisbane River, Bailey.

Caulis 2 mm. altus; folia 2 mm. longa; pedunculus 4 mm. altus.

F. incurvus, Schwægrichen, J. Hook. Fl. Tasm. II., 167.
Tasmania, Gunn, Oldfield.

F. Taylori, C. Mueller; F. pygmæus, Tayl. in Lond. Journ. of Bot. 1846, 66.
Swan River, Drummond; Tasmania, Archer.

F. pacificus, Angstrœm in Œfvers of Kongl. Vetens. Fœrh., 1872-3.
New South Wales, Prof. Anderson.

F. delicatulus, Angstr., Œfvers of Kongl. Vetens. Fœrh. 1872-3.
New South Wales, Prof. Anderson.

F. linearis, Brid., Syn. I., 71.
Australia.

F. semilimbatus, C. Muell. & Hampe in Linnæa 1853, 501.
Yarra; Gippsland, F. v. M., Australian Mosses, pl. XVIII.

F. oblongifolius, J. Hook. & Wils. in Fl. N. Zeal., t. 83.
Tarwin, F. v. M.; Tasmania, Archer.

F. strictus, J. Hook. & Wils. in Fl. Tasm. II., 167.
Tasmania, Oldfield.

F. integerrimus, Mitt. in J. Hook. Fl. Tasm. II., t. 171.
Tasmania, Archer.

F. hyophilus, Mitten; monoicus; caulis decumbens, ramosus; folia linealia, obtuseacutata; lamina vera apice subæqualis, immarginata; nervus pellucidus, ante apicem evanidus; cellulæ minutæ, rotundæ, obscuriusculæ, marginales minutissime prominulæ; theca in pedunculo folii longitudinis parva, ovalis, subæqualis; operculum rostratum.
Ranges between the Burnett and Brisbane Rivers, F. v. M. Caulis 5-10 mm. longus; folia, 2 mm. longa; pedunculus 2 mm.; color luteo-viridis.

F. pallidus, J. Hook. & Wils. in Fl. N. Zeal., t. 83.
Tasmania, Gunn.

F. tenellus, J. Hook. & Wils. in Fl. N. Zeal. II., t. 83.
Sealers' Cove, F. v. M.; Tasmania, Archer.

F. perpusillus, C. Muell. & Hampe in Linnæa, 1855, 214 (Conomitrium).
Sealers' Cove, F. v. M., Australian Mosses, pl. XVI.

F. basilaris, C. Muell. & Hampe in Linnæa, 1853, 501.
Barossa Range, F. v. M.

F. macrodus, Hampe in Linnæa, 1860, 645; F. v. M., Austr. Mosses, pl. XIX.
Yarra River, F. v. M.

F. elamellosus, C. Muell. & Hampe in Linnæa, 1855, 214; F. v. M., Austr. Mosses, pl. XX.
Yarra River, F. v. M.

F. Victorialis, Mitten; caulis gracilis, elongatus; folia integerrima, parva, oblongo-lanceolata, acuta; lamina vera apice inæqualis; nervus intus apicem evanidus, obscure fusco-flavus; cellulæ minutæ, rotundæ, limitibus latius culæ, pellucidæ.

Victoria River, F. v. M.

Caulis 1 centm. altus, cum foliis $1\frac{1}{2}$ mm. latus.

One of the only three mosses seen by me in North-west Australia in 1855 and 1856—F. v. M.

F. Dietrichiæ, C. Muell. in Linnæa, 1871, 146.

Brisbane River, Dietrich.

F. dealbatus, J. Hooker & Wilson.

Tasmania, Archer.

F. Archeri, F. v. M.

F. adiantoides, Wilson in J. Hook. Fl. Tasm. II., 168 non Hedwig.

Tasmania, Gunn, Archer.

XX. POLYTRICHEÆ.

Buxbaumia, Haller.

B. Tasmanica, Mitt. in J. Hook. Fl. Tasm. II., 199.

Tasmania, Archer.

Atrichum, Beauvois.

A. Muelleri, C. Muell. & Hampe in Linnæa, 1855, 211 (Catharinea); A. ligulatum, Mitt. in J. Hook. Fl. Tasm. II., 200.

Dandenong, Apollo Bay, Tarwin River and other places in Gippsland, F. v. M.; Parramatta, Woolls; Tasmania, Archer.

Psilopilum, Bridel.

P. crispulum, J. Hook. & Wils. in Fl. N. Zeal., t. 87.

Tasmania, Archer.

P. Australe, J. Hook. & Wils. in Fl. N. Zeal., t. 87.

Tasmania, J. Hooker, Archer.

P. pyriforme, Hampe in Linnæa XXXVII., 517 (Catharinea).

Blue Mountains, Mrs. Calvert.

Polytrichadelphus, C. Mueller.

P. Magellanicus, Hedw., Sp. Musc., t. 20, f. 1. (Polytrichum, L.); P. innovans, C. Muell. in Bot. Zeit., 1851, 548.

Tasmania, Oldfield, Archer, Mossman.

P. Australasiæ, Hampe in Linnæa, 1876, 315.
Sub-tropical East Australia, Eaves; Richmond River, Capt. Stackhouse.
P. Arnoldi, Hampe.
Mount Arnold, Upper Yarra, and Goulbourne River, F. v. M.

Pogonatum, Bridel.

P. alpinum, L. (Polytrichum); P. austro-alpinum, F. v. M.; P. pseudo-alpinum, C. Muell. in Bot. Zeit., 1853, 750.
Cobberas Mts., Australian Alps, F. v. M.; Tasmania, Archer.
P. Gulliveri, Hampe in Linnæa, 1876, 315.
Mt. Wellington, Tasmania, Gulliver.

Polytrichum, Dillenius.

P. commune, Linne, sp. pl. 1109.
Victoria, F. v. M.; Tasmania, Gunn, Archer.
Var. perigoniale.
Cobberas Mts., F. v. M.
P. Novæ Hollandiæ, Jæger, I., 732; P. densifolium, Hampe in Linnæa, 1860, 635.
Mount Wellington, F. v. M.
P. juniperinum, Hedwig, Spec. Musc., 89.
Victoria, up to the highest Alps, F. v. M.; near Melbourne, Adamson; Mt. Wellington, Tasmania, Mossman, Archer.
P. Sullivani, Hampe in Linnæa, 1876, 316.
Between Mt. Ararat and Mt. William, Sullivan.

Dawsonia, R. Brown.

D. superba, Greville in Ann. and Mag. of Nat. Hist., 1847, 226, pl. 12.
N. S. Wales; Dandenong, Upper Yarra, Sealers' Cove and many other places in Gippsland, F. v. M.; Tasmania, Archer.
D. polytrichoides, R. Brown.
Near Port Jackson, R. Brown; Parramatta, Woolls.; Brisbane River, Bailey; Ash Island, Mrs. Forde.
D. longiseta, Hampe in Linnæa, 1860, 634; F. v. M., Austr. Mosses, pl. IX.
Parramatta, Woolls; Brisbane River, Bailey.

D. appressa, Hampe in Linnæa, 1858, p. 635; F. v. M.; Australian Mosses, pl. X.
Onkaparinga Valley, St. Vincent's Gulf, F. v. M.

XXI. SPHAGNEÆ.

Sphagnum, Dillenius.

S. confertum, Mitt. in J. Hook. Fl. Tasm. II., 163.
Tasmania, Archer.
S. Australe, Mitt. in J. Hook. Fl. Tasm. II., 163.
Tasmania, Archer.
S. cymbophyllum, F. v. M., second gen. rep., 1854, p. 17; S. cymbifolioides, C. Muell. in Bot. Zeit., 1851, 546 (nomen vix servandum) et forsan S. contortum, Wilson in J. Hook. Fl. Tasm. II., 162.
Australian Alps, F. v. M.; Tasmania, Gunn, Archer. Oldfield.
S. molliculum Mitt. in J. Hook. Fl. Tasm. II., 163.
Tasmania, Archer.
S. Novæ Zealandiæ, Mitt. in J. Hook. Fl. Tasm. II., 163.
Tasmania, Archer.
S. cristatum, Hampe.
Australian Alps, F. v. M.
S. compactum, Bridel.
Tasmania, Oldfield.
S. subcontortum, Hampe in Linnæa, 1876, 301.
Mount Warning, Guilfoyle.
S. cymbifolium, Dillenius.
Gippsland, F. v. M.; Brisbane River, Bailey; Tasmania, Gunn, Archer, Oldfield.

XXII. ANDREÆÆ.

Andreæa, Ehrhart.

A. subulata, Harvey in Hook. Icon. pl. rar. II., 201.; A. pseudo-subulata, C. Muell. in Bot. Zeit., 1864.
Tasmania, Archer.
A. Australis, F. v. M.; Mitten in Kew Journ. Bot. VIII., 257.
Munyang Mountains, Mt. Wellington and other places high in the Australian Alps, F. v. M.

A. montana, Mitt. in J. Hook. Fl. Tasm. II., 161.
Tasmania, Archer.
A. nitida, J. Hook. & Wils. in Fl. Antarct., t. 53.
Tasmania, Archer.
A. asperula, Mitt. in Journ. Linn. Soc., 1859; A. Muelleri, Sonder.
Australian Alps, F. v. M.
A. petrophila, Ehrhart Beitr. I., 192.
Tasmania, Archer, Gunn.
A. acuminata, Mitt. in Journ. Linn. Soc., 1859.
Tasmania, Archer.

ART. IV.—*Electric Lighting.*

BY R. E. JOSEPH.

[Read 11th May, 1882.]

A FEW months back, in a paper read before you, I briefly reviewed the progress and improvements that had taken place in electric lighting, and then promised to lay before you, at a future time, further information on the subject. In my former paper I gave you an account of the principal machines used in generating currents, of the lamps in use, and the adaptation of different systems for various requirements. Since then certain changes that have taken place, not so much in the construction of the apparatus as in the methods of using them, have necessitated a slight alteration in my views on the matter. Commencing with generators of the current, the battery appears to have remained in exactly the same position as before, and I am not aware of any improvements having been made in any of the numerous forms, to render it a useful agent for electric lighting. In dynamo-machines the principle of construction remains the same; very little, if anything, has been done to render the machines more efficient. As a proof of this, the Siemens, Gramme, and Brush, which were spoken of as giving the best results, still hold the foremost position amongst the now numerous descriptions of machines. The original Siemens machine gives now, as before, a very high per centage of useful work per horse-power, followed, however, very closely by the Gramme. Since my former paper some twenty or thirty new descriptions of dynamo-machines have been introduced, but a very slight examination shows that they are all constructed on either the Siemens or Gramme principle, and that if they possess any advantage over them, it is, in most cases, in mechanical details, such as simplifying their manufacture, reducing the tendency to over-heating, and arrangements of certain parts to facilitate cleaning, &c. There are, however, one or two exceptions in which a very high amount of efficiency has been obtained, with the use of less wire on the revolving coils than usual; this extra efficiency being gained by the methods of arranging the coils, and also by placing nearly the whole of the wire in the magnetic field. Amongst the most prominent and successful of these modifications are the Weston, Burgin, and Schukert machines. The Weston has a Siemens armature, but contains half the number of coils on its circumference, the place of the wire being taken by soft iron, and the wire itself laying in a channel surrounded by soft iron, has its inductive effects considerably augmented. The Burgin is a combination of the Siemens and Gramme. The revolving bobbin is long,like the Siemens, but it is built up of a series of rings, wound something like the Gramme, and connected together. The Schukert is a Gramme ring, but exposes nearly the whole of the wire in the magnetic field. Dynamo-machines are now required, giving two different kinds of current—low tension for single, and high tension for multiple arc lights. The low tension is of course easily attainable, large wire and low speed, giving a very large current of very low tension. The most remarkable description of machine of this kind is Edison's, the armature being built up of bars of copper, having practically no resistance whatever, driven at a speed of 350 revolutions per minute, it is stated it will supply sufficient current to maintain 1000 incandescent lamps of about seven candle-power each, all joined up of course in parallel circuit.

To obtain currents of high tension is not so easy. With the present system of generating currents, it is attained by either decreasing the size of the wire on the bobbins and increasing the number of convolutions, or by increasing the speed of rotation. In the first instance the trouble of heating and destroying the coils makes its appearance, and in the second the difficulties of mechanical construction—that of making the revolving bobbin in such a form as to be perfectly secure, and to prevent the wire flying off when revolved at very high speeds. Consequently, up to the present time, the highest tension current machine made is that of Brush, capable of supporting forty arc lights on one circuit.

The armature is a modification of the Gramme ring, and contains a very large quantity of wire wound in spaces cut out of the iron ring. Special precautions are taken to prevent cross-currents being generated, and for keeping the armature cool. The wire coils pass very close to the pole-pieces of the field-magnets, the very excellent workmanship shown in the construction of the machine enabling this to be done with safety. The commutator is so arranged as to supply a current to excite the field magnets without passing into the outside circuit, whilst it also cuts out all coils that are not used in generating a current, thus reducing the resistance of the machine. In other machines the same end is obtained by using a separate machine to excite the field-magnets of the generator; this, whilst keeping the field-magnets in perfectly uniform condition, lowers the resistance and increases the electro-motive force to a considerable extent. The question, however, arises as to the advisability of using machines of high tension. Looking at electric lighting as a thoroughly practical means for illumination, it appears certain that it will be necessary to maintain a considerable number of lights on one circuit. I refer now to arc lights. The difficulties I mention do not apply to the same extent to the incandescent lamp. In the earlier days of electric lighting, where instalations were used in certain buildings only, lights fed from single machines were found convenient, and unquestionably the most economical for very powerful lights. When, however, the method of lighting from a central station and supplying a very great number of lights distributed at various distances from the generator had to be determined, it became evident that it would be impossible to carry it out by the same system. The immense number of conductors required would alone be sufficient to condemn it, apart from the cost of attendance to the number of machines that would be in use. Therefore, systems capable of supporting a number of lights from one machine rapidly gained public favour, and the system that could support the greatest number of lamps in the same circuit has commercially been the greatest success. But has this advantage been gained in a right direction? and if the present system be adhered to, does it not amount to either a limit to the number of lights to be used or the introduction of machines which for safety to human life are hardly to be desired. The original dynamo-machines constructed to generate low tension currents are perfectly harmless, the current may be conducted by imperfectly insulated conductors, as in the instance of the Berlin electric railway, where the iron rails laid on wooden sleepers are the only conductors used, and they answer perfectly even in wet weather. A person coming in contact with the wires or any portion of the apparatus might, and probably would, detect the presence of a current, but that is all; so that for safety and facility for conducting the current, the low tension was all that could be desired. But then it became clear that if a considerable distance intervened between the lamp and the machine, a very large conductor became necessary, whilst if more than one light was required on one circuit, the low tension current failed to support them. Consequently the tension of the current was increased in proportion to the number of lights required to be maintained, or for the distance the current had to pass between the machine and lamp, and attended with the usual characteristics of currents of this nature.

The insulation of everything in connection with the circuit has to be most carefully attended to; and such insulation requires to be of a very high nature, or failures must occur. The recent failures of the Brush system in London, Edinburgh, and elsewhere, have all been traced to imperfect insulation of the circuit, and if it has been found difficult and expensive to provide a perfect insulation for a current supporting from 30 to 40 lights, those who are familiar with the behaviour of high tension currents will at once realise the state of affairs, if machines were made to support, say, even 100; and with the difficulties of insulation comes the dangers from fire, and loss of human life. With a badly insulated conductor from such machines, fires have occurred undoubtedly; whilst there have also been several instances recorded of fatal accidents occurring through the same cause, and although, by taking careful precautions, the risks of mishaps may be reduced to a minimum, they are always liable to occur, and with any increase in the tension of the current, probably would constantly occur. It would therefore appear that machines capable of supporting, say, from ten to fifteen powerful arc lights, are the largest that should be used, both for safety and certainty in working, as long as high-tension currents are required for such purpose. This would therefore point to the conclusion, that, for successful and commercial electric lighting, we should look in another direction, even if we have to re-arrange the whole of our present system of working.

Since writing this I have come across a paper read by Mr. Swan, before the Royal Institution, and printed in *Engineering* for March, and in which the following paragraph appears :—" Can electricity be distributed as widely and cheaply as gas ? On one condition, which I hope can be complied with, this may be answered in the affirmative. The condition is that it be found practicable and safe to distribute electricity of comparatively high tension."

It will thus be seen that Mr. Swan assumes that a high-tension current is absolutely necessary for an extended and economic distribution of the current, and with our present method of working, there is very little doubt that his views are correct. I am, however, of opinion that, instead of endeavouring to perfect any system which requires for its success the employment of such currents, we should turn our attention to obtain the required results by the safe and easily worked low-tension current.

Respecting arc lamps, I have little to add to my former remarks. Their construction has been considerably simplified, and by this means several difficulties formerly experienced in their working have been removed.

The specimens before you this evening are the " Siemen" pendulum and differential lamp, fitted with Dr. Siemen's abutment pole, for burning from fourteen to nineteen hours ; the " Brush," double rod, burning sixteen hours ; and the " Weston" lamp, slightly modified and manufactured in the colony. The last two lamps contain no wheel work or delicate mechanism to feed the carbons, the regulation being effected solely by electro-magnets so arranged that the proper length of arc is maintained by means of a shunt of fine wire placed in circuit between the two carbons, and acting in an opposite direction to the main wire coils. The arc light remains as before the most economical means of illumination for large spaces, a light of about 3000 candle-power being maintained by an efficient dynamo-machine, and driven by a gas-engine consuming about sixty feet of gas per hour, or as much as would suffice for the support of from twelve to fifteen gas-jets for the same period, and when it is borne in mind that gas costs three times as much as coal for an equivalent amount of power, the economy of the arc light becomes at once apparent. The Jablochkoff candles still maintain a prominent position in electric lighting on the Continent; but beyond lighting part of the Thames embankment, London, the system does not appear to have made much progress in England. Semi-incandescent lamps also do not make very much headway. One that has been prominently before the public for some time is the Joel incandescent lamp, and consists of a slender pencil of carbon, the point of which impinges on a copper button. The success it has met with is not due to the principle, which is old, but to the thought and care bestowed in carrying out mechanical details of construction in rendering the lamp certain and automatic in its action.

The use of powerful currents demands a special system of testing. The ordinary methods adopted for battery-testing cannot always be conveniently used, although of course they are the most reliable; but as all of them would involve the use of shunts and a very delicate apparatus, special galvanometers or dynamometers have been introduced, which give fairly approximate measurements. Siemen's dynamometer consists of a coil of wire through which the powerful current is sent, and passes by means of mercurial contacts through a rectangular frame of stout copper wire, suspended by a spiral steel spring at right angles to the wire coil. The instrument being set at zero, the current will deflect the wire-frame, the opposing force being the torsion of the spiral spring. The angle of torsion through which the spring has to be moved in order to bring the wire frame to its zero point, can be read off on the dial, and its value having been previously determined by experiment and a table prepared, the amount of current in ampères flowing through the instrument can at once be ascertained. The accuracy of this instrument depends entirely on the stability of the spiral spring; and in order to render it as stable as possible, it is made of finely tempered steel wire and then gilded.

The absence of permanent magnets in this instrument renders it of use for measuring alternate currents, for which purpose another coil of thinner wire is provided. Another form of galvanometer, lately introduced by Professors Perry and Ayrton, is a modification of the Desprès galvanometer, in which a very small compound magnet needle is placed in the field of a powerful permanent horse-shoe magnet. The needle is also in the centre of a small wire coil, constructed of a strand of ten wires, and so connected with a commutator that the current can be either sent in parallel circuit —that is, with the wires joined together at each end, and representing a short and thick wire—or in series, which would be the wire joined in continuous circuit, of one-tenth the size, but ten times as long as in the former case.

The action of this galvanometer renders the needle perfectly dead beat, returning to zero quickly, whilst the proportions of the instrument are so arranged that the amount of current passing can be read off in ampères without the aid of tables, and by the double arrangement of the wire-coil the galvanometer is ten times more sensitive when joined up in series than in parallel circuit, thus rendering the instrument available for the measurements of small currents. Perry and Aryton's galvanometer has the advantage of being portable, and is sufficiently accurate for ordinary testing or ascertaining the amount of current passing through an electric light circuit. It is particularly valuable in incandescent systems, because it becomes absolutely necessary to keep the current constant and steady, and with such a galvanometer in circuit, any alteration in the current strength can at once be seen. For a temporary instalation of the electric light, and where an engine not specially adapted for driving dynamo-machines is used, the galvanometer, if placed near the engine-driver, serves the purpose of an auxiliary governor. The engine-driver watches the galvanometer needle, and having been directed to keep it at a certain position, increases or diminishes the speed of the engine according to any alteration in the galvanometer. This method answered perfectly well recently at a lecture given at home, the steady working of the Swan lamps shown there being entirely governed by the above arrangement.

In my former paper I spoke with great distrust of Edison's attempts at incandescent lamps. I felt justified in the remarks then made, because really nothing but failures had been recorded against him. Since then he has unquestionably achieved a success, and produced an incandescent lamp, which is stated to be quite equal to that of Swan. The specimens of lamps before you are the "Original" and "New Swan," the "British," and the "Maxim." These lamps are similar in construction—a fine carbon loop in an exhausted and hermetically sealed glass bulb. The Swan carbon is prepared from ordinary crotchet cotton, treated with sulphuric acid and carbonised. The Maxim is made out of cardboard. Edison's is constructed from bamboo fibre, so that they may all be classed as the same—all being converted into carbon. But whilst their construction is apparently the same, their behaviour and endurance differs slightly. Thus the old Swan lamp should not be pressed beyond fifteen to twenty candle-power, when it will last about 600 hours. The new form has lasted over 1000 hours. The Edison lamps must not be pressed beyond seven candle-power, whilst the Maxim ranges from twenty-five to eighty candle-power, absorbing, of course, a larger, but not proportionately larger, amount of current. The incandescent lamp, whilst not being nearly so economical as the arc light, possesses advantages that would more than compensate for this deficiency. It may be accepted, I think, as a fair average that about 200 candle-power per horse-power can be obtained from incandescent lamps, everything being in its highest state of efficiency; but it probably will be found with respect to endurance that from 120 to 150 would produce the most economical results. Probably one of the most peculiar features about the carbon loop is the alteration in its resistance when heated. It is of course well known that increase of temperature in metals increases their resistance; with the carbon loop it is different, increase of temperature reducing the resistance to a remarkable degree, in some cases as much as 60 per cent. A Swan lamp with a resistance of 65 ohms when cold, will only have a resistance of about 37 when heated to incandescence. The current necessary to maintain a Swan lamp of about fifteen candle-power is 1·25 ampères, with an electro-motive force of forty volts. It will thus be seen that certain arrangements have to be made in placing a number of incandescent lamps in circuit. They are arranged usually as parallel, compound parallel, and in parallel series circuit, according to the resistance of the lamps and the machine supplying the current. No difficulty need therefore be experienced in working any number of incandescent lamps from very large dynamo-machines of low tension.

For purposes of regulation, two or three methods present themselves as being efficient—by interposing a high resistance in the leading circuit, by alteration of the position of the brushes on the commutator of the machine, or by interposing a resistance in the circuit of the field-magnets when a separate exciter is used. By this means less power is absorbed, and, consequently, it is the most economical.

Incandescent lamps can be supported by either continuous or alternate currents, by either high or low tension, so that almost any kind of machine can be adapted to them.

That the successful introduction of incandescent lighting will cause a revolution in ordinary systems of illumination is now, I think, quite evident. Even in its present stage incandescent lighting has commenced to play an important part, and is being rapidly introduced for lighting places of amusement, churches, and large establishments, whilst nearly every modern steamship has been, or is being, fitted up with one of the systems.

With respect to the economy of the incandescent lamp, I think it can be shown that even at the present time the cost of producing an equal amount of illumination will not exceed that of gas.

A ton of coal will, I believe, produce 10,000 cubic feet of gas—enough to supply 2000 good gas burners for one hour. A ton of coal burnt in the steam-engine will produce 748 horse-power and will support 7460 incandescent lamps of the same power as the gas burner for the same period of time. I have only estimated the horse-power at 3 lbs. of coal per hour, but in an extensive system of lighting to take the place of gas the amount of coal used per horse-power would not be so much. I think on board some of the large steamers from 1½ to 2 lbs. of coal per horse power per hour is all that is used; but, as in the manufacture of gas the residue of the coal yields products of great value. I have quoted the larger amount as a set off.

The cost of manufacture, wear and tear, &c., should not be more in the one case than the other; whilst the distribution would be in favour of the electric lamp; whilst the cost of renewals would not amount to anything like the difference shown to exist between the two systems.

Taking another example. Twenty-five cubic feet of gas will produce one horse-power in a gas-engine for one hour, and thus support ten incandescent lamps; whilst the same amount of gas burnt would only suffice for five burners of equal illuminating power. I have not in this paper treated on the subject of secondary batteries or accumulators, neither having spare time to make any experiments in this direction, nor information of a reliable nature to show that their use in electric lighting has been extended beyond the lecture-room or for experimental work.

Art. V.—*Experiments upon the Hardwoods of Australia.*

A compilation by F. A. Campbell, C.E.

[Contributed 11th May, 1882.]

The strength, durability, and other properties of the colonial hardwoods is a subject involved in considerable obscurity. This arises from the small number, and the fragmentary nature of the experiments yet made, the incompleteness of the records, the great diversity of results where uniformity was to be expected, and the want of exactness in the designation of the various timbers tested.

Notwithstanding that the experiments are few in number, and many of these incomplete, it might, I think, be a work of some interest and service, a work, moreover, which as far as I know, has not yet been attempted, to collect and compare the records of those experiments which have been made up to the present time, to note the conditions under which they were carried out, and to place in a convenient form for reference mean results derived from the whole of the observations.

Such a work would establish an index and starting-point for those who might wish to follow up the subject, and would furnish engineers, architects, and others with at least approximate values for many of the properties of the various timbers tested. To accomplish this in a concise form, and as far as the data which I have been able to collect will permit, has been my aim and desire in writing this paper.

The useful hardwoods of Australia belong almost entirely to the Eucalypt family, and to this fact is due much of the difficulty in affixing the true names to the timbers procured for the purpose of experiment; for not only do many of the varieties greatly resemble one another, and bear in consequence the same popular name, but the same variety is frequently so altered by the influence of locality, that it goes by many different names.

This of course causes much confusion, and detracts greatly from the value of those experiments, where the true botanical names have not been supplied. There is now, however, being issued from the press a work which should do much to rectify this. The *Atlas of the Eucalypts,* by Baron F. von Mueller, supplies a want long felt, and supplies it in a manner eminently worthy of the genius and learning of the author.

I will now proceed to notice the different series of experiments which have been made upon colonial timbers up to the present time, and to which I have had access.

Fowkes.—These were experiments made by Colonel Fowkes upon timbers sent to the International Exhibition of 1862. A great variety of woods from the different colonies came under his notice. The experiments upon them are numerous and very fully recorded. Specific gravity, crushing weights along and across the fibre, elasticity, and transverse strength were tested. The scantlings were 12 inches between bearings and 2 inches square, 1-inch cubes being used for crushing weights.

This is the most extensive series of experiments yet made upon colonial timbers, but its value is considerably diminished, from the fact that the botanical names of the trees furnishing the specimens have not been given.

Sydney Mint, 1858.—These are taken from May's *Australian Builders' Price-book.* They were carried out by the Commissioner of Railways, four experiments being made upon each of four different kinds of woods. The scantlings were 4 feet between the bearings and 1¾ inches square. Transverse strength only was tested, and no botanical names are furnished.

Sydney Mint, 1861.—This series was carried out by Colonel Ward, and a very full report furnished to the Parliament of New South Wales. A wide variety of the timbers of New South Wales and Queensland are noticed, information being appended as to the locality, size of tree, and uses to which the timber is put. The botanical name is also given in many instances. The scantlings were 4 feet between bearings and 2 inches square. Specific gravity, elasticity, and transverse strength were tested, and a valuable series of experiments is the result.

Victorian Railway Department, 1865.—These were carried out at Sandhurst, Victoria, and are entirely devoted to red-gum timber. Altogether, nine experiments were made upon scantlings of unusual size—viz., 14 feet 8 inches between bearings—the breadth and depth ranging from $10\frac{1}{4}$ inches by 7 inches to $11\frac{1}{2}$ inches by $8\frac{1}{2}$ inches. The specific gravity, elasticity, and transverse strength were tested, very full particulars as to the deflection being given. These experiments are of great value, on account of the large size of the pieces tested.

Tredgold.—These are taken from Tredgold's *Carpentry*, edition of 1875. The information is stated to have been furnished by Mr. Josiah Atwool, at one time resident in New South Wales. The information refers to the specific gravity and transverse strength of three timbers only, no particulars being given as to how the experiments were carried out.

Laslett.—Mr. Laslett is the author of a work termed *Timber and Timber Trees*, and, when this was written, was timber inspector to the Admiralty. This work is one of the most valuable treatises devoted to timber yet published. In it the author discusses a very great variety of British and foreign woods, and gives details of numerous experiments which he has carried out. Many of the colonial timbers come under his notice, and he applies to them in most cases their true designation. Four to six experiments were made on each variety, the scantlings being 6 feet between bearings and 2 inches square for transverse, 2 inches square for tensile, and various-sized cubes for crushing tests. The specific gravity, elasticity, tensile, transverse, and crushing strengths were tested. Where comparison can be made, the results arrived at by Mr. Laslett are very generally in accord with those of other experimenters, tensile strengths excepted, for which he gives much lower values. The length of the pieces tested for transverse strength is stated to have been 7 feet, but only 6 feet between bearings. Now, in calculating the values of E. and S., Mr. Laslett has unfortunately taken the length as 7 feet, thereby arriving at incorrect conclusions. This is to be regretted, as the error is embodied in the tables, to which one naturally turns for information of the kind. Observing this discrepancy, I have calculated afresh the values of E. and S. for all cases to which I have found it necessary to refer.

Mueller.—These experiments are taken from the *Eucalyptographia.* They were carried out by Baron von Mueller and Mr. Luehmann. The scantlings were 2 feet long and 2 inches square. The specific gravity, elasticity, and transverse strength were tested for twelve different species.

Of course, the various timbers are properly designated; and it is to be hoped that these gentlemen will be able to extend their labours in this direction, as their work derives so much value from the perfect identification of the timbers in hand.

Mitchell.—These experiments were made upon blue-gum timber only; the records being taken from Mueller's *Eucalyptographia.* The scantlings were 7 feet long and 2 inches square. The specific gravity, elasticity, transverse and tensile strength were tested, and the period of seasoning which each piece had undergone is noted.

Campbell.—These were tensile tests only, made by the writer upon nine of the colonial woods, a report of which was read to this Society in May, 1879. The sectional area was from one-sixteenth to one-eighth of an inch. The results obtained are much higher than those of Mr. Laslett, but correspond closely enough with those of Mr. Mitchell, and the quotations in Rankin and Molesworth.

Hurst, Rankin, and Molesworth also give values for different properties of some of the woods, but as these have in all probability been derived from some of the experiments already noticed, I have not made use of them.

In recent numbers of the *Australian Engineering and Building News,* to which I have contributed some papers on the subject, will be found details of the experiments which have here been mentioned. I will in this paper only give in a condensed tabular form, the mean results of the whole, noting opposite to each the names of the experimenters, and by means of the figures under each name, indicating the particular work done by them. The table is arranged in order of the transverse strength of the timbers mentioned.

Species of Timber.	1 Specific gravity.	2 Crushing weight per square inch.		3 E. from forml. $E = \frac{l^3 w}{16\, a d^3 \delta}$	4 Modulus of Rupture.	5 Tensile strength per sq. inch.	Authority.
		Longl.	Transverse.				
1. Ironbark— (*E. Leucoxylon and E. Siderophyloia*)	1·117	10,166	4,100	488,066	18,258	15,950	S. Mint. 1-3-4. Fowkes. 1-2-3-4. Laslett. 1-2-3-4-5. Tredgold. 1-4. Campbell. 5.
2. Tuart— (*Eucalyptus Gomphocephala*)	1·169	9,340	..	447,700	13,890	10,284	Laslett. 1-2-3-4-5.
3. Blackbutt— (*E. Pilularis*)	·990	8,449	8,064	313,600	13,529	..	S. Mint. 1-3-4. Fowkes. 1-2-3-4.
4. Bluegum— (*E. Globulus*)	1·017	7,730	6,600	509,750	13,140	20,100	Mitchell. 1-3-4-5. Mueller. 1-3-4. Fowkes. 1-2-3-4. Laslett. 1-2-3-4-5. Tredgold. 1-4 Campbell. 5.
5. Yellow Box— (*E. Melliodora*)	1·017	..	..	472,605	12,312	..	S. Mint. 1-3-4. Mueller. 1-3-4.
6. Bloodwood— (*E. Corymbosa*)	·918	..	..	399,450	11,970	..	S. Mint. 1-3-4.
7. Spotted Gum— (*E. Goniocalyx*)	·981	9,072	7,308	322,900	11,943	..	S. Mint. 1-3-4. Mueller. 1-3-4. Fowkes. 1-2-3-4.
8. Stringybark— (*E. Macrorrhyncha*) ..	·995	7,744	6,650	231,850	11,656	22,000	S. Mint. 1-3-4. Mueller. 1-3-4 Fowkes. 1-2-3-4. Campbell. 5.
9. Kari— (*E. Diversicolor*)	·980	12,513	..	568,620	11,640	7,070	Laslett. 1-2-3-4-5.
10. Woolybutt— (*E. Longifolia*)	1·054	7,297	2,968	285,995	11,524	..	S. Mint. 1-3-4. Fowkes. 1-2-3-4.
11. Redgum— (*E. Rostrata*)	·990	..	..	433,000	10,250	16,400	Vict. Ry. Depart. 1-3-4. Mueller. 1-3-4. Campbell. 5.
12. Jarrah— (*E. Marginata*)	1·007	7,166	..	177,690	9,250	2,940	Laslett. 1-2-3-4-5.

I have also compiled a table in which is given what might be termed safe practical moduli of rupture for six of the principal hardwoods of the group. This I have made up from the different series of experiments, giving them values in accordance with their comprehensiveness and completeness, and then making certain deductions to ensure being upon the safe side. I have confidence that the results present fair average values for the transverse strength of the timbers named; that they err, if at all, in being below the mark; and that they are sufficiently sure data for all calculations for purposes of construction.

Timber.	Moduli of Rupture.
1. Ironbark	16,000 lbs.
2. Bluegum	11,000
3. Yellow box	10,000
4. Spotted gum	10,000
5. Stringy-bark	9,000
6. Redgum	8,000

Tamworth, N.S.W., October 31st, 1881.

ART. VI.—*Floods on the River Barwon.*

BY W. C. KERNOT, M.A., C.E.

[Read 8th June, 1882.]

HAVING been prevented by circumstances of a very painful and urgent nature from taking part in the discussion upon Mr. W. W. Culcheth's paper upon the above subject, I venture at this comparatively late period to submit my views upon a question which all will admit to possess the highest practical importance.

The due proportioning of the waterway of bridges is a question of vital moment to the railway, road, or hydraulic engineer. If the waterways are made needlessly large, the waste of money may be most serious; if they are unduly small, as I maintain them to have been at Geelong, disasters of unparalleled magnitude may be the result. The problem that has been presented at Geelong will recur from time to time as our railways and roads extend, and the damage to property, in the event of insufficient waterway being provided, will increase indefinitely as population becomes denser, and the margins of our rivers become fringed with mills and factories and dwellings. Hence it is of the highest importance that a proper scientific system of dealing with the question should be adopted generally by the profession.

The enquiry before us is this, was the department's design for the Barwon Bridge right or wrong, sufficient or insufficient, and was the flooding of the Woollen Mills independent or not of the presence of the railway works? The former view was strenuously maintained by the Government witnesses at the trial, including amongst their number the gentleman at present occupying the honourable and important position of Engineer in Chief of Victorian Railways. The latter is Mr. Culcheth's opinion and my own.

Without going into the arithmetical details, I would say at the outset, that my own calculations, made prior to the publication of Mr. Culcheth's results, agree very closely with his conclusions as to the discharge of the river, and the extent to which the water rose in the mills above what would have been its level had the railway works not been in existence. This latter amount is given by him as 3.70 feet, and by me as 3.50 feet.

In order to verify this result as far as possible by direct experiment, a model was made representing, to scale, the bed and valley of the river for a distance of about a mile and a half above and below the railway works, and corresponding in this respect with Mr. Culcheth's lithographed section. Water was caused to flow over this model until a flood was produced, corresponding with the actual flood marks of 1880. The railway works made in a separate piece were then removed, and the water fell through a height of 4 feet, according to the scale of the model. On replacing the wooden representative of the railway bank, the water rose again to its original position. The experiment was repeated a considerable number of times with identical results, and taken in conjunction with the calculations, establishes most conclusively the truth of the proposition, that had the railway bank not been in existence, the water in the factories would have been from three to four feet lower than it actually was. An inspection of the water as it flowed over the model threw important light on some points of difficulty. For example, the comparatively high water level at Haworth's Tannery, which is on the downstream side of the bridge, had been a source of a little perplexity, but on the model the true constriction and most rapid fall of the water was seen to be *not under the bridge itself, but on a line drawn from the south end of the bridge to the south-west angle of the tannery.* The width of the stream at this point is *less than half* the length of the bridge. Another point of interest that presented itself was the marked effect of the piles of the bridge in breaking up the stream and retarding the flow.

I propose to criticise in detail the departmental mode of dealing with the problem, and also various statements made at the trial by the departmental witnesses, and which I conceive to be erroneous and unscientific.

The first noteworthy point is the serious error that occurred in determining the high flood level of 1852. This was at the time of constructing the works fixed at 16.53 feet above datum, but on the trial commencing, the old value was abandoned and 19.85 substituted. The ease with which evidence was obtained for this latter value, leads to the conclusion that but little care was taken at the earlier date to obtain a reliable height. Further, it is to be noted that the flood mark of 1852 was well known at Collins' Mill, 1½ miles higher up the river, and that a calculation based upon this and the 16.53 flood mark, leads to a discharge of enormous magnitude, many times greater than the part of the valley lower down could possibly carry away without the water rising to a level far higher than 16.53. In view of the accessible and highly reliable flood mark at Collins' Mill, the 16.53 flood level is physically impossible. Had the above-mentioned calculation been made when the works were being first laid out, a most serious error would have been detected.

Next it was reiterated that, however the case might be with a 19.85 feet flood, that the railway works provided ample waterway for a 16.53 feet one. Now I would most emphatically endorse Mr. Culcheth's opinion, that it is impossible to determine waterway by reference to high flood mark alone. It is absolutely necessary that discharge should be also determined, and this it seems was never ascertained by the officers of the department. Calculating the discharge from the Collins' Mill flood mark and the 16.53 level at the railway, the result is found to be no less than 180,000 cubic feet per second. But the openings provided at the railway have an effective area up to a level of 16.53 of less than 5000 square feet. Dividing 180,000 by 5000 we find that to discharge the flood the water must pass through the openings at the incredible velocity of *36 feet per second,* or more than 20 miles per hour. To produce this velocity a heading up of *20 feet in height* would be needed. Had the railway engineers made this simple calculation when designing the bridge, one of two results must have happened—either they would have enlarged the waterway at least fourfold, or they would have rejected the data upon which the computation was based, and sought further information.

If we abandon the Collins' Mill flood mark, and take the 16.53 flood level at the railway as the only datum, it is not possible to make any calculation at all, as no velocity can be ascertained. However, an experiment upon the model before-mentioned showed that when the water stood at 16.53, at the Breakwater it was about level with the flow of the Victoria Mill, 17.30, and that if the railway bank were then inserted the water rose to 20 at the mill, flooding it to a depth of 2.70 feet. In view of this experiment and the preceding calculation, I must dissent most emphatically from the statement of the railway engineers, that the bridge was correctly designed in view of the data supplied by the field officer.

In the evidence given on the side of the department, it was repeatedly asserted that the railway works gave about double the waterway of the large road bridge in the vicinity, and the waterway was stated to be 735 and 390 lineal feet in the two cases respectively. Upon this comparison the opinion of the railway engineers as to the sufficiency of their works appears to have been based. But the comparison is altogether erroneous. In the first place it is tacitly assumed that the road bridge was large enough, whereas experience proves that it is not, a portion of the flood escaping over a low part of the approaches. Next the 735 feet includes the Waurn Ponds Creek Bridge 135 feet long, and as this creek is a totally distinct stream from the Barwon, it is manifestly quite unfair to include it. Thirdly, the bridge over the main stream, though really 600 feet long, is placed in so peculiar a position as to leave only 290 feet between its south end and Haworth's Tannery, through which the whole stream has to pass, and this 290 feet is so surrounded by obstructions in the way of piles, iron rods, walings, braces, stanchions, and chains, also a great bed of reeds, and several dead trees, that I fail to see that it is equal in discharging power to more than one half of the clear unobstructed opening of 390 feet at the road bride. Thus the railway bridge *instead of double, affords only half the effective waterway of the road bridge,* which itself has proved not quite large enough. In the experiments with the model, it was observed that the heading up of the water at the road bridge was always less than half that which occurred at the railway, and that in this latter case the great fall in the surface of the water took place, not under the bridge, but between the south end of the bridge and the south-west corner of Haworth's Tannery, and just below the point where the true constriction exists.

In conclusion, I feel bound to raise my most earnest and emphatic protest against the way in which the gentlemen on the defence set aside scientific laws and formulæ as "mere theory," and insisted on practice being the only guide. Now, Sir, what is this theory but the practical experience of the best and wisest men that have ever given their attention to the subject, systematised, verified, and adapted to cases of ordinary professional work? And what is practice but simply one's own way of doing one's work, differing in every individual case, which may be right or wrong, scientific or crude, economical or extravagant, according to the mental constitution, and amount of education possessed by the engineer? The popular idea that science is mere theory, and unreliable when brought to the test—while practice, ignorant, inconsistent, and unintelligible, as it too often is, is the only guide to be followed, is a delusion leading to the most deplorable results.

Art. VII.—*Influence of Light on the Development of Bacteria.*

By J. Jamieson, M.D.

[Read 8th June, 1882.]

It is a common opinion, and probably a correct one, that abundance of light is favourable to the preservation and restoration of health. In how far the evil effects, resulting from the occupation of badly lighted dwellings, are due to the want of light in itself or to other insanitary conditions, damp, bad drainage, dirt, &c., which are often associated with it, is not easy to prove with certainty. It has been supposed, further, that the spread of epidemic and other contagious diseases is favoured by conditions, which prevent the access of the sun's rays to the walls and to the interior of ordinary dwellings, and still more of hospitals, This unfavourable result of shutting off direct sunlight has even been ascribed to the effect of that light in destroying disease germs. Very much of all this is simply matter of opinion, the supposed destructive action of sunlight on germs being, perhaps, assumed from the common observation, that the various species of mould grow and multiply most freely in close, dark, damp places. Even here, however, I am not aware of exact observations or experiments having been made to test the share that darkness, by itself, without the other conditions, may have in favouring mouldy growths.

Confirmation of the common opinion about the destructive action of sunlight on those low forms of life, with which the germs of some diseases are probably closely allied, seemed to be supplied by the investigations of Messrs. Downes and Blunt, reported in detail in the "Proceedings of the Royal Society of London," for 1877 (vol. xxvi., p. 488). The general conclusions to which they had come were summarised in a short communication in *Nature*, for July 12th, 1877, to the following effect:—Light is inimical to the development of bacteria, and may either prevent or only retard their development; but that, for the attainment of the full effect, direct insolation is necessary. The germs originally present are destroyed by direct insolation, while the fitness of the solution in which they were contained, to serve as a nidus, is not affected. They used Pasteur's solution, inoculated with bacterial germs, and then exposed to direct sunlight in test tubes. The experiments described seemed to bear out their contention, though the results were not of a uniform character. They found an exposure of 3½ hours suffice for sterilization in one case, while in another it was not produced after 11 hours. They could suggest no other explanation than "that external conditions—notably temperature—may retard or counteract the preservative quality of the solar rays." Remarkably enough, they found that in weak solutions, diluted to one-tenth, they failed to accomplish sterilization. Professor Tyndall read a communication before the Royal Society on the same subject (Proceedings, vol. xxviii., p. 212), in which he stated that when flasks, containing infusions of cucumber and turnip, were inoculated and exposed to the sun, they were not completely sterilized, as they showed abundant formation of bacteria after they were removed to a warm room. In view of the anomalies which had been met with by Messrs. Downes and Blunt, and the different conclusions he had arrived at, he suggested the necessity for repeating the experiments. In the same volume of the Proceedings (xxviii., p. 199), there appeared another paper by these gentlemen, extending and confirming their conclusions. Finally, at the meeting of the British Association in 1881, Professor Tyndall read a paper (*Nature*, Sept. 15th, 1881), in which he gave the results of another series of experiments. He found the statements of Messrs. Downes and Blunt correct, in so far as the suspension of development was concerned, but he never succeeded in producing perfect sterilization, all the flasks exposed to sunlight becoming turbid when removed to a shady place. He expressed the definite opinion that the difference between flasks exposed to the sun, and those kept in the shade, after inoculation, was not owing to difference of temperature. It seems to have been tacitly assumed, both by him and by the other investigators, that any elevation of temperature, to which their tubes and flasks were liable in the course of their exposure, could only be favourable to bacterial growth, and merely noting this fact, I go on to relate my own experiments, which have brought me to different conclusions.

I was led to make them by the discussions going on as to the sanitary condition of the Melbourne Hospital, and the injurious effects supposed to have been produced by the comparative exclusion of the sun's rays from parts of the buildings. Though my investigations have not led me to conclude that light is inimical to the development of bacteria, I by no means wish to derive therefrom the further conclusion, that it is a matter of indifference whether or not hospital wards, or other human habitations, are well lighted. I do think it probable, however, that insufficient lighting does not act, by allowing the free growth of disease germs, and so favouring the origination or spread of erysipelas and allied diseases.

In the experiments, now to be described, I used Cohn's solution, as in a series of investigations on the action of disinfectants, already communicated to this Society (11th October, 1877). This fluid, admirably adapted for the cultivation of the *Bacterium termo*, the active organism in the production of putrefaction, has the following composition:—

Tartrate of Ammonia ...	2
Sulphate of Magnesia ...	1
Acid Phosphate of Potash	1
Chloride of Calcium ...	$\frac{1}{10}$
Distilled Water ...	200

My ordinary procedure was to put about two fluid drams of this solution into ordinary one-ounce phials, and, after inoculation, plug them with cotton wadding. Free access of air was thus allowed, while solid particles were excluded. A considerable series of experiments, sixteen in number, were made to determine—(1) Whether ordinary diffused light interferes in any way with the development of bacteria in Cohn's solution; (2) whether direct insolation has that effect; and (3) whether direct insolation quickly causes the destruction of bacteria in the dried state. They were begun in February last, and continued as other occupations permitted.

Exp. I. On February 21st three phials, inoculated each with three drops of putrid meat juice swarming with bacteria, were placed outside, on the sill of a window on which the rays of the sun fell nearly all day. The weather was very hot. On the 23rd all were still quite transparent, and one was removed and put in a shady place. On the 26th this showed three specks of mould, but no opalescence from bacteria. On the 28th the others left in the sun were still perfectly transparent, and showed no mould formation.

Exp. II. On 28th February, at 11.40 a.m., an ounce of solution was inoculated with twenty drops of putrid meat juice, and distributed in four bottles. Two were exposed to the sun, and the others, wrapped in brown paper, were placed alongside of them. The weather was bright but cool. On 3rd March both of the covered bottles began to show cloudiness, and soon became quite opalescent. Next day (4th), at 2.30 p.m., both of the exposed bottles were quite transparent. One of them was then wrapped in paper, and both left in the same place, but on the 6th they were still transparent.

So far these results seemed fully to confirm the conclusions of Downes and Blunt. Direct insolation had not only checked the growth of the bacteria, but had actually sterilized the solutions so far as they were concerned. The survival of mould spores, after the destruction of bacteria, also agreed with what these observers had found.

I proceeded next to try what the effect of diffused light would be.

Exp. III. On 11th March, at 2.30 p.m., I inoculated six drams of solution, with five drops of opalescent fluid from one of the bottles left from a previous experiment, and distributed it equally in four bottles. Two were wrapped in brown paper, and the others left uncovered, and all placed in a bright light on an inner window sill, but guarded from the direct rays of the sun. On the 13th, at 9 a.m., they were all nearly opaque, no difference being perceived. It was evident from this, that bright diffused sunlight is not inimical to the development of bacteria. This experiment, conclusive enough in itself, was confirmed by the next.

Exp. IV. An ounce of solution, inoculated with four drops of opalescent fluid from previous experiment, was put into four bottles. Two were exposed to the sun; one in the same situation but wrapped in brown paper, and the fourth left exposed to the light inside, at 2.30 p.m. on 15th March. The temperature in the sun was noted at 110° F., and next day at 112° F. On the 17th, at 9 a.m., the wrapped bottle and the one in diffused light were already cloudy, the latter most distinctly. The two exposed bottles were perfectly transparent, and both remained so till the 19th, at noon, though one of them had been taken out of the sun.

Having apparently established the fact that the bacteria in Cohn's solution may be not only retarded in their development, but even killed by exposure to the sun's rays, I tried next to discover the time needed for their destruction.

Exp. V. On 27th March, at 11.30 a.m., four bottles charged with solution, inoculated as in Exp. IV., were taken; one of them left in ordinary diffused light for a test, and the other three placed in the sun, and left for 1½, 2½, and 5 hours respectively, and then put beside the test bottle, the thermometer marking 116°, 124°, and 108° F. at different times in the course of exposure. On the 30th, at 9 a.m., the test solution was found to be milky and crusted; those exposed for 1½ and 2½ hours showed traces of opalescence, while that which had been exposed for five hours was quite transparent, remaining so till the morning of 1st April, when it began to show slight opalescence; the others, before that time, having become almost opaque. With the conditions under which I experimented, therefore, five hours proved almost sufficient for the sterilization of the inoculated solution.

I began now to ask myself in how far the effect, so clearly produced by insolation, might not be due to the solution being raised, by standing on a hot window sill, to a temperature sufficient to paralyse and even kill bacteria, and that independently of any chemical or other action of the sun's rays. The utter want of any such destructive influence in diffused light made this not improbable, and I altered my procedure in the next two experiments.

Exp. VI. On 6th April, at 2 p.m., the weather being bright but cool, three bottles, containing each two drams of inoculated solution, were suspended outside of a window, in front of the glass, with the same exposure. The 7th was cloudy, the 8th bright and cool, and on the 9th, which was bright and warm, all were still found transparent; and at 9 a.m. one was brought inside out of the sun. On the 10th, which was also bright, another was taken in at 9 a.m., the one which was left out then showing faint signs of cloudiness. A thermometer hung up beside it marked a temperature of 98° F. Next day (the 11th), at 9 a.m., the exposed bottle was quite milky, the others just beginning to show traces of opalescence, the one removed on the 9th being least advanced. Here then the solution which had been longest and continuously exposed to insolation became first altered by bacterial development. There was scarcely any explanation conceivable, but that, in all, the development had been retarded by the coolness of the weather at first; and that the warmth (98° F.) outside, on the 10th and 11th, favoured that development in the bottle exposed to it; the others, inside of the house, being at a lower temperature. Long and continuous insolation had here certainly been little, if at all, inimical to the growth of bacteria.

Exp. VII. On 14th April, at 12.30 p.m., I inoculated six drams of solution with two drops of bacterialised fluid, and divided it equally over three bottles. They were all suspended in the sun, one of them having been first wrapped in brown paper. The weather was cloudy and almost cold on the following days, the 19th and 20th, however, being bright all day; and only on the 21st were the exposed bottles found to be opalescent. The solution in the covered bottle was quite milky. My interpretation of these conditions was, that the coldness of the weather had checked the multiplication of the bacteria in the first days, growth only beginning actively in the brighter and warmer weather of the 19th and 20th. The more advanced development in the covered bottle was most naturally to be ascribed, I think, to the wrapping keeping it at a more uniform temperature, and especially preventing that from sinking so low during the night.

The result of these two experiments was clearly to show that insolation, associated with moderate or low temperature, has no destructive influence on bacteria, not even apparently retarding their growth. I was, therefore, driven to conclusions directly contradictory to those both of Professor Tyndall and of Messrs. Downes and Blunt. The doubt, of course, which at once suggested itself was, whether the sun's rays, even in summer in England, would raise a solution exposed to them to a temperature sufficient of itself to destroy bacteria. To settle this point it was necessary, first of all, to ascertain the lowest temperature at which the *Bacterium termo* is paralysed or killed. This information has been provided by the careful experiments of Dr. Eduard Eidam, reported in Cohn's "Beiträge Zur Biologie der Pflanzen" (heft. III., p. 208). He found that while very low temperatures check indefinitely the growth of this organism, growth becomes more active with gradual elevation up to 35° C. (95° F.). Temperatures above this are again less favourable, and between 40° and 45° C. (104°-113° F.), the bacteria remain in a torpid condition, a kind of heat rigidity (Wärmestarre), but are not killed. An exposure for seven days to a temperature of 45° C. was sufficent to cause their destruction; while fourteen hours of exposure at 47° C. (116.3° F.), three to four hours at 50°-52° C. (122°-125.6° F.), and one hour at 60° C. (140° F.) sufficed to produce the same effect. Under a hot Australian sun there is no difficulty about getting a temperature of 140° F. or over, 125° F. being quite common, and so the destruction of bacteria by insolation is easily accounted for. Whether a high enough temperature for that purpose is readily attained in England may be doubtful, and the fact that Professor Tyndall never succeeded in sterilizing his solutions, meets its explanation in this way. It is possible that, in June or July, when Messrs. Downes and Blunt carried on most of their investigations, a heat of 125° F. may be occasionally reached for three or four hours continuously, and this would suffice. An anomaly, to them apparently unaccountable, viz., that solution in very small test tubes was more easily sterilized than when contained in larger ones, may be explained by the circumstance that a small body of fluid would more speedily and certainly be raised to the required temperature than a larger one. The fact that Professor Tyndall, in his experiments, used flasks, which I presume were of considerable size, would on the same principle account for his failure to get complete destruction of germs—the attainment of temporary torpidity, by a temperature slightly exceeding 104° F., being comparatively easy.

While, therefore, it might be going beyond my competence to deny to direct sunlight any influence inimical to the development of bacteria, I have no hesitation in expressing the opinion that such inimical influence of light *per se* is not established, either by my own experiments, or by those which I have ventured to criticise, and to interpret in a different sense from their authors. I can explain their error only by supposing that it had not occurred to them as possible, that bacteria might be paralysed, or even killed, by continuous exposure to ordinary summer heat. An expression, contained in one of Messrs. Downes and Blunt's Memoirs, already quoted, to the effect "that temperature may retard or counteract the preservative quality of the solar rays," seems to show clearly that it was actually their opinion, that any elevation of temperature, to which their solutions were exposed, could act only by hastening the development to such an extent as to overcome the destructive power of light as light. Professor Tyndall says, "On many occasions the temperature of the exposed flasks was far more favourable to the development of life than that of the shaded ones."

When it is considered how much greater is the difficulty of destroying bacteria or their germs in the dry than in the moist state, either by heat or disinfectants, it might almost with safety be concluded that insolation, which fails to destroy the *bacterium termo* in solutions, is not likely to injure it when dried.

As reported in my previous communication to this Society, I found dried bacteria resist a temperature of about 212° F. for fifteen minutes, and, therefore, no solar heat could be expected to kill them. But as desiccation, when sufficiently complete, has that effect, it might readily happen that exposure to the sun's rays in hot weather might act destructively, in virtue of its drying effect. To test the influence of insolation on the dry bacteria, I soaked blotting-paper with bacterialised solution, obtained from a bottle used in one of the previous experiments, and exposed it to the sun freely suspended by a piece of thread. Similar pieces of paper were hung up in a shady but well-aired passage, and in a well-lighted room. This was done twice; and, to test the condition of the bacteria in the pores of the paper, the following precautions were taken:—Bottles, as before, after receiving about two drams of pure solution, were plugged with cotton wadding, and then kept for some time in boiling water to secure complete sterilization. After time was allowed for cooling, the plug was taken out, a little square of the blotting-paper dropped quickly in, contact only with scissors being allowed, and the plug replaced. In the first series of experiments, carried on in hot weather, it was found that, after two days, the bacteria had not been killed in any of the papers; that, after four days, they had been killed in that exposed to the sun, and that hung in a current of air, but in the shade; and not killed in that which had been suspended in bright, diffused light. After seven days, the last also failed to bring about milkiness in the solution. I conclude, therefore, that it was simply a question of desiccation with all of them, the time needed to produce destruction in that way varying with temperature and exposure to currents of air. In the other series, a similar result was reached. The growth of bacteria in the bottle containing the sun-dried paper was later in occurring than in the others, but was not completely prevented even after five days of exposure. The interest of these experiments consists in the proof supplied, that, under conditions very favourable to rapid and complete desiccation, such as free exposure to air and sun, bacteria may be destroyed in a comparatively short time, not less, however, than from two to four days being needed even in this climate in summer, and even longer, unless the weather be actually hot.

Since writing this paper I find from a passage in a letter contained in *Nature* (vol. III., p. 247), that Dr. Bastian had been led to ascribe to the actinic rays of the sun an important influence in promoting the spontaneous generation of organisms in organic infusions. Though that notion may be considered as fairly set aside by Professor Tyndall's experiments, recorded in the *Philosophical Transactions* (part I., 1877), and again in his *Essays on the Floating Matter of the Air* (p. 231), the interesting fact remains that, at different times, both a favouring and an inimical action on the development of these minute organisms should have been ascribed to the sun's rays, when in reality they appear to have little, if any, appreciable direct influence in either direction.

ART. VIII.—*Remarks on Railway and Marine Signals, and on the Necessity of Accurate Testing of the Sight of Signal and Look-out Men by Land and Sea.*

BY JAMES T. RUDALL, F.R.C.S.

[Read 8th June, 1882.]

THE great increase of travelling in recent years, the large numbers of ocean-going and other steamships, the frequency of railway trains running over the same lines, and the numerous intersections of these, have become attended by dangers of which some cannot be wholly eliminated; and others, though avoidable, are only now beginning to receive attention.

If one remembers that between New York and Liverpool nearly thirty large steamship companies have their vessels constantly running over almost the same track of ocean at a speed often of sixteen or eighteen knots an hour; or if one observes the succession of trains at a large railway station like the Victoria, in London, one is likely not to underrate the necessity of increasing vigilance and perfect physical capability on the part of the signallers and look-out men and the drivers of trains. Very little reflection suggests the necessity of using a code of signals suited as regards size and colour to the optical capacities of the normal eye, as these have been determined by scientific examination. Of course this has already been partly attended to long ago in a rough way, but by no means with the accuracy which the subject now both permits and demands. Almost equally apparent is it that the signals should be, at least in the case of ocean steamers and railway lines of coterminous countries, not national but international.

Another at least equally important condition requisite to ensure safety in travelling is visual competency on the part of all those who are engaged in signalling or in looking out for signals.

The essential requirements therefore are:—

1. A series of signals for sea, to be agreed upon and accepted by all maritime nations; and, further, an uniformity as to size, colour, and signification of land (railway) signals.
2. That these signals should be in relation with the visual acuity and colour perception of the normal human eye.
3. That no signallers or observers should be employed who do not come up to a certain fixed standard of visual acuity, refraction, and colour sense.

In regard to the first of these requirements, the necessity of a commission of delegates from the principal maritime Governments was strongly urged by the International Medical Congress of 1881, in order to secure uniformity in size, colour, and disposition of signal lights. Such a commission would at the same time ensure the conditions required under the second heading. But there should be no delay in carrying out the third requirement. This is absolutely essential to the safety of life of the travelling population.

It might be thought that nothing can be easier than to decide, with but little trouble or method, whether a person has good sight and good perception of colours. In a very small percentage of those who would present themselves for examination this question might, perhaps, be at once decided in the negative; but in a relatively large proportion the incapacity would be detected only by a detailed and systematic examination.

It is, of course, well known that one condition essential to distinct vision is that an image of the object looked at should be formed on the retina.

As regards refraction, it is now generally accepted that the dioptric media in the normal eye accurately focus parallel rays on the percipient layer of the retina; consequently neither divergent nor convergent rays can be brought to a focus on that percipient layer without some alteration.

For divergent rays this alteration is effected by an increased convexity of the crystalline lens, produced through the agency of the ciliary muscle.

Hooke* investigated the angular distance required to observe two fixed stars separately, and he found that among a hundred persons scarcely one was in a position to distinguish the two stars when the apparent distance is less than 60″. The correctness of this observation of Hooke has been confirmed in different ways by modern investigators. Professor Snellen, of Utrecht, some years ago devised a series of black letters on a white ground, which are easily read in good light by the normal eye at such a distance that the whole letter is seen under an angle of 5′, but the openings in the letters under an angle of 1′. These test types have come into general use by those concerned in the management of optical defects of the eye. It is necessary that the results of an examination by the types should be further supplemented by determination of the refraction, because it is possible for a myopic,† or short-sighted person, sometimes to read No. 20 Sneller at 20 feet by partly closing the eyelids, so as to diminish the circles of dispersion on the retina (and, perhaps, by, at the same time, slightly flattening the eye), and, on the other hand, a hypermetropic‡ person, with good accommodation, may also read the same letters—viz., No. 20 at 20 feet.

There is yet another anomaly of refraction—viz., astigmatism, in which, owing to the curvatures of the dioptric system being unequal in the different meridians, no true

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* *Posthumous Works* (1705), quoted by Professor Donders.

† In whom parallel rays are brought to a focus in front of the retina.

‡ In whom parallel rays, if continued, would come to a focus only behind the retina.

focus is formed. If the vertical meridian has a shorter radius of curvature than the horizontal, a point of light in the focus of the latter will not be seen as a point, but as approaching the form of a horizontal line, and *vice versa.* An eye may be normal or hypermetropic in one meridian and myopic in another. So, besides deciphering the test types, the eye must also be proved emmetropic—*i.e.,* to possess normal refraction.

Of course if any of these anomalies of refraction were present in a high degree, the individual would not be able to read the large test types at the required distance, yet a dangerous amount of ametropia might remain concealed it special attention were not also directed to the state of the refraction. The visual field must also be complete; there are cases in which, with great contraction of the field, the sharpness of sight remains good in the central parts.

We now come to the colour perception, which has of late years attracted so much attention. Absolute colour-blindness is a very rare condition; but in the male sex of the white races, diminished colour sense would appear to be of quite unexpected frequency. Thus, according to Mr. George Lawson, Professor Donders, of Utrecht, found amongst 2300 railroad *employés* that 152, or 6·60 per cent., were colour-blind. Professor Holmgren, of Sweden, found amongst 32,165 males that 1019, or 3·25 per cent., were colour-blind. Dr. Cohn found amongst 2429 schoolboys of Breslau 95, or 4 per cent., colour-blind. Dr. Magnus found amongst 3273 school boys of Breslau 3·5 per cent. colour-blind. Dr. Joy Jeffries, of Boston, found amongst 10,387 that 431, or 4·149 per cent., were colour-blind. In the female sex colour-blindness seems rare. It is known that for ordinary vision that part of the retina including the macula lutea and its immediate neighbourhood is the most sensitive, and that in proportion as images are formed on the more peripheral parts the impression conveyed to the sensorium is less exact and intense. From careful examinations it has been found that blue is distinguished over a larger portion of the visual field than red, and red over a larger part than green. It appears that within the limit of the visual field in the normal eye there is a zone of about 10° in which pigment colours are not recognised. What seems at first surprising is that many colour-blind persons (I use the term in the sense before ascribed to it) do recognise and name correctly the principal colours. "Thus," says Professor Pole, "a soldier's red coat or a stick of red sealing-wax conveys to me a very positive sensation of colour, by which I am able to identify in a great number of instances bodies of this hue. If, therefore, the investigation of any experiences ended here, there would be no reason to consider me blind to red. But when I examine more closely what I do see, I am obliged to come to the conclusion that the sensation I perceive is not one that I can identify separately, but is simply a modification of one of my other sensations. It is, in fact, a yellow shaded with black or gray, a darkened yellow, or what I may call yellow-brown. I find that all the most common hues of red correspond to this description; and in proportion as they are more scarlet or more tending towards orange, the yellow I see is more vivid. The explanation, I suppose, is that none of such reds are pure—they are combinations of red with yellow, so that I see the yellow element of the combination, while the true red element of the combination is invisible to me as a colour, and acts only as a darkening shade."

Dr. Wolfe, referring to colour-blindness, says:—"It may well be asked, how is it possible for a colour-blind engine-driver, for instance, to perform his duty for any length of time without exposing his deficiency? But the explanation given by Holmgren is simple when we come to remember that a colour-blind person may come to distinguish between red, green, and white lanterns or flags, and even learn to call them by their right names, whilst all the time it is not colour which he sees; he only differentiates by the degree of intensity of light." "In short, the colour-blind person supplements his defective vision of colour by all secondary aids. He trains himself to notice differences which escape most other eyes; these differences serve him in lieu of colour. That is the reason why collisions do not daily occur on railways and at sea from mistakes made by colour-blind officials."

When the conditions are unfavourable for the colour-blind person supplementing his deficiency of sight by other means, as in rain, mist, and some other states of the atmosphere, the danger of making mistakes in the colours of signals becomes very great.

From the statistics quoted above, we cannot escape the conclusion that there are on board of our steamships and on our railways numerous instances of persons whose visual deficiencies disqualify them for their important responsibilities in regard to human life, for the tests hitherto employed are nearly useless, perhaps even mischievous as leading to a false sense of security.

Without contending that all the requirements are thoroughly worked out, I am convinced that the systematic testing recommended by the International Medical Congress of last year (and copies of the "resolutions" have no doubt before now been widely distributed over the civilised world) would, if carried out as directed, at once reduce to a small fraction the dangers to travellers through mistakes from visual defects of officials on steamships and railways.

ART. IX.—*Descriptions of New, or Little Known, Polyzoa.*

PART II.

BY P. H. MACGILLIVRAY, M.A., M.R.C.S., F.L.S.

(WITH THREE PLATES.)

[Read 13th July, 1882.]

Membraniporella distans, n. sp. Fig. 5.

CELLS remote, glistening; costæ, about eight or ten on a side, expanded and perforated at their inner ends; a narrow, slightly raised line down the middle of the cell; mouth straight below, arched above, with several (2—5) blunt spines round the upper margin; ovicell small, rounded, smooth, with an elevated ridge across the front:

Port Phillip Heads.

This species is closely allied to *M. nitida,* of which it may eventually prove to be only a variety. In the only specimen I have seen, the cells are irregularly scattered over a small fragment of Retepora; some are contiguous, although most are widely separated and arranged in no definite order. The retepore is very dirty and rotten, and it is impossible to make out the nature of the connection between the remote cells. The ribs are generally expanded towards the mesial extremity, and frequently there perforated. This is caused by the ribs, in growing, dividing dichotomously towards the inner part, and these divisions by again uniting, or by their union with those of the opposite side, leaving the round or oval openings. The ovicell is smaller and shallower than in *M. nitida,* and has a slight ridge separating an area from the smooth, round, superior part.

Microporella renipuncta, n. sp. Fig. 1.

Cells broadly ovate; surface smooth, or faintly granular, or areolated; a large, reniform, punctate plate below the mouth, toward the middle of the cell; mouth straight below, arched above, with four or five spines on the upper margin; a transverse avicularium, with an acute mandible, between the lower lip and the reniform pore; ovicell large, prominent, the front with a semicircular area, smooth, or marked with radiating lines, the circumference being thickened, and nearly smooth or granular.

Port Phillip Heads.

This beautiful species is at once distinguished by the large, reniform, perforated plate and the transverse avicularium. The avicularium is absent in some of the cells, but seems to be present in all those supporting ovicells. The reniform plate is distinctly raised, and has the appearance of a thin membrane bulging forwards and pierced by numerous punctures. In old, calcified specimens, the surface is markedly areolated.

Microporella stellata, Smitt.* Fig. 4.

Cells broadly oval or rhomboidal, slightly convex; surface thickly covered with rounded eminences, each of which is pierced by a stellate pore; mouth wide, shallow, slightly arched above and slightly projecting forwards below, margin thickened; at the summit of the cell and at each lower angle of the mouth is a rounded eminence, on which is situated an avicularium with the triangular mandible directed towards the mouth, the superior vertically downwards, the lateral obliquely upwards and inwards.

Port Phillip Heads, a single specimen, Mr. J. B. Wilson.

Microporella Malusii, var. *personata*. Fig. 8.

Cells pyriform, smooth; mouth arched above straight below, with slightly thickened edges; no spines; a transverse, lunate, dentate pore below the mouth with the sides elevated, especially inferiorly, into a mound-like prominence; ovicell large, granular, the lower angles produced across the front of the cell to form a large collar.

Port Phillip Heads, a single specimen, Mr. J. B. Wilson.

This differs so much from the normal form of *M. Malusii*, that it may be doubtful whether it ought not to be characterised as a new species. There are no lateral pores, the margin of the ovicell is not sculptured in the usual way, and the lower angles are produced across the front of the

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* ***Porina stellata***, Floridan Bryozoa, Part II., p. 26, Pl. V. Figs. 130—133.

cell to form, by their junction, a large collar, obscuring the lower part of the mouth. Busk's *L. thyreophora,* already shown by Hincks to be an unimportant variety of *M. Malusii,* also occurs at the Heads.

Lagenipora tuberculata, n. sp. Fig. 15.

Cells large, flask-shaped, erect or semi-erect; mouth rounded or oval, with a thickened projecting peristome; surface studded with large, hollow, pointed tubercles, which occasionally, owing to attrition, form raised pores.

Port Phillip Heads.

Schizoporella lata, n. sp. Fig. 7.

Cells quadrate or oval, arranged in linear series; front slightly convex, granulo-punctured; mouth large, with a rather wide, shallow-pointed sinus below; below the mouth is a small elevation bearing a minute avicularium; ovicell large, rounded, thickly punctate.

Port Phillip Heads.

S. triangula (Hincks), which also accurs here, differs in the cells being much flatter, the mouth wider, and the suboral avicularium larger and more distinct.

Schizoporella insignis, n. sp. Fig. 11.

Cells large, quincuncial, indistinct; surface deeply areolated; mouth semicircular, or rather higher than wide, nearly straight below, and with a deep rounded sinus; four or five spines above; avicularia very large, situated below and outside the mouth, on one or both sides, and with the mandible extending obliquely upwards and outwards to nearly opposite the centre of the upper margin of the mouth of the cell in the adjacent series; ovicell mitriform, deeply imbeded in the cell above, divided into two parts by a thick ridge parallel to the outer edge, the inner part nearly smooth but areolated at the edges, the outer sloping and also deeply areolated.

Dredged off Port Phillip Heads by Mr. Wilson and myself, always in the Hemeschara form.

The mandible of the avicularium is sometimes much narrower and more pointed, and also situated lower down, than in the specimen figured.

Schizoporella punctigera, n. sp. Fig. 13.

Cells ovate, arranged in linear, radiating series, smooth or nearly so; mouth rounded above, nearly straight below, with a narrow deep sinus; four spines on the upper margin; a minute transverse avicularium on an elevated umbo immediately below the mouth; ovicell rounded, thickly punctate, and with a smooth rim.

Port Phillip Heads, dredged by Mr. Wilson and myself.

Closely allied to *S. lata*, but I think distinct. The mouth is narrower, the sinus is much narrower and sharper, and the ovicell is more prominent.

Lepralia setigera, Smitt. Figs. 2 and 3.

Cells pyriform or ovate, convex, smooth; a series of long, slender, rigid spines attached to the circumference of the cells except at the base; mouth higher than broad, arched above, straight or rather rounded upwards and forwards below, constricted at the junction of the middle and lower thirds by a projecting, pointed process, the edges bevelled inwards, especially on the upper border; a long, very slender vibraculum on either side, opposite the lower part of the mouth, extending downwards nearly the whole length of the cell: ovicell rounded, with a thickened rim.

Port Phillip Heads, dredged by Mr. Wilson and myself.

I have no doubt that this species is the *Escharella setigera* of Smitt* and the *Lepralia Kirchenpaueri*, var. *teres*, of Hincks.† Heller's *L. Kirchenpaueri* is, probably, a different species. The chief peculiarity is the remarkable series of stiff, slender spines fringing the circumference of the cells which is found in perfect specimens; in older ones, however, they are not present, and their absence, as well as that of the delicate vibracula, with the more strongly calcified and shorter cells, gives it a very different appearance. The surface of the ovicell is divided into two parts, the circumference being thickened; sometimes the inner edge of this thickened part forms a distinct ridge, although I have not seen it so prominent as in Hincks' figure of *L. Kirchenpaueri*, var. *teres*. It can always be distinguished

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* Floridan Bryozoa, Part II., p. 58. Fig. 206.

† Annals and Mag. of Nat. Hist., July, 1880.

by the peculiar shape of the mouth and the vibracula, or the mark of their attachment, which in the oldest specimens is very conspicuous.

Hincks notices a form from Bass's Straits as *L. Poissonii* (Audouin), to which he doubtfully refers *L. setigera.* He does not describe it, but gives as its remarkable peculiarity the line of spines fringing the base of the cell for about half its length, which are not described or figured by Smitt. Smitt's and the present species are undoubtedly identical, and it is probable that they are referable to *L. Poissonii*; but as I have not seen Savigny's figure of the latter, I have thought it better to retain Smitt's name.

Lepralia magnirostris, n. sp. Fig. 6.

Cells large, confused, indistinct, surface with numerous perforations; mouth rounded above, nearly straight below, peristome raised; a very large avicularium on each cell opposite the side of the mouth with the mandible projecting upwards and inwards.

Port Phillip Heads.

In this species, of which all the specimens I have seen are in the Hemeschara form, the polyzoary is thick, and the posterior surface smooth. The cells are arranged in irregular quincunx, with no distinct divisions; they project slightly forwards superiorly; the mouth is raised, rounded above, and nearly straight below. There is a very large avicularium on each cell; it is situated opposite the middle of the mouth, the base being in the hollow between two adjacent cells, and the mandible is directed nearly transversely inwards, so that the point almost touches the summit of the mouth. In some specimens the mandible is much more slender than in that figured, and is pointed to the side or bottom of the mouth, although the normal arrangement is as represented.

Lepralia striatula, Smitt. Fig. 17.

Gemellipora glabra, forma *striatula,* Floridan Bryozoa, Pt. II., p. 37. Fig. 202.

Polyzoary encrusting; cells irregularly shaped, elongated, usually attenuated downwards or pyriform, arranged more or less in linear series, distinct, very slightly prominent; surface glassy, marked with irregular, mostly transverse, fine striæ, and thickly punctate with small white-bordered pores; mouth horse-shoe shaped above, with a large, wide and deep sinus below; at the junction of the sinus and upper part there is a prominent sharp denticle on each side for the articulation of the operculum; a small, broadly oval avicularium on a separate punctured area at the base of the cell; ovicell large, slightly elevated, appressed to the cell above, punctate, and with an avicularium on the summit.

Port Phillip Heads, on *Eschara mucronata.*

Lepralia longipora, n. sp. Fig. 18.

Cells much elongated, distinct, arranged in linear series, convex, surface smooth and sparsely punctured; mouth nearly circular, with the lower lip slightly straighter, margin thickened; ovicell large, rounded, smooth.

Port Phillip Heads.

Smittia oculata, n. sp. Fig. 12.

Cells elongated, distinct; surface glassy, thickly covered with slight elevations, which, on deeper focussing, appear as large rounded pores; primary orifice horse-shoe shaped or rounded; secondary orifice, with the sides very largely raised and a thickening below, on which is a rounded avicularium, and inside a denticle; ovicell slightly prominent, with a slightly raised vertical ridge, on each side of which is a rounded pore, with a slightly thickened margin.

Port Phillip Heads, Mr. J. B. Wilson.

The surface of the cell is covered with numerous large, slight elevations, which, in deeper focussing, are shown to be elevated pores, covered by a thin layer. The pores on the ovicells, which are probably of the same nature, are usually two, but occasionally three. It is allied to *S. Landsborovii,* which, as well as *S. trispinosa,* is abundant at the Heads.

Smittia reticulata, var. *spathulata.* Fig. 14.

Cells elongated, separated by distinct, raised margins, deeply punctured or areolated round the margins; mouth rounded in young cells, with three or four spines, the peristome in older cells produced on each side, leaving a narrow sinus below, inside of which is a squared denticle, with a smaller one on each side; a single large, spatulate avicularium on one side, opposite the lower part of the mouth, with the mandible pointed downwards; ovicell prominent, thickly perforated by round foramina, and frequently with a thickened rim.

Port Phillip Heads.

Hincks (Ann. and Mag. Nat. Hist., August, 1881) has already noticed this variety, which, as he points out, differs only from the normal form in the position and shape of the avicularium. This is situated on one side of the mouth, with the large, spatulate mandible pointed directly downwards. The size of the mandible varies considerably, being sometimes very broad, and extending the whole length of the cell, while in other cases it is much shorter and narrower. Rarely there is another smaller one on the opposite side. There are occasionally small isolated raised patches of more prominent cells, with the avicularia enormously developed. I have not found the normal form of *S. reticulata,* but Hincks mentions it as occurring in Bass's Straits.

Mucronella munita, n. sp. Fig. 10.

Cells oval, indistinct, glassy; when young deeply areolated on the margins, when older smooth or with irregular elevations; mouth with a projecting denticle on each side, above which is a long, articulated, cylindrical spine, and sometimes one or two others on the upper margin; mucro squared above; usually a sessile avicularium, with the mandible pointed outwards, on one or both sides of the cell; ovicell large, frequently somewhat umbonate in front.

Port Phillip Heads, Mr. J. B. Wilson.

I am not sure that this may not prove to be a form of *M. coccinea,* from which it seems to differ in the smaller size of the cells, the greater development of the mucro, and the form and position of the avicularia.

Mucronella lævis, n. sp. Fig. 16.

Cells broadly ovate, arranged in linear series, slightly convex, smooth; mouth rounded above, a broad denticle deep in the lower lip; peristome raised round the lower lip, produced in the centre into a prominent square or blunt mucro; six stiff, articulated spines on the upper margin; ovicell small, globose, smooth, three spines shewing on each side in front of it.

Sorrento, Mr. J. B. Wilson.

Allied to *M. Peachii*, from which it differs in the greater prominence of the mouth, the larger size of the mucro, the stouter spines (the articulations of which are usually dark-coloured), and the presence of three spines on each side in front of the ovicell. It is probably also closely related to *M. teres*, described by Hincks, from specimens dredged off Curtis Island.

Mucronella serratula, n. sp. Fig. 9.

Cells irregular in shape, rhomboidal or elongated, distinct, separated by faintly raised margins; front slightly convex, glassy, and more or less covered with distinct round granulations; mouth with margin smooth or usually with a rounded somewhat digitiform projection of the peristome, about the middle on each side; mucro large, upper edge straight and serrated, and seemingly with a transverse avicularium on its summit; a central and two lateral denticles inside the lip; ovicell large, granular.

Dredged at Port Phillip Heads, by Mr. J. B. Wilson and myself.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Microporella renipuncta.* Fig. 1*a.* A single cell, showing spines.
Fig. 2. *Lepralia setigera.* The division on the ovicell ought to be more marked.
Fig. 3. Older specimen of same, showing marks of attachments of vibracula.
Fig. 4. *Microporella stellata.*
Fig. 5. *Membraniporella distans.* Fig. 5*a.* To show growth of costæ. Fig. 5*b.* Outline of cell and ovicell.
Fig. 6. *Lepralia magnirostris.*
Fig. 7. *Schizoporella lata.*

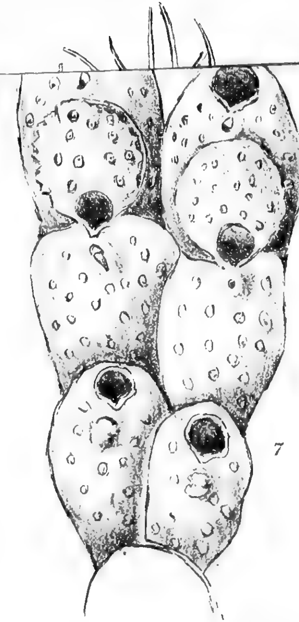
PLATE II.

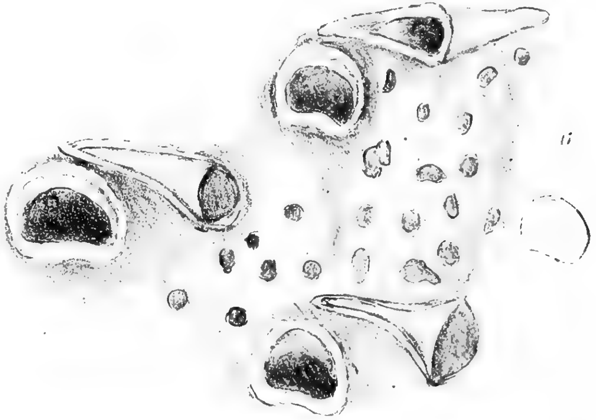
Fig. 8. *Microporella malusii*, var. *personata.* One cell, showing young ovicell. Fig 8*a.* To show ovicells and collars.
Fig. 9. *Mucronella serratula.*
Fig. 10. *Mucronella munita.*
Fig. 11. *Schizoporella insignis.*
Fig. 12. *Smittia oculata.* Two marginal cells. Fig. 12*a.* Single cell, showing elevations on surface. Fig. 12*b.* Portion more deeply focussed, to show the pores, &c.

PLATE III.

Fig. 13. *Schizoporella punctigera.*
Fig. 14. *Smittia reticulata*, var. *spathulata.* Two young marginal cells. Fig. 14*a.* Older cells, showing the large lateral avicularia and ovicells.
Fig. 15. *Lagenipora tuberculata.*
Fig. 16. *Mucronella lœvis.*
Fig. 17. *Lepralia striatula.* Fig. 17*a.* Part of a cell more highly magnified, to show the form of the mouth.
Fig. 18. *Lepralia longipora.*

Plate 1.





P.H.Mc[illegible] del. & lith.

C. Troedel & Co imp

Plate 1.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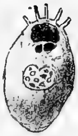
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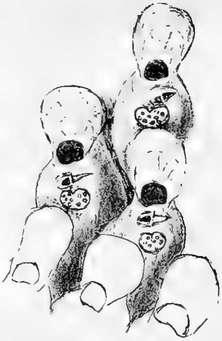
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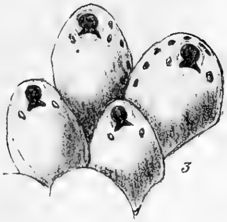
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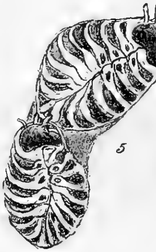
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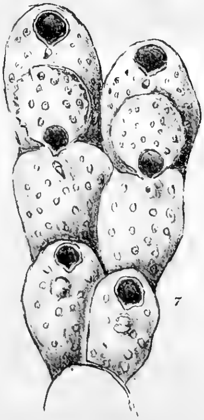
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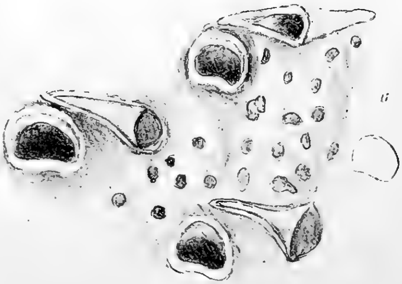
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P.H.M^c.G. del. & lith. C. Troedel & Co imp


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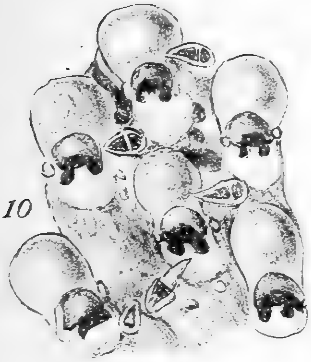
8a


8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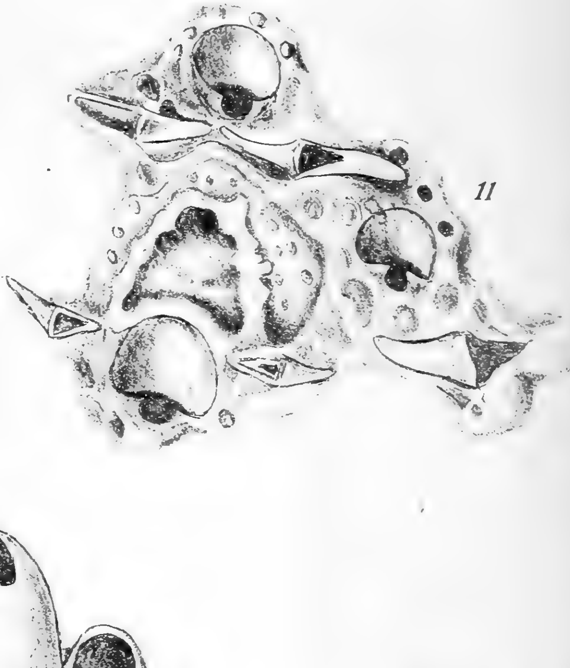
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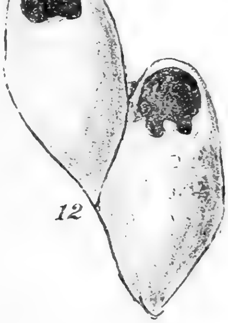
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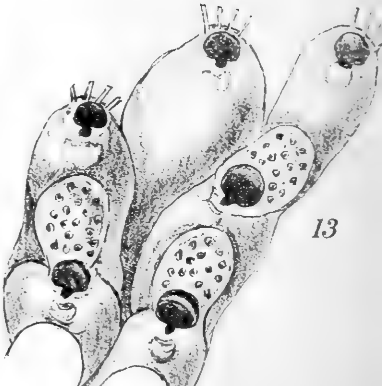
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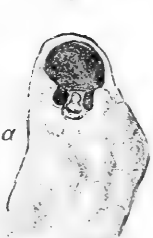
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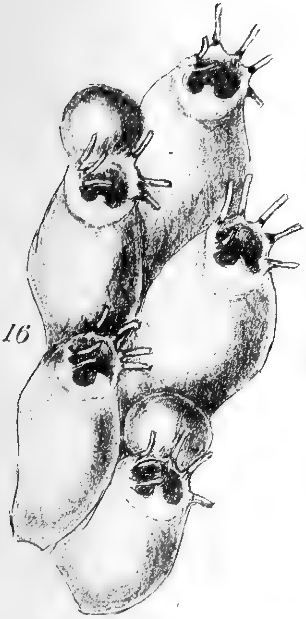
R. H. McG del & lith.

C. Troedel & Co imp

Plate III.


14 a


14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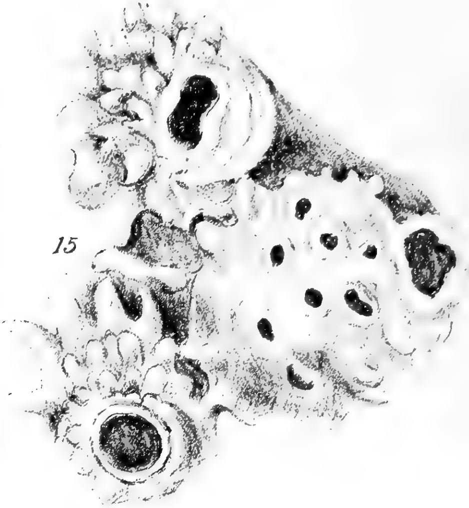
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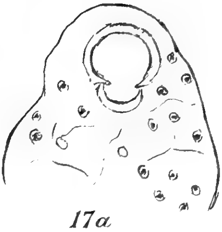
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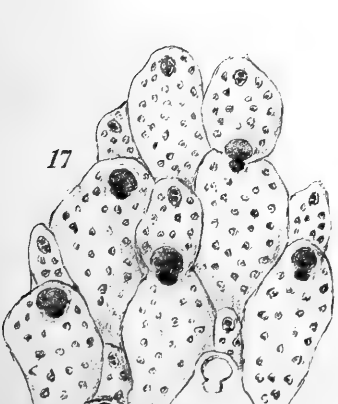
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ART. X.—*Notes on the Storms of High South Latitudes.*

BY D. W. BARKER, F.M.S.

[Read 13th July, 1882.]

IT is to the southern hemisphere that we must look for an explanation of phenomena attendant on all cyclonic and anti-cyclonic systems. To the southward of the 39th parallel there is nothing to stop the storms in pursuing an uninterrupted course round the world, and none of those disturbing areas of high temperature that are found in the northern hemisphere.

It is my intention, in this paper, to endeavour to show, from an isolated and entirely observational point—first, the general appearance of this region between 39 deg. and 60 deg. S., as seen by a spectator placed at some distance above the earth (supposing it to be possible to see the storms actually); second, general formation and weather attendant on them; third, cloud motions, and general prognostics to be obtained from them; and fourth, direction of propagation or movement.

If an observer outside, and perfectly independent of the earth, were to watch the motions of the atmosphere over this belt, he would probably see that there is a general prevailing set of the surface-wind towards a south-easterly point, and a set in the upper regions towards a north-easterly point; but this would be so broken up in some places by cyclonic and anti-cyclonic systems as scarcely to be discernible. In some places would be large irregular anti-cyclonic areas, while in others there would be strings of cyclonic disturbances. If he still watched, he would see the anticyclones broken down by the cyclonic disturbances, and forming again in other places; in fact, the whole system would be propagated round in an easterly direction. In summer time the appearance would be much more irregular, caused by the sun's influence. Off the continents of Australia and South America there would always be breaks, caused especially in the former by the large interior hot surface.

2. I propose the following ideal figure to represent approximately the shape of these storms, which seems to answer to all the veerings, &c., much better than anything else I have seen. Of course it is very unlikely that one would ever be seen so regular; but this is only to give a general idea. The shape they seem more generally to assume is elliptical, the southern half being a great deal broken up and more irregular than the northern, though it still exists, and can generally be traced. The isobars in front are very much compressed, caused by the resistance to its propagation, while in the rear they are often greatly extended. The following general description of one will show reasons for this, and also the general incurving of the wind outside and near the centre :—Barometer steady; light airs or calms; then light wind begins to make from N., with cir.-s. spreading over sky. Wind backs more to N.N.E., and barometer begins to fall. Soon after the clouds begin to lower, and it becomes quite overcast; barometer falling fast, and rain coming on; wind steadily freshening with hard gusts, backing still more to N.E. by N., where it keeps steady for some time. When the barometer falling more rapidly, rain comes on heavy, and wind again backs to N.E. The glass will now stop going down, and there is generally a lull for a few moments, and the wind suddenly shifts round to the westward with hard squall. This is supposing the centre to pass over observer. It will now clear up, but keep squally till the wind veers round to S., falling lighter all the time, and barometer rising. When S.E. there will be light airs and calms. They seldom go single, but several follow one another in succession, the wind then, after getting to S., backs again instead of going round. It is a remarkable thing how very seldom the wind goes right round to E. and N.E. by S.E. It may apparently seem to, but in most cases that this is observed light airs and calms are noted, and the cases are rarer of its going completely round the other way. After several of these an anticyclone will probably be experienced, the wind conditions in which are almost exactly the reverse. The weather fine and dry, and a good deal of a well-known dry weather stratus about. The wind changes quickly from S. or S.W. to a northwesterly point, and the stratus cloud breaks up before the next disturbance comes on. The anticyclones seem to have little or no movement in them.

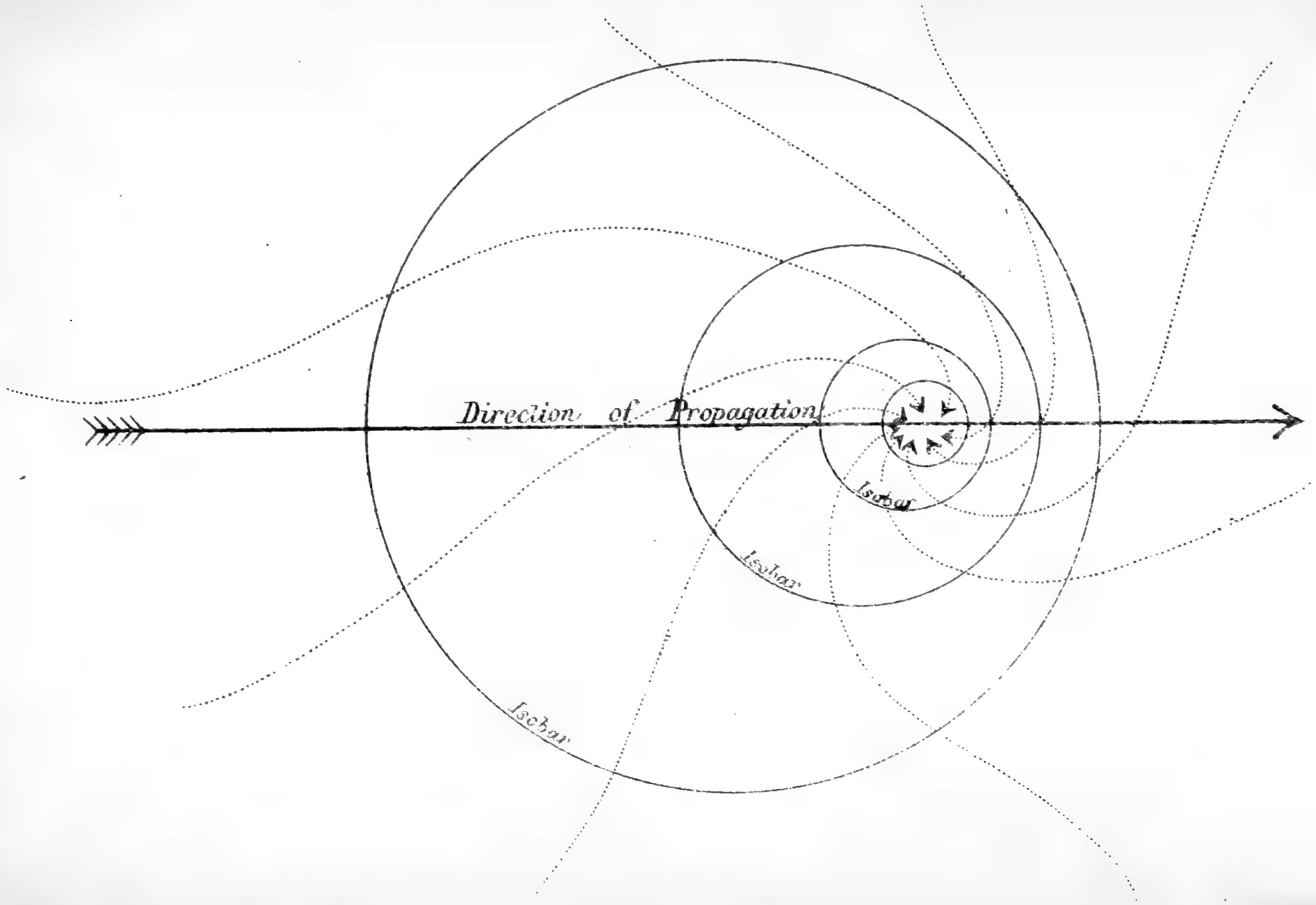
In a case where the centre passes well to southward of an observer, the wind does not shift suddenly, but veers gradually round to the westward. Heavy gales are occasionally experienced from the eastward of S., and when they come are generally lasting, and the weather takes some time to clear up. One thing especially tends to show the prevalence of westerly winds, which are the prevailing winds in the rear of these disturbances, is the constant, steady swell from that quarter, which can, with a few rare exceptions, be always traced. It is very noticeable before the cyclonic disturbances set in, and when the wind gets round to the quarter from which it is coming, it soon mounts up into the tremendous, regular seas, only to be seen in these parts of the globe. The temperature of the water does not seem at all affected by the shifting of the wind, though the air generally is to the extent of several degrees.

3. The movement of the upper clouds in these storms seem to be much more regular than they are in the northern hemisphere. Observations on their movements as observed from a ship are very difficult, on account of the double motion of rolling and going ahead, and especially when there are other clouds beneath, which then makes it appear as if the upper were in movement. I have frequently found old sailors even giving a point from which they are coming almost opposite to their real one. I shall now again take the case of a storm passing over an observer. It will be found that cirri first appear on and parallel to north-western horizon, and will apparently be moving from that point; but it will soon be seen that their movement is almost from a point at right angles to this, but they will appear to be spread over the sky from N.W., and the motion would probably be noted in nine cases out of ten that they were coming from N.W. But it will be found when they arrive overhead that they are moving from S.W., but are still being propagated from the north-westward; they thus have a twofold motion. These lines are often very perfectly formed, and all appear to meet at two points—S.W. and N.E. There will also be a slight short stratification across the lines at a large angle.

The more gradual the forming and propagation over of the upper cloud, together with its perfect form, as above described, the more severe and lasting the storm; but it must be understood that there are storms which are not forecasted in this perfect way. As the storm approaches the cirrus becomes denser and lower, till the sky is covered with a uniform layer, without any stratification; and, if the motions can be made out, they will still be found to come from some point to southward of W. The stratification often appears at intervals after the rain has set in, when the threads or lines will be found to have backed—that is to say, the line of direction of the threads will have moved round till they lay from N.W. to S.E. The storm is now in full force, and it is only at intervals that the upper clouds can be seen; they will be seen to be moving from a north-westerly point till the centre has passed over. It often happens that at or near the centre the weather clears up for a time, when the sky will be seen full of dense fragments of cir., cir.-s., and cir.-c., very much broken up and watery-looking, enveloped in a thick haze, all moving from a north-westerly point. But the sky soon becomes overcast again till the wind shifts round to a south-westerly point, when all the upper clouds will be found to have left, fragments only here and there moving from a south-westerly point. Large cumuli clouds are now continually formed, which are edged by cirrus-looking clouds, and seem a good deal affected by electric action, as seen by their abrupt serrated edges, sticking out in all directions above the cloud, and apparently strongly repelling each other's ends. These are also more or less attended by vivid flashes of lightning, which at night-time are a valuable warning of the approaching squall, before the cloud itself becomes visible. There is generally a strong gust of wind in them, and heavy downpours of hail and rain, but only for a short time, the wind also being unsteady, varying at times several points, mostly towards a more southerly point.

One thing may be worth noticing before passing on—it is the warning that the wind will soon veer to the southward when it is at W. or W.N.W., with fine weather. Fine high hard-looking cirrus clouds which, in the neighbourhood of the sun exhibit the most beautiful prismatic colours, and when the moon is up at night-time a green corona, at times very well defined, round it against the blue sky. It would be a valuable help to upper-cloud observations if the places where the cirrus is parallel to the horizon, and the apparent radiant points were always noted down, for, although it is noticeable that in the northern hemisphere the movements are very eccentric at times, yet to the southward I have always noticed that they move from a point, almost, if not quite, at right angles to the point to which they are parallel; and these points could always be noted with great exactness, whereas the point from which they move is not exact often,

Ideal Cyclonic Disturbance, S. Hemisphere.



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unless the observer can or will give the time to notice them properly.

4. The direction of propagation of these storms seems, as nearly as possible, to be about E.S.E. From numbers of opportunities I have had of observing them while the ship was going on this course, the storms follow one another much more regularly, and follow out all the necessary conditions of the diagram, while in steering either more to the northward or southward the conditions are altered, but still agree with the translation of the storm along this particular point. But until a number of really good sychrmous observations are to be obtained, this will always be more or less doubtful. I have every reason for knowing that ships' logs are not as accurate as to winds' direction and the weather as they might be; different people writing up the same log alone causing considerable errors, more especially in the velocity of the wind, which is generally considerably overrated. The subject has lately been taken in hand here, and we may hope soon to have some valuable information, only here again land influences tend considerably to alter these storms, and will not tend to throw very much light on their true formation over the sea.

ART. XI.—*Propulsion of Steam Vessels without Machinery.*

BY CAPTAIN GRIFFITHS.

[Read by MR. KERNOT, 13th July, 1882.]

ART. XII.—*A Physical Description of the Island of Tasmania.*

BY THE REV. J. E. TENISON-WOODS, F.G.S., F.L.S., HON. MEM. ROY. SOC. N.S.W., TASMANIA; COR. MEM. ROY. SOC. VICT.; VICE-PRES. LINNÆAN SOC. N.S.W., &C., &C.

[Contributed 10th August, 1882.]

THE island of Tasmania lies off the south-east extremity of the continent of Australia. It is separated from it by straits about 150 miles wide, and lies between lat. 43° 39′ and 40° 44′ S., and long. 144° 38′ and 148° 24′ E. It is somewhat wedge-shaped, the narrow end being towards the south, as in most islands and continents. Its area is estimated at about 27,000 square miles. Its contour is extremely diversified with numbers of deep indentations, estuaries, and bays, which give it a coast line of very great extent, far superior to any equal area in Australia. It may almost be described as a cluster of high mountains, with a large lake area on its tablelands, and a very extensive drainage or river system.

Tasmania is generally considered as a detached portion of the great Australian Cordillera, or mountain system of the eastern side of the continent, which extends from Wilson's Promontory right up to Cape York, in Torres Straits. Tasmania is nearly in the same line south of this mountain range, and is more or less connected by long islands lying in the same direction and a chain of rocks. But this unity of direction would not of itself prove them to belong to the same mountain system. The two separated portions should belong to the same geological formations, and owe their elevations to the same forces. That this is the case is capable of demonstration.

The great Australian Cordillera may be described as a mountain system composed of certain definite formations, which are more or less well represented in the whole of its course. There is first a granitic axis, on the sides of which altered rocks, schists, slates, and gneissose rocks of uncertain age are seen to rest. Above these are rocks belonging to the Cambrian, Siluro-Cambrian, and Silurian systems, on which are found quartz veins with gold and other minerals. The stratified rocks of this system are always much folded and crusted together so as to give them an almost vertical dip, and lead to great mistakes as to their thickness, unless attention be paid to the way the same strata are repeated in the various folds. Above these are found the Devonian rocks. They lie unconformably upon the Silurian strata, and though in places they have been much disturbed, yet are, as a rule, not so much inclined as the older system. Above these again are found the carboniferous rocks, consisting of lower and marine beds, as they are termed, and the upper or fresh-water series. These beds do not lie comformably upon the Devonian. They are nearly horizontal, but perceptible dips can be observed where they are studied over large areas. These beds are again succeeded by sandstones, called by various names. The two formations do not pass quite conformably from one to another, and the line of division is well marked. It is probable that these beds may be considered as Trias, or Lias, but this is of no moment just now. Their age will depend upon the age ascribed to the coal deposits of which so much has been written. Quite conformably with these are the strata next in succession, which are called the Wianamatta shales, which may be Liassic. Certain sandstones of aërial origin next succeed, whose true position is not yet decided. They lie above the Cretaceous rocks in Queensland, and, possibly, those of N. S. Wales (the Hawkesbury sandstone) may be older. Associated with all these are igneous or metamorphic rocks, called greenstones, or diorites. They are partly volcanic, and partly, no doubt, ash beds, or dykes, but so altered that we can only speculate generally upon their origin. But it is clear that some are the most recent in age, for they have broken through all the older formations, and in some cases altered and disturbed them. They form a very large portion of the rock system of the country. They overspread and completely hide immense tracts of the underlying formations, and sometimes, no doubt, they have broken them up and destroyed them.

Above the sandstones of aërial origin we find nothing of a more recent age until we come to the tertiary drifts, tertiary volcanic rocks, and recent alluvial deposits. These are more or less well represented, but the tertiary volcanic rocks by far the best of the three. Some very large tracts of country are covered with very recent basaltic lavas, doleritic for the most part, but evidently belonging to several periods of deposition. On the southern and extreme northern portions of the chain there is no vestige of any marine formation of later mesozoic or tertiary age. In the middle or central portions of the chain there are a few outliers of secondary formation, but with these exceptions there is an immense blank between the epoch of the carboniferous and geologically recent times.

All these features of the great Cordillera are found in the mountain system of Tasmania. There is the granite axis, then the metamorphic rocks, the Silurian strata, the Devonian, the carboniferous, and probably the Hawkesbury sandstones. After these and amidst them we have an immense development of intrusive greenstones. Then follows a vast blank, until the tertiary basaltic rocks and alluvial drifts are reached. In the whole island there is not the slightest trace of any marine mesozoic rock. On the extreme north side there is a small patch of miocene tertiary, and no doubt there are other such fragments underlying the basaltic rocks on the low lands of the north coast. Such deposits form no exception to its general resemblance to the great Australian Cordillera. On the low-lying flats of those mountains similar miocene or later formations occur, at least on the side opposite to those of Tasmania.

Thus we have in Australia and Tasmania a mountain system composed of the same elements, apparently upheaved under the same conditions, probably belonging to the same epoch, and subject to the same changes afterwards. The differences between the two systems are that the development of greenstones is much more extensive in Tasmania than in any equal area in Australia; and the disturbance and dislocations of all the strata have been more violent and numerous. Thus it is that no single formation can be followed for any great distance in Tasmania. It is broken up and faulted and overlaid by the intrusive rock. This has a most important economic bearing on the mineral productions of the rocks. Coal of fine quality and in thick seams is of frequent occurrence in the carboniferous rocks, but mining has not been very successful hitherto, partly because of the continued dislocations or faulting of the seams. It would appear as if the disturbances which during a long course of ages uplifted the Cordillera, had its period of greatest activity in the southern extremity, which is now represented by the Tasmania mountain system. Before dealing with these various formations separately, it will be necessary to say something about the general direction of the mountain ranges of the island.

As in south-east Australia, the most precipitous portions of the ranges are on the east side. They seem to abut upon the ocean at various places in the whole mountain chain, but this peculiarity becomes more marked towards the south, and most of all in Tasmania. On the east side the mountains confront the ocean with little or no intervening level ground. On the north side there is a considerable area of low-lying ground between the sea and the mountain ranges. This is not a level tract. These are spurs from the elevated plateau which divide the basins of the Tamar, the Mersey, the Forth, the Leven, and other rivers. All these streams empty upon the north side of the island; they have their origin in the elevated tableland, but descending from that have a long course through the comparatively lower land which intervenes between the plateau and the ocean. In some of the valleys or river basins there are patches of tertiary rocks. Some are fresh-water deposits, with abundance of leaves and plant impressions. Some tertiary marine shells have also been found. The dividing ridges between the streams are the usual paleozoic rocks of the Cordillera. As the same rocks are found upon the tableland, there must be a great fault, or a series of them, between these sedimentary rocks and the more elevated plateau This causes the inclined edges of the fossiliferous rocks to abut upon the greenstone masses of the interior.

The plateau or tableland occupies the centre, or perhaps a little to the north of the centre, of the island. In its highest portion it is over 4000 feet above the sea, and the average is not much under that height. It is distinguished by possessing large and deep lakes of fresh water. The Great Lake has a length of thirteen miles, with a maximum width of eight miles, and an average of three to four. It covers an area of 28,000 acres. There are besides Lakes Sorell, Crescent, St. Clair, Arthur, and Echo. They are the sources of all the important rivers in the island. This tableland is for the most part covered with beautiful grass lands, with no important mountains in their vicinity, unless in the case of Lake St. Clair. It is probable that the descent from this plateau is by a series of terraces (notably the Middlesex Plain and Mount Bischoff plateau, averaging 1800 to 2000 feet); and there are also in various parts of the island other tablelands of smaller extent and lower elevation. Thus Lakes Tiberias, Dulverton, and Tombs, on the east side of the island, are similar features. They are seen again in the south-east of New South Wales. The outline of the country around Lakes Bathurst and St. George in that colony is very similar to the lake districts of Tasmania. They are of good elevation, and the geological structure of the rocks is the same.

But though the elevation of the island of Tasmania has resulted in a certain extent of elevated plateaux, yet it has produced in far the greater portion of its extent an uneven surface, composed of broad or narrow mountain ridges or isolated hills. There are three phenomena which are visible here as elewhere:—1. Elevation; 2. Intrusion, or overflowing of volcanic rock; 3. Denudation, or weathering. All these causes may have been in operation until recently, and the last is still going on. The results of endless change, breaking up, and redistribution have produced such alteration in the strata that it is next to impossible to assign any particular appearance to its original cause. Thus a mountain which is now a pinnacle may originally have been a dome, and a sharp or jagged range may have been the edge of a tableland. There are many and various chains of mountains running through the island, some on the edges of the plateaux, and some running actually through their midst. Thus different directions have been traced by Count Strzelecki and others. It must be borne in mind when studying them that they are not certainly axes of elevation, and do not correspond in every respect with the general configuration of the coast line.

Beginning at the north-east extremity of the island—Cape Portland—we find a small ridge about 700 feet high. At a point called the Black Ridge the commencement of the great area of elevation is reached, and the land suddenly rises to above 3000 feet. The chain then takes a south-west direction, and sends off three long branching spurs. The first is the source of the River Boobiala, and terminates in a cluster of conspicuous granite hills, of which the most prominent is Mount Cameron. Next to that is the greenstone of Mount Horror, Mount Barrow, Mount Arthur, and Mount Direction. This spur continues as far as the mouth of the Tamar and ends with Mount Royal. The last spur is the highest part of the mountain system of this side of Tasmania, including the lofty summit Ben Lomond. "It is impossible," says Count Strzelecki,* "to give an adequate

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* *Physical Features of N. S. Wales, &c.*, p. 66.

idea of the outline which these spurs have produced; of those endless sharp-edged ridges, which run in all directions, interbranch, and form, as it were, a network of mountain chains woven intricately together. At times the eye can seize upon their distinct and independent courses, radiating from a common centre, and gradually sloping into flat-bottomed valleys; at times their flanks are erect and perpendicular, imparting to the ridges an appearance of having been rent asunder, and presenting between dark chasms and gorges, from which roaring torrents make their escape." From the northern extremity of what the Count called the "lofty and precipitous battlements" of Ben Lomond, the mountain overhangs profound and tortuous abysses. The central part of the mountain top is a mass of prismatic greenstone columns, 8 or 10 feet in diameter, and their ends projecting over chasms more than 3000 feet in perpendicular depth.

The chain of which Ben Lomond forms the culminating point reaches the sea at St. Patrick's Head. It then takes a south-west course for about sixty miles. It turns westward between Lake Tomb and the Eastern Marshes, and runs north of west to St. Peter's Pass. A spur runs out south at St. Peter's Pass, which separates the Coal River valley from that of the Jordan; and another which separates the Jordan from the Clyde. In this spur, Table Mount (3596 feet) is very conspicuous. It is a slope of tableland which, at a distance, appears like elevated strata of sandstone, though I believe it is an escarpment of greenstone.

The main axis or chain then proceeds northwards, dividing Lake Sorell from Lake Arthur, and extending to Dry's Bluff (4257 feet). The latter is a commanding elevation which forms a conspicuous abutment to the plains of the north coast. Between Dry's Bluff and the Western Bluff the chain has a semi-circular bend, and sends one spur to the north, which terminates at Quamby's Bluff. It also sends others to the south, which divide the lakes from some of the tributaries of the Derwent. At Western Bluff it sends to the north-east a long spur, which divides the valleys of the Mersey and Meander. The range from St. Peter's Pass averages 3500 feet in height, and presents an extremely dark, rugged aspect. Its crests are almost all greenstone very rocky and barren. To the southward it is still bolder "Its spurs in the vicinity of Lake St. Clair, to the north, north-west, and west, are topped for the most part by more lofty, bare, and cloven summits of quartz rock and syenite, and are divided by darker gullies, the beds of which are furrowed by the torrents" (*Strzelecki*, p. 69). The greenstone and basaltic spur which divides the Forth from the Leven, and that which stretches to Cape Grim on the extreme north-west, are all equally rugged and wild. South of Lake St. Clair there is a spur which divides the valleys of the Gordon and King Rivers, which empty on the west coast. This culminates in the mountain called Frenchman's Cap (4756 feet). The country in this neighbourhood is very little explored, and it is of wild and picturesque character. Another spur makes a semi-circular curve to the eastward, and divides the basins of the Huon and Derwent Rivers, terminating in Mount Wellington (4166 feet). The chain beyond these two spurs bends in a south-easterly direction, sending forth minor spurs, and, with Mounts Adamson (4017 feet), La Perouse (3800 feet), Bathurst Range, and Wilmot Range, barren mountains, standing out conspicuously from various parts, until the axis terminates at South Cape.

The above is only a very general idea of the mountain system of the island, which is more or less picturesque and ruggedly uneven throughout. As the west and south coasts are not settled upon except by a few scattered families of splitters, and as it has been very little explored, much has to be learned about the physical structure and geology of the mountain system of Tasmania. I have not specified all the offshoots from the main chain. Thus the north-west spurs send off two westerly offshoots in succession, one of which divides the Arthur and Pieman Rivers, and another—the Eldon Range (4789 feet)—dividing the Pieman, and its tributary the Murchison, from the King River, which flows into Macquarie Harbour. The south end of this port receives the River Gordon, which drains the north side of another spur from the Wellington Range. The southern side of this spur drains by many tributaries into the Huon. Mount Picton (4340 feet) is one of the highest peaks of this very little known mountain chain.

The general aspect of these mountain ranges is picturesque in the extreme. The summits of the hills are for the most part bare, and studded with romantic crags and precipices. Where the soil is derived from greenstone, and not too precipitous, the forest is extremely dense. The gigantic *Eucalyptus amygdulina* and *E. obliqua* grow thickly with tapering stems of extraordinary height; while the undergrowth is of moss and fern, and shaded by almost impassable thickets of *Pomaderris elliptica, Fagus Cunninghami,* and tree ferns (*Dicksonia antarctica*). The sides of the smaller streams are thus nearly always surrounded by forest. But there is a great difference between the dense vegetation of the comparatively level and open rivers of the plains and those which are supplied from the mountain gullies. The latter are all completely shaded in by a thick growth of forest extending for a long distance on either side. The tablelands are, as already stated, grassy, and free from timber; and in all the country to the south and west, between the densely wooded gullies, the land is open, and clothed with a sedge called button grass (*Gymnoschœnus sphærocephalus,* Hooker) and *Xyris gracilis, Schizœa bifida,* and many mosses, fungi, and lichens. In all the elevated regions of the western and southern mountain systems the soil is open, poor, and wet. The snow lies upon it for many months, and its humidity and exposed situation render it worthless for settlement.

I will now describe the various geological formations which form the mountain systems of the island.

Granite, syenite, and *porphyritic* granite are well represented on the east coast at George's Bay. It is also found at Mount Bischoff, and occasionally along the Eldon Range, near Ben Lomond, Mount Barrow, and other places. Its connection with other formations is not well made out. As a rule it does not play the most important part in the geology of Tasmania. It does, however, contribute a very important item to the mineral richness, as it is in connection with the granite formation that the remarkable deposits of tin have been found.

Metamorphic Rocks.—It is probable that the base of most of the mountain ranges to the westward consist of metamorphic rocks. They are principally varieties of quartz rock and schist, which appear to alternate and pass into one another. They are especially developed in the country about the Eldon, Arthur, and Frankland Ranges, Frenchman's Cap, Mount Murchison, &c. The mica schist, according to Mr. Charles Gould, consists of quartz and mica in varying proportions. These minerals are sometimes arranged in alternate laminæ, while at others the quartz is aggregated into nodules, which are imbedded in soft micaceous, or occasionally chloritic schists. Those varieties are the most abundant in which the quartz preponderates over the mica, frequently passing into a homogeneous quartz rock. The greater part of these beds possess a very foliated structure, with a lamination in general definite directions. There are no quartz reefs in connection with these deposits. Whatever quartz there is exists in the form of bed rock, and is part of the whole altered strata.

There can be no doubt that these belong to some formerly stratified rocks lying below the Silurian, or even the Cambrian. They are too much altered to contain fossils, if, indeed, they ever did possess them. It is very singular that there are no quartz reefs in connection with them. The beds contain gold in small quantities. Possibly the metamorphic action which changed them from the stratified state has been too partial or limited to segregate thoroughly the gold and quartz into reef deposits. The metamorphism to which they have been subjected is due to—1. The pressure to which they have been subjected when covered by great masses of formations, which have subsequently been nearly all denuded away; 2. Heat accompanying that pressure; 3. Water also much compressed and heated.

Silurian.—At the base of the western half of the Eldon Range, and extending southwards to the Collingwood Valley, certain strata are found a considerable thickness of dark grey mudstones and clay slates with slight admixture of arenaceous rocks, and towards the base calcareous bands and limestones. The dip is not easily ascertained, from the cleavage which affects the upper beds and the contortion of the lower ones. Succeeding these are highly micaceous beds, siliceous grits and clay slates, the latter resting uncomformably upon the metamorphic rocks. On the north shore of the Macquarie Harbour, and the course of the Gordon River for thirty miles from its mouth, and for a short distance of the courses of the King's and Franklin Rivers, and on the line of country between the Eldon Ranges and the West Coast, the usual upper paleozoic and greenstone formations, so common on the east side of the colony, are absent. Their places are taken by several marked divisions of the Silurian rocks, but their exact sequence has not yet been determined. According to Mr. Charles Gould they are chiefly of Silurian, and some of them of Cambrian formation. The most prominent formation consists of fossiliferous limestones, the *entire* thickness of which is not less than 1000 feet, called by Mr. Gould the Gordon limestones.* They are, in some cases, slightly argillaceous and thickly bedded, but ordinarily compact and massive. They are jointed in a variety of directions, and the fissures have been filled with calcareous spars. Irregular fissures or veins of calcareous spars and quartz ramify through the formation. These vary in thickness, and contain galena. These limestones appear again at the great bend of the Gordon River, and at Point Hibbs on the West Coast, at the junction of the Franklin and Gordon. They are then succeeded by sandstones and grits. Below these is a coarse conglomerate consisting of quartz pebbles in a siliceous cement, succeeded by siliceous grits and a variety of sandstones, micaceous sandstones, purple grits, and streaked with quartz veins, apparently passing down into clay, slate, quartzite and micaceous schists. The conglomerate forms the most conspicuous summits of the ranges west of the King's River. Steel grey and yellow clay slates, with fossils, are found in the Mersey district. The organisms include Phacops and Ogygia, Calymene Conocephalites, Orthis Euomphalus.† Messrs. Etheridge, Lesquereux, and Dana have considered the fossils as indicating one of the Lower Silurian formations. Similar formations, but of undetermined age, have been received from Fingal.

The following Lower Silurian fossils have been recorded from Western Tasmania:—Retzia minima, Cyrtodonta auriculata, C. compressa, C. distorta, C. gibbulosa, C. inflata, C. obliquata, C. pinguis, C. reversa.‡ Tellinomya amygdala, T. antipoda, Bellerophon pugnus, Eunema æmula, Helicotoma Milligani, H. pusilla, Holopæa munica, Hormotoma nerinæa, H. usitata, Murchisonia Franklinii, M. mimetica, Raphistoma æterna, Scatites australis, Trochonema, Bigsbyana, Lituites Gouldii, Orthoceras, antilope, P. Murchisoni, P. theca, C. Youngii. There is no Upper Silurian fossil recorded from Tasmania.

Silurian strata, but without fossils, were reported by Mr. Charles Gould (at one time Government geologist) from the north-eastern part of the island, in the county of Dorset. He says it would be impossible to define the limits of these forma-

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* The Gordon limestones are most probably the equivalent of the Chudleigh and Midland Plains beds.

†*Proceedings of the Royal Society of Victoria for* 1874, p. 27.

‡ All these are quoted as MS. names of Salter in Bigsby's *Thesaurus Siluricus*, 1868, p. 140.

tions, as they are covered by a drift of sand clay and rounded quartz pebbles. The paleozoic beds are regarded as connected with the Silurian schists of Fingal and the west side of the island. Cambrian rocks are also reported by the same authority along the valley of the Tamar, on low ridges parallel with the ranges, and which have been eroded by the river. Silurian rocks have also been reported from the south side of the island, near Port Cygnet, but I am not aware of the occurrence of any fossils.

Silurian rocks are also stated to occur in the neighbourhood of Mount Bischoff, in the north-west, but are so overlaid by basaltic lava as only to be visible in a few places.*

Devonian.—No fossils peculiar to this formation have been found in Tasmania, though the period is well represented in the Cordillera of New South Wales. As, however, a great many carboniferous fossils are common to the Devonian rocks, it is not at all unlikely that when an accurate survey is made many of the rocks now regarded as carboniferous will prove to belong to a lower horizon.

Upper Paleozoic Carboniferous.—These formations are so very extensively developed in Tasmania that a very long list would be required to name all the localities. As a rule they are exposed in alternate layers of yellow and white sandstones, with shales and thin beds of limestone over which again other sandstones are found. The sandstones are generally firm and hard, but the limestones fall to pieces very readily in some places, and in others these qualities are interchanged. The dip varies, and in many localities there is scarcely any dip at all, but where there has been much faulting from intrusive basalts or greenstones the dip is almost at every angle. No attempt has ever been made to settle geologically the regular sequence of the strata or to determine the horizon to which the various fossils belong. Until a geological map of the east side of the island is drawn after a careful survey it would be premature to say anything decided from the fossil evidence, which is very abundant. Coal is more or less abundant throughout the island. It belongs clearly to the period of the carboniferous fossils. These marine beds, as they are called, are found both above and below the coal. Fossil plants are also found both above and below the marine fossils. It is said that

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* "Geology of the Tin Country:" a series of very interesting letters in a local paper, by S. H. Wintle.

the aspect of some of these fossil plants is not paleozoic; and at one time discredit was thrown upon the statement that such plant remains were found under the marine paleozoic fossils. There can be no question whatever that they are found under the marine paleozoic organisms.* It is generally admitted that some of the coal beds are more recent than others, as for instance those of Fingal, but the relative position has not been accurately worked out. As instances of where the fossiliferous strata are found I may mention the valley of the Derwent, New Norfolk, Mount Dromedary, Tasman's Peninsula, the valley of the Tamar, the Mersey, the Don, many places on the East Coast of the island, Oatlands, Fingal, &c.

The following fossils are recorded as from Tasmanian carboniferous deposits:—*Plantæ,* Glossopteris browniana, G. ampla, G. elongata, G. linearis, G. reticulatum (var. browniana ?), Lepidodendron sp ? Phyllotheca hookeri, Alethopteris australis, Thinnfeldia odontopteroides, Sphenopteris alata, Vertebraria australis ? Endogenophyllites wellingtonensis, Zengophyllites elongatus.

Animalia, Favosites ovata, Stenopora informis, S. tasmaniensis, Fenestella plebeia, F. ampla,†E. antiqua (F. densa) (F. fossula), F. gracilis, Orthis michelini, Productus cora, P. murchisonianus, P. pustulosus, P. rugatus, P. scabriculus, P. n.s. close to P. prattianus (Davidson ms.), P. brachythœpus, P. granulosus, P. n. s. (Davidson fide lit), Spirifera clàrkei, S. convoluta, S. rassicostata, S. glabra, S. stokesii, S. strzeleckii, S. tasmaniensis, S. trigonalis, S. vespertilio, S. 12-costatus, S. darwinii, S. duplicostata, Strophomena crenistria, Terebratula ambigua, T. sacculus, Astartilla ? Aviculopecten limæ-formis, A. squamuliferus, A. tasmaniensis Othonota (?) compressa, Pachydomus carinatus, P. globosus, Pterinea macroptera.

It must be admitted that this is a most imperfect list, but the fact is, that Tasmania, though extremely rich in fossils of the upper Paleozoic rocks, has never had its paleontology fairly worked out. It must also be remarked that there are probably two coal floras. One, Oolitic (?),

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* See *Proc. Roy. Soc. Tasm., 1873,* p. 36, where, in a paper on the Mersey Coal Measures, by T. Stephens, Esq., M.A., the occurence of *Glossopteris browniana* in beds *underneath* marine paleozoic fossils is recorded.

† Proretepora, according to De Koninck, who unites four of the species. *See Foss. Pal., N.S.W.,* p. 178.

characterised by Thinnfeldia (Jerusalem); the other, Permian (?), with Glossopteris, &c.

Carbonaceous Sandstone.—In the Oatlands district there is a tableland forming an inclined plane, of which the highest portion is Lake Tiberias. This is about 1460 feet above the sea. The floor of this plain is almost entirely composed of sandstone, which very closely resembles the Hawkesbury rocks. The strata are in two divisions slightly uncomformable to each other. The upper beds are formed of a fine grained sandstone, more or less ferruginous, in thin layers with much false beddings decomposing into a worthless soil from the upper beds. Small seams of coal and carbonaceous bands are met with in the formation, just as they are in a similar deposit in New South Wales. I have no doubt on my own mind, from all I have seen of this district, that the formations are the same. The town of Oatlands is built upon it, and it is well seen round the borders of Lake Dulverton. I am not aware how far this formation extends in Tasmania. I never noticed it except on the Oatlands tableland. It is not fossiliferous. I should say it was of considerable thickness, 200 or 300 feet at least. The line of junction between it and the coal formation is well marked. They are not quite conformable; the coal measures having a slight dip to the south, which brings them to the surface at the north side of York Plains. The junction often shows pebbles of coal and rodled masses of shale and coal measures, marking the denudation previous to the deposition of the sandstone. Both formations are very extensively overlaid by outflows of greenstone; and no doubt were an accurate geological survey to be made many faults would be found as well.

Greenstone.—The rock which bears this name in Tasmania no doubt belongs to several distinct groups of intrusive or metamorphic rocks. It plays such an important part in the geological structure of the island that a detailed examination will be necessary. Its appearance is certainly posterior to the deposition of the carbonaceous sandstone, as it breaks through that rock and overflows it. It forms the capping of nearly all the mountains of the island, from which we gather an important insight into the denudation to which the rocks have been subjected. It is probable that all these deposits of greenstone formed large, unbroken deposits, covering much of the undulating surface of what is now Tasmania. This may have been then a sea-bottom, formed in some places by carboniferous and in others older paleozoic rocks. It did not come from one outlet; in fact, dykes are as commonly distributed as the stone, but the dykes do not always correspond with the mountains. We must, therefore, imagine that the high-peaked summits crowned with this igneous rock mark former points of ejection. They may in some cases, but in the majority these mountains are the jagged, uneven portions of a surface which has been broken by upheaval, volcanic outbursts, earthquakes, and dislocations of various kinds, then cut and scarred by the denudation of wind and rain and sea and flood. The evidence of all this is found in the strata below. They are faulted and wedged out by dykes and intrusive masses of rock in many localities; but there are others where, though the greenstones are in very thick masses above, the strata underneath are very little disturbed. On the extreme west coast, for instance, near Macquarie Harbour, greenstone occurs only rarely, and then it is at great elevations and in the form of capping to the underlying stratified deposits. According to Mr. Chas. Gould, it has the appearance of outliers from the great mass of trappean rocks upon the east; for the regularity and undisturbed condition of the stratified formations below preclude the idea of its having been ejected through. It seems rather to have flowed across from east to west. Boulders of greenstone occur occasionally of great size and in considerable quantities at distances remote from where it exists *in situ.* The junction of the greenstone and underlying rocks is at various elevations, and this is not due to any upheaval, but to the irregularly eroded surface upon which it was deposited. It has been suggested that some of the lakes of the interior have been formerly craters, and Lake St. Clair, with a depth of nearly 600 feet, has been especially cited. What lends a colour to this supposition is that it is surrounded by mountains of greenstone. But, according to Mr. Gould, sandstone crops out from below the greenstone of Mount Olympus, and these sandstones are nearly horizontal, and there are no scoriæ, ashes, or other deposits around the lake.* The more solid portions of ash deposits are often converted into greenstone, and the lighter portions may have easily

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* There is, however, one large deep lake-crater in South Australia named Mount Gambier. The ashes lie there upon perfectly horizontal limestones, which are full of tertiary fossils.

disappeared in the course of time. This is only mentioned to show that the reasons alleged by Mr. Gould are not decisive of the question; but, at the same time, he gives a much more feasible explanation of the lake than a crater origin, which most persons will be disposed to accept. According to him the waters have been penned up in a natural valley by a recent outflow of basalt. It is hardly to be supposed that we should be able to trace the craters which have been formed during the overflow of the greenstones. It may be safely affirmed that the amount of basalt which has been outpoured in recent times in New South Wales or Victoria, or in South and South-east Australia, fully equals, if it does not surpass, the greenstone deposits. The basalts are comparatively very recent, for they are but little, if at all, altered, yet there does not remain a single crater in all South-east Australia, and in the colony of Victoria they are very few. It is only as we go westward to where the evidence of volcanic action dies out that we find undoubted ash craters with tufaceous deposits.

In all probability the greenstones of Tasmania are ordinary basaltic lavas, alternated by metamorphic action, or chemical change, in which time and weathering were probably the principal agents. After the researches of Mr. J. A. Phillips on the "greenstones" of Cornwall, we cannot hesitate to pronounce on those of the island. In Cornwall they are proved to be lava, closely resembling those of modern date. They are, in fact, dolerites, in which the augite has gradually been transformed into hornblende and viridite*, while the felspar merges into a granular mass. The titanic iron is gradually replaced by a greyish-white product of alteration, and a little epidote subsequently appears. The quartz, when found in these, is a result of aggregation. No attempt has been made to my knowledge to determine the character of the Tasmanian greenstones. They are described thus by Count Strzelecki (*Loc. Cit.*, p. 101):—

Diabase.—Brongniart; Diorite, Haüy.—The varieties of this kind of rock are uniformly composed of felspar and hornblende, in the state of grains or small crystals, in

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* Viridite.—This term refers to microscopic petrography, and is used to express green or transparent substances visible in thin sections under the microscope, forming scaly or fibrous aggregations, resulting from decomposition of augite, hornblende, or olivine. The composition varies, but consists chiefly of silicates of monoxyde of iron and magnesia.

proportions somewhat different, but in which the hornblende predominates. They vary, also, in their structure, being—1. slaty; 2. prismatic; 3. amorphous. 1. Slaty greenstones or schistoid Diabase. Colour, in recent fracture between leek and pistachio green, decomposing on the external surface to a dull reddish brown. Internal surface has a waxy lustre. The imbedded crystals of hornblende are generally brilliant. Its structure is schistose, but the layers are never parallel, and are running from a thickness of two or three inches to a wedge-like termination. For the most part its seams present a lenticular form resembling convex lenses, thus (says the Count) beautifully illustrating the successive overflowings of the incandescent matter. It does not adhere to the tongue, and exhales an argillaceous odour. The streak varies. Its powder is a brownish yellow colour. Structure, compact and hard. The Count adds that the localities which supply the most important facts bearing on its geological relation are between Launceston and Mount Direction, Mount Direction and George Town, Stony Head, Cape Portland and St. Patrick's Head, Break-o'-Day River and the Tyne, Ben Lomond, Ben Nevis, Port Sorell, Day's Bluff, Lake Arthur, Lake Sorell, the Great Lake, Lake St. Clair, Western Bluff, Mount Cradle, and the source of the Nive, and Mount Cameron West. He says, also, that this variety of greenstone occurs at various heights, capping all the prominent elevations of the interior of the island. It is invariably and intimately associated with porphyries, argillaceous schist, mica, slate, syenite, granite, siliceous slate, and limestone. When it is isolated from the prismatic or amorphous greenstone, its seams are horizontal. When, however, these varieties are in contact with it, the seams are vertical, broken, and distorted.

The examination of the great area which this schistose greenstone covers in Van Diemen's Land, leads to the discovery of sources from which it overflowed the island. The principal sites appear to have existed in the vicinity of Cape Portland, between Mount Barrow and Mount Arthur, on the north side of Ben Lomond, on Mount St. Patrick, at Port Sorell, on Mount Cradle, Mount Cameron West, and at the source of the Nive. In all these places the schistose greenstone is associated with porphyry. This association strongly led the Count to believe that the greenstone flowed along the pre-existing slope of the consolidated porphyry.

2. *Prismatic Greenstone.*—This rock does not differ from the preceding, except that its structure is prismatic, the prisms having from three to seven sides. It is principally seen on Ben Lomond, where prismatic columns are found from three to eight feet in diameter, and sometimes one hundred feet long. There have been no observations on this rock in Tasmania. Similar rocks in New South Wales, Victoria, and Queensland have been microscopically examined. Mr. Allport, of Birmingham, says of that of Gympie (Queensland) that it is a diorite, containing hornblende triclinic felspar, orthoclase, biotite, and pyrites. There was also a little chlorite and quartz filling up the spaces between the crystals. Many of the crystals were imperfectly crystallised, but the rock was not much altered.

Some of the diorites of Victoria have formed the subject of a very elaborate paper by Mr. A. W. Howitt, F.G.S., read recently before the Royal Society of Victoria. He says that dykes of diorite are of very frequent occurrence at the Swift's Creek diggings. They are from one to five feet wide, and have not any common direction of strike. They are sometimes visibly crystalline, and composed of white plagioclase and dark green hornblende. A microscopic examination shows quartz, viridite, apatite, and combinations of iron.

There can be no doubt that these rocky masses and dykes of diorite wherever they are found are portions of one continued period of volcanic disturbance to which this part of the globe was subject during mesozoic times. In New South Wales and Queensland many of the igneous rocks are intercalated with the carbonaceous deposits. I am not aware that this has been noticed in Tasmania, though the examinations have been very imperfect. But one thing seems to be very certain, and that is that the bulk of the Tasmanian diorites flowed out after the coal period, and probably at the end of the mesozoic epoch alluded to. In a paper on the Hawkesbury sandstone, read before the Royal Society, New South Wales, May, 1882, I have stated my reasons for believing this formation to be an aërial one. It may, therefore, have accumulated round the igneous rocks, and is not in reality under them, though it has that appearance. This may be the explanation of the greenstone cappings or outliers.

Has the island been submerged since the mesozoic period? On the north side it has—that is, the low-lying portion of the north coast, far away from the table-land. But with regard to the rest we may say that there is an extreme probability that it has not. It is true that we have evidence of immense denudation in the greenstone, and that in north-east Australia we have an extensive development of secondary rocks and formations ranging from the oolitic to the cretaceous, but these formations seem to be confined to the north-east side of the continent. It is hardly likely that any formations could have existed here without leaving any trace, not merely of fossils, but of other changes.

It must be admitted that this negative evidence is not conclusive. It receives a little more confirmation from the extensive outbursts of basaltic lava which are found throughout the island. These lava-flows lie either upon the carbonaceous deposits, or upon drifts, or directly upon the greenstone. They are of various ages, but probably not earlier than the tertiary period. If there be yet any hope of finding secondary formations in the island it will be underneath these basalts. The tertiary lava flowing over them would thus preserve them from wearing. No such deposits have yet been found, as far as marine fossils are concerned, but plant remains are not uncommon. This shows clearly that the land was above the sea at the time of the outpouring of the basalts.

These modern volcanic rocks are nearly of similar character throughout. They are black or dark blue vesicular basalts, similar to what are found in New South Wales and Victoria. They are almost as extensively distributed as the greenstones, and are found at every altitude. They form densely wooded hills on the south-east side of the island, and are more or less visible in the east and north coast, on the table land, and through the island, such as near Oatlands, Lake Arthur, Lake St. Clair, Launceston, Table Cape, Cape Grimm, &c., &c. Near Brighton a very fine section of columnal basalt is visible. The general character of the rock is doleritic. The only specimen I ever had an opportunity of examining appeared to me to show a felspathic dolerite, with triclinic felspar, augite, magnetite, and either olivine or pseudomorphs, after olivine. The augite is in small brown crystals. Mr. Ulrich, of Victoria, made sections of the basalt at Table Cape, and found the composition to be very similar to some of the recent basalts in Victoria. It was a felspar, with very little augite. Vitreous quartz, magnetite, and olivine basalt from Breadalbane, where there are plant remains and leaf deposits, contained well-developed crystals of augite. No conclusion as to the age of the rocks can be formed, except that they are tertiary. Of that we may be certain—first, because at Table Cape they overlie marine tertiary beds of miocene age; secondly, because at Breadalbane some beds overflow plant remains, which are tertiary, and identified by some of the plants with pliocene vegetable remains in Victoria and New South Wales. These two outbursts must be of different age, because the Table Cape beds have flowed over the bottom of the sea, which has since been upheaved; but those of Breadalbane have flowed later, over dry land.

No crater remains to show the points of ejection. It does not take long to destroy such records, but we may conclude at least that there has been no volcanic activity in very recent times in Tasmania, such as we know existed in Western Victoria or the south-eastern district of South Australia, where several craters are still visible. The more westerly they are situated the more recent in character they become. The one most to the westward is quite modern.

The tertiary marine beds at Table Cape form a small patch of fossiliferous strata which owe their preservation entirely to the capping of basaltic lava. Probably similar patches are to be found under the basalt on the north coast. At Breadalbane, miocene fossils are sometimes found in wells. The formation is part of the great tertiary deposits of Southern Australia, which extends with occasional interruption over 20° of latitude and 10° of longitude. It consists at Table Cape of bands of limestone, marl, and clays, the latter often ferruginous and containing gravel, as if the beds had been derived from decomposing traps. The fossils identified are:—Murex eyrei, Fusus meredithæ, F. roblini, F. johnstonii, F. tateana, F. transenna, Triton abbotti, T. minimum, Buccinum fragile, Trophon fragile, Cominella lyræcostata, C. cancellata, Thala marginata, Nassa marginata, Terebra additoides, T. simplex, Cassis sufflatus, Cassidaria reticulospira, Syrnola bifasciata, Actæon scrobiculatus, Columbella oxleyi, C. caniozoica, Pleurotoma johnstonii, P. paracantha, P. sandleroides, P. pullulascens, Ancillaria mucronata, Voluta hannafordii, V. anticingulata, V. antiscalaris; V. weldii, V. macroptera, V. granatina, V. maccoyi, Marginella wentworthi, M. strombiformis, M. octoplicata, C. platyryncha, C. gastroplax, C. eximia, C. archeri, Trivia mimina, T. avellanoides, Daphrella columbelloides, D. tenuisculpta, D. gracillima, Mangelia gracillina, N. wintlei, N. vixumbilicata, N. polita, Turbonilla lyræcostata, T. pagoda, Eulima danæ, Cerithiopsis johnstonii, Turritella tasmanica, T. sturtii, T. warburtonii, Vermetus conohelix, Tenagodus occlusus, Rissoa stevensiana, Rissoina varicifera, R. tateana, R. johnstonii, Turbo etheridgei, Imperator imperialis, Trochus josephi, Thalotia alternata, Gibbula crassigranosa, G. clarkei, G. æquisulcata, Astralium flindersii, A. ornatissimum, Margarita Keckwickii, Zizyphinus blaxlandi, Delphinula tetragonostoma, L. tasmanica, L. discoidea, L. lamellosa, Solarium gibbuloides, Fissurella concatenata, Emarginula transenna, Crepidula lævis, Trochita turbinata, Cylichna arachis, Humphreya arachis, Dentalina kicksii, D. lacteum, Terebratulina davidsoni, Waldemia gerybeldiana, W. macropora, W. gambierensis, Terebratella compta, Rhynconella lucida, Ostrea sp., Lima bassi, L. sp., Plicatula, Spondylus gaderopoides (?), Cucullea corioensis, D. cainozoica, Arca sp., Pectunculus laticostatus, Limopsis belcheri, L. aurita, Nucula tumida Leda crebricostata, Chama lamellifera, Venus allporti, V. propinqua, V. cainozoica, Cardita gracilicostata, Cardium sp., Crassatella oblonga, C. aphrodina, Tellina cainozoica, Solecurtus legrandi, Lyonsia agnewi, Myodon, Trigonia acuticostata, T. semiundulata, Vulsella sp. Balanus, Micraster brevistella, Lovenia forbesi, Leiocidaris, Heliastrea ————, Thamnastrea sera, Balanophyllia australiensis, Dendrophyllia epithecata, Trochoseris woodsi, Conotrochus maccoyi, Sphenotrochus excisus, S. deltoideus, Montlivaltia discus, Placotrochus elongatus, Conocyathus viola, Dendrophyllia duncani, Flabellum duncani, F. victoriæ, F. gambierensis, Cellepora gambierensis, C. spongiosa, C. nummularia, C. hemispherica, Spiroporina typica, Retepora sp.

Tertiary Plant Beds.—In Mr. Chas. Gould's report of the exploration of Macquarie Harbour, he gives the following account of a tertiary formation existing there. He says that on the north side of Macquarie Harbour and for some miles up the Gordon River there are cliffs, at many points, 70 or 80 feet in height, consisting of coarse sand, rock and shales, largely impressed with leaves of existing plants, and containing occasional thin seams of lignite, which have caused reports of coal there. Raised beaches (?) of loose quartz-pebbles surmount them, and form elevated pleateaux of marsh land on the southern as well as on the northern side of the harbour. I am not aware of any further attempts to explore these tertiary beds. Mr. Gould is right in supposing the plant impressions to be those of existing species. The formation is probably a pliocene one, and the rolled pebbles above suggest a drift like that in which the alluvial deposits of gold are found in Victoria. The lignite is, however, not usual.

Other plant beds of tertiary age have been ably described by Mr. R. M. Johnston. In the immediate vicinity of Launceston and scattered over the westward plains there are accumulations of water-worn gravel, one to three feet thick, arranged in horizontal layers, and associated with clays and tufa more or less laminated. The most extensively exposed bed is on a railway cutting between Perth and Longford. This is on a tableland about 115 feet above the present channel of the South Esk, at Longford, and 630 feet above the level of the sea. These beds are principally composed of siliceous pebbles and gritty concretions, all more or less waterworn and cemented together. Opalized wood is scattered throughout the whole of the gravelly accumulations. With them are also associated pebbles of limestone, derived from the carboniferous beds, and containing casts of fossils characteristic of that formation. In the laminated clays are found beds of lignite intercalated with beds of fine blue clay, containing remains of water plants, fragments of branches, twigs, and leaves, and occasional *Unio* shells. In a cutting beyond Breadalbane a section of tufaceous rock is exposed, in which there are numerous fragments of branches and trunks of trees disposed horizontally. These are principally composed of lime.

Mr. Johnston divides all the beds into the upper, middle, and lower, which he thus characterises :—Lower beds: Composed of series of beds of blue and white clays, occasionally inter-laminated with thin bands of tenacious clay, containing leaves, for the most part exogencus, and a considerable portion coniferous. Myrtaceous forms do not seem to predominate, but there are leaves very similar to our finely pinnate acacias. In an exposed cliff section on the North Esk, Mr. Johnston states that he found fragments of Banksia and Eucalyptus, which, of course, would approximate the deposits to the living flora. The middle beds are chiefly composed of beds of clay and sand, with leaf impressions. The upper beds are represented by the low rounded hills and terraces flanking the present course of the River Tamar. They are composed of alternate beds of conglomerates, breccias, and gravels, and the detritus of the lower strata. At a bend in the River Tamar, called Stevenson's Bend, there is a very rich deposit of leaf impressions in the banks; and at Breadalbane Mr. Johnston gives the following section:—Superficial soil, 2 to 3 feet; basalt, 50 to 60 feet; conglomerate of waterworn fragments of basalt, 3 to 4 feet; white arenaceous clays, 20 to 30 feet; lignite, with embedded trunks and branches of pine and other trees, 3 feet. White and grey arenaceous sands of unknown depth.

From this it would appear that the plant beds denote a flora which existed at the time of some of the volcanic outbursts, but Mr. Johnston is of opinion that the lowest beds rest upon a very old basaltic stratum. My own impression is that the lowest sands are contemporaneous with the older pliocene deposits of Victoria (?) and South Australia, where they are manifested in a similar manner. They rest upon older basalts which cover marine miocene formations, and these may be the basalts which overlie the Table Cape deposits, and which were deposited on the bottom of the miocene sea.

Close to Hobart, on the south side of the island, tertiary plant remains, with land shells, have been found. They occur in a deposit of travertin in Geilston Bay, on the Derwent River, on the opposite side to Hobart. Abundant leaf impressions, with fossil leaves and wood, have been found in this travertin, with two species of Helix, a Vitrina and a Bulimus. The plant beds have been displaced by a basaltic dyke. The displacement of the stratified beds by the dyke has caused many fissures and cavities, in which the bones of existing animals are lying in abundance. The seeds found in the travertin beds show the deposit to be contemporaneous with the pliocene drifts of Victoria.

I have now dealt with all the evidence that is known in Tasmania as to physical condition of the island in former geological periods. The question remains to be asked whether we have any evidence that it was formerly united to the Australian continent? There is no geological evidence. It forms a part of the continent geologically, and the space between the two is bridged over by islands. They are of the lowest formations known in Tasmania, covered, in some cases, with miocene and pliocene marine deposits. In the tertiary era, therefore, it is extremely probable that the sea rolled between them, even to a larger extent than it does now. The evidence is in favour of Tasmania, like South-east Australia, being dry land during the latter part of the Mesozoic period. We have nothing to show us that the lands were connected then, except the present similarity of the fauna and flora, which I hope to deal with at some future time. Let it be well borne in mind, however, that the similarity or identity of a fauna and flora is not a proof that the lands were formerly continuous. This similarity may arise from many independent causes, which I need not specify.

Art. XIII.—*An Improved Grab Crane.*

By C. W. Maclean.

[Read 10th August, 1882.]

The system of dredging by means of a bucket formed of two hinged scoops or forks, known as grabs or clam-shells, having mechanical contrivances for opening and closing by chains worked by a derrick crane in such a manner as to grapple and lift spoil, has long been known and used by engineers on the Continent, India, Great Britain, America, and other parts of the world.

Having observed several defects in the working of the usual forms of grab cranes, I designed a new grab and crane which effectually overcomes these defects, and which I will now proceed to describe, prefacing the description by an extract from my British patent specification:—

"My improvements in grabs relate to the contrivances through which the grappling portion receives its necessary motions of opening, closing, hoisting, and lowering. The improvements in the contrivances used for working the same consist, first, in the substitution of a counterbalance barrel, supported and running in racks at the back of the crane, for the ordinary counterbalance weight, and in so arranging such counterbalance barrel that it assists instead of retards the engine in all the operations of working the grab;

and, second, in a modified construction of crane for working my grab, by which it is made a portable machine."

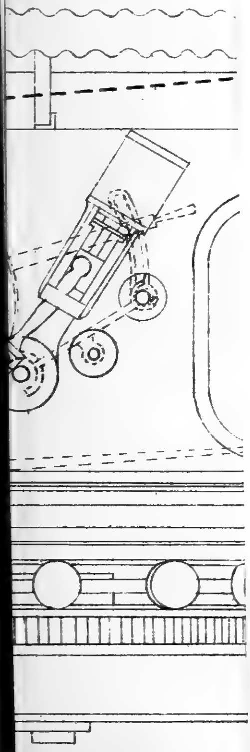
The sketch shows the grab crane, which has pivoted jaws, *a a*, and connecting links, *b b*, similar to the ordinary grab; but the crosshead and shaft of the ordinary grab are combined in one shaft, *n*, which is capable of a vertical motion between guides in a frame, also of a rotary motion, and is supplied with a barrel, *o*, and two smaller warping barrels, *p p*. The larger barrel has two lifting chains, *q q*, which are at one end wrapped round and fastened to it, then led over two jib-head sheaves to two chain pulleys, *r r* (one close to each cheek of the crane), which are capable of being revolved by the hoisting engines, or of being stopped by a brake; thence by a series of guide pulleys to the roling counterbalance barrels, *s s*, round which they are wrapped and fastened. The main barrel of the grab has also a lowering chain, *v*, wrapped round it in the opposite direction to that of the lifting chains, and led over a jib sheave to a barrel, *t*, which is capable of being put into gear and revolved by the hoisting engine, or stopped by a brake by the action of one lever acting on an eccentric and friction wheel. The two warping barrels have each chains, *x x*, the ends of which are wrapped round and fastened to them and to a fixed point, *w*, of the framing at the pivots of the jaws in such a manner that when the lifting chains, *q q*, are pulled by the engine the bucket closes, and when the lowering chain, *v*, is pulled the bucket opens. Two rolling counterbalance barrels, *s s*, which have the ends of the lifting chains attached to their circumferences, are fixed to a shaft, having pinions shrouded to their pitch lines, keyed to each end, which are free to roll down or up inclined shrouded racks as the lifting chains are either pulled or let out by the engines, and at the same time coiling or uncoiling the chains on their outer circumferences in a self-acting manner.

By this new machinery, which I have endeavoured to describe, the various operations of closing, digging, hoisting, opening, lowering, and partly counterbalancing the grab jaws, are effected in a novel and improved manner, as follows:—

Assuming that the grab is resting in the open position on the material to be lifted, the grab is then closed by putting the chain pulleys, *r r*, into gear with the engines, and thus pulling the lifting chains, *q q*, which, being wound round the main barrel of the grab, causes the warping barrels, *p p*, to revolve and drag down the shaft, *n*, by the warping chains winding round their respective barrels. During this operation of closing and digging, the counterbalance barrels, *s s*, take in the slack of the two hoisting chains, and assist, instead of retard, the engine while performing the operation. The engines by continuing to pull the lifting chains, after the jaws are closed, raise the grab with its load, the counterbalance barrel still taking in the slack of the lifting chains, and assisting the operation of hoisting. When the grab has attained the required height the brake is applied to stop the lifting chain pulleys on the crane, the engines being at the same time disengaged. The engines are next engaged to pull the lowering chain, *v*, which being wound round the larger chain barrel, *o*, on the grab, causes it to revolve, thus unwinding the warping chains from their respective pulleys, and dragging up and opening the grab jaws. When the grab is opened the lowering chain is held by its brake, and and the grab remains open, partly suspended by the lowering chain and partly by the lifting chains. The grab can now be lowered by the pressure being slightly taken off the lowering chain brake.

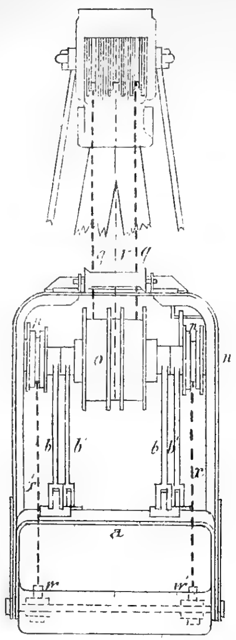
Having gone through these operations, it will be observed that, unlike other machines for effecting a similar purpose, the digging of the grab in any material is not interfered with by the counterbalance, which assists, instead of retards, the engines in performing this operation; while the whole weight of the grab bears on the points, and enters the material to be lifted. In other machines the grab cannot be raised open, but in the machine just described the grab jaws can be opened by the opening chain when the grab is in any position whatever, and the grab can be raised while open to any required height. Again, in other machines when opening the grab the load is suddenly transferred from the lifting to the lowering chain, which throws a severe strain on the chains and other parts of the crane; but in this machine the load is discharged while all the chains are taking part of the strain, and there is no sudden strain put at any time on them. Another advantage is gained by having two lifting chains, either of which will continue the work should the other break, and when they are both at work they prevent the grab from swinging and twisting the chains, which goes on to some extent in other machines. The weight of the barrel shaft of the grab tends to close the jaws.

GRAB CR

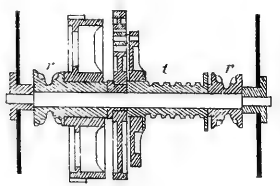


Elevation.

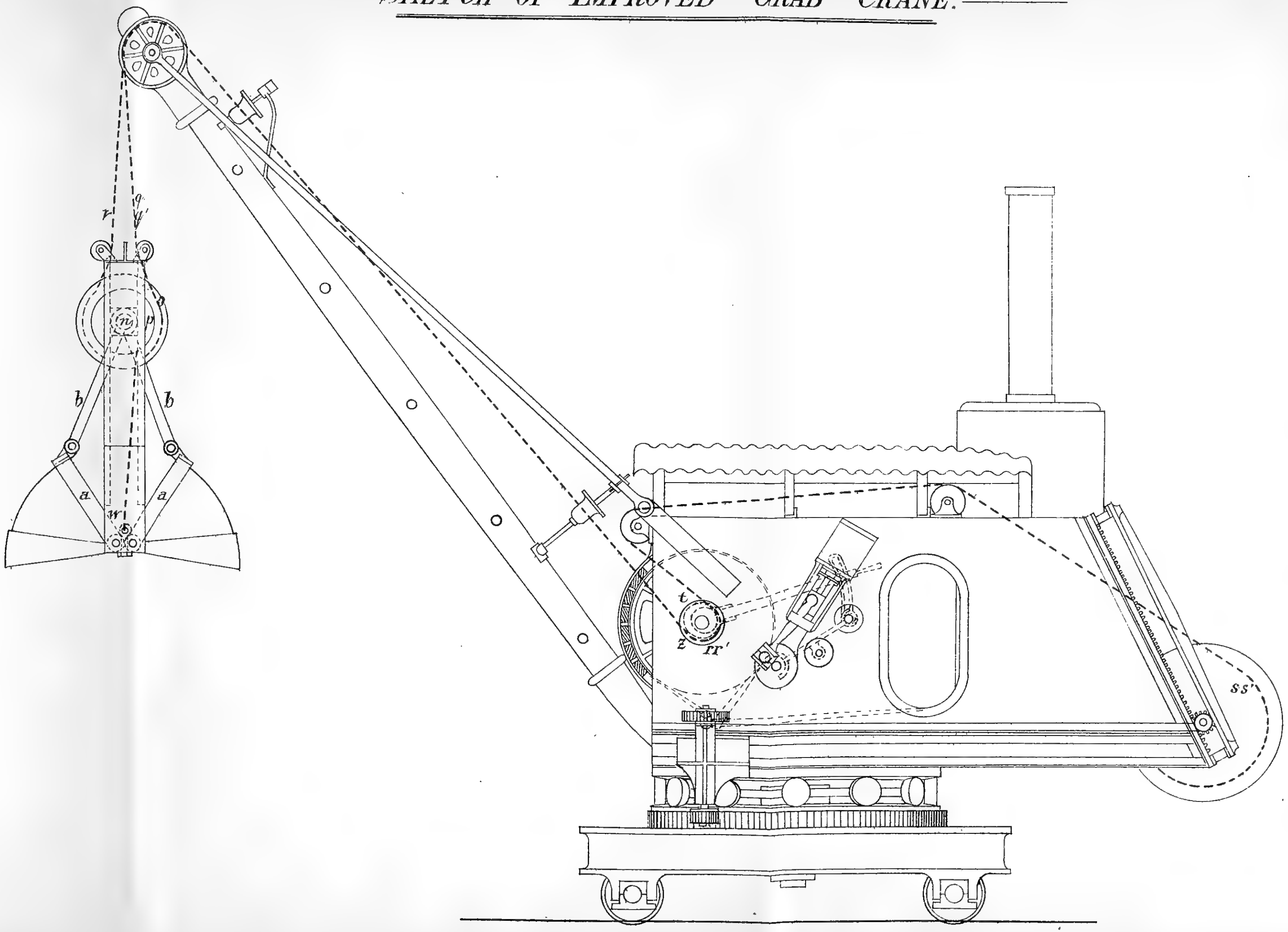
SKETCH OF IMPROVED GRAB CRANE.



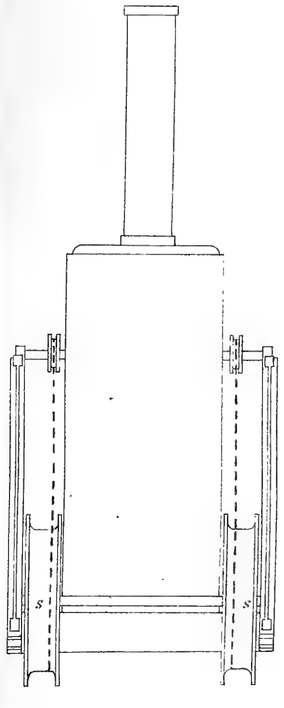
Front Elevation of Bucket and Jib.



Section of Shaft Z.



Side Elevation.



Back Elevation of Boiler and Counterbalance Gear.

The grab bucket can be opened in three ways—(1) By pulling the lowering chain while holding the lifting chains, which raises as well as opens the bucket; (2) By holding the lowering chain and letting out the lifting chains, which lowers as well as opens the bucket; (3) By a combination of the first two methods, which simply open the bucket without altering its height. These methods of opening the bucket have been found to be of great advantage, for the driver need not be very particular as to the height of the grab bucket when about to open it, as he has complete control of all its actions.

The cheeks of the crane are formed of wrought iron, and with a roof serve as a protection from the weather.

The Melbourne Harbour Trust Commissioners having had a crane on this principle constructed, mounted on a Smeaton's ring and built on a special pontoon for dredging purposes, I have been enabled to prove by actual experiment that the dynamical principles of the machine, as described, are correct. The crane is now at work on the Yarra, where it is found to be capable of making a complete set of dredging operations in forty-five seconds, so that the bucket, containing from two and a-half to three tons of silt, can be lifted easily within one minute, controlled by one man.

The crane is capable of being constructed in a portable form. The modification referred to in the patent specification is designed for digging dams and other pastoral station work, and for portability.

ART. XIV.—*A Note on the Apparatus to be used in Viewing the forthcoming Transit of Venus, in December,* 1882.

BY R. L. J. ELLERY.

[Read 14th September, 1882.]

ART. XV.—*On the Performance of Some Timekeepers.*

BY E. J. WHITE, F.R.A.S.

[Read 14th September, 1882.]

AT the International Exhibition held in Melbourne in 1880-1881, there was a fine display of clocks and watches of nearly every kind, as almost every country celebrated for their manufacture was well represented. The principal deficiency was with the clocks; of these the English sent few specimens, and the principal part of the American exhibit was lost by shipwreck. It became part of my duty, as a juror, to examine these, and from my position in the Observatory I had to take part in their testing. The result has been published in the Official Record of the Exhibition. I have been several times asked, however, whether the method of testing adopted, in which the watches were kept in stands, was a proper trial for an article like a watch, which is generally carried in the pocket, and is, therefore, subjected to all the motions of the body; that these motions are anything but slight, even in inactive persons, may be proved by a ride in a vehicle along the St. Kilda Road. My interest having been excited, and having unusual facilities for the purpose at the Observatory, I determined to test some watches in what may be called a natural way—that is, whilst being worn during the day and put under the pillow or hung up at night. For this purpose I purchased one or two of the fine watches from the Exhibition; these, together with one in my possession before, and some confided to me by friends for regulating, formed the subjects of my trials, the results of which, together with a few others from different sources, form the subject of my paper to night.

Nearly all the timekeepers of the present day may be divided into two classes—clocks and watches; the former, I shall call those which have their motions regulated by a pendulum, controlled by gravity; and the latter, those whose motions are regulated by a spring governed by its elasticity. Many of these latter are commonly called clocks, such as carriage clocks, lever clocks, &c.; they are, however, really watches, and will go in any position, whereas a clock requires to be kept at a certain definite angle with the horizon, and although marine chronometers are intended to be kept in one position, yet they will go in any, and they are only a superior class of watches. In using the term watch, however, without any qualification, we usually mean one of from about an inch to two inches diameter, so that it can be conveniently worn in the waistcoat pocket.

In ordinary talk, watches are usually named from their outward cases, as a gold watch, a silver watch, an open face, or a hunter; it is needless to observe that this classification is totally useless as a guide to the quality of the mechanism. Occasionally they are called after their nationality, English, American, or Swiss watches; in this case we can generally form an idea as to their internal arrangements, though the lines of demarcation are now much more faint than formerly. The typical English watch has a full-plate movement, covered with a cap, the whole of which opens out from the case on a hinge, and the hands are set from the front; its most distinguishing feature, however, is the fusee with its chain to equalise the motion of the mainspring, which is retained in watches of even the lowest class. English watches were formerly noted for their durability and timekeeping qualities. In this latter quality, however, they are now greatly excelled by the American (and when I say American, I mean Waltham, for I have had little experience of their other makes) and by the better class, yet moderately priced, Swiss watches. Still, the highest class English watch, which is also a very expensive article, is a perfect triumph of skilled work, and is unrivalled as a timekeeper. At the same time, the other extreme is reached by the low-priced English productions, which are a disgrace to the science of horology. The Waltham watch has usually a three-quarter plate, a going barrel without stopwork, so that the mainspring can act throughout its whole length; the case opens, and the hands are set at the back, and it has a real compensation balance in lower grades than is usually found in English and Swiss watches. No other escapement is used, I believe, than the lever with open jewels for pallets. The pivots are larger than in most other watches. It is, on the whole, a most substantial piece of work, and is a first-class timekeeper. In this respect, indeed, I think the lower grades of Walthams are unapproachable. I have found them keeping better time than English watches costing five times the money. Their moderate price is due mainly to the absence of much of that manual labour which is used in other countries to finish the parts after they have been formed by the machines; so, to a watchmaker's eye, they do not present that finished appearance he so dearly loves; but, as Sir Edmund Beckett says, "so long as smooth work which everybody can see is easier than accurate work which few people can judge of, watches, like other things, will be got up for show." Old Mr. Dent used to say—"We must work for the fools." First-class Walthams, however, have no lack of finish—indeed, they gained the first prize at our Exhibition for their artistic qualities.

Swiss watches are characterised by great delicacy of construction, and by delicacy I do not necessarily mean weakness. They have going barrels with stopwork, so that only a selected portion of the mainspring is brought into action. The cases open, and the hands are set at the back; and the top pivots, instead of turning in holes made in a full or three-quarter plate, work in cocks and bridge pieces, so that most of the wheels may be removed without disturbing the others. The best Swiss watches, though somewhat expensive, are excellent timekeepers, and in the making of small, complicated, and low-priced watches the Swiss are unsurpassed. They also exhibit great variety in their escapements. A few years ago I should have said that the cylinder, or horizontal escapement, was a special feature in Swiss watches. It is now, however, getting supplanted by the lever.

French and German watches were also shown at our Exhibition. They are constructed somewhat like the Swiss, but I think that they are scarcely brought to Australia yet in commercial quantities. The former were not sent to be tested at the Observatory, so that I cannot speak of their performances; and some of the watches sent out were not exhibited at all, owing to some trouble at the Custom-house. The German watches, as exhibited by the celebrated makers, Lange and Söhne, of Glashütte, near Dresden, proved themselves to be of first-rate excellence and moderate in price.

Instead, however, of a national classification, watches for scientific purposes are generally called after their escapements. The mechanism of a watch, as is well known, consists of a train of wheels impelled by a large coiled spring at one end, and regulated by the reciprocating motion of a very small spiral spring attached to the axis of a wheel with a heavy rim, called the balance, at the other end, together with hands and a dial to indicate the revolutions of some of the wheels. If the short hand of a common watch makes two revolutions while the earth is turning once round, as referred to a fictitious regularly-moving sun in the heavens, which is never very far from the real sun, then the watch is said to be keeping exact time. If, however, the watch be required for astronomical work, and to keep what is called sidereal time, then the short hand should make two revolutions while the earth turns once on its axis, as referred to a fixed star. There is, therefore, no difference in the mechanism of a mean-time and sidereal watch; the latter simply gains 3 mins. 56·55 secs. a day on the former, or one day in a year. In a watch train that part of the mechanism which converts the continuous revolutions of the last, or, as it is called, the scape wheel, into the reciprocating motion of the balance, is called the escapement, and on its construction, as well as that of the regulating spring (which is called the hair or balance spring) and the balance itself, the timing qualities of a watch chiefly depend.

The oldest form of escapement is that known as the verge or vertical escapement. From the time of the invention of watches till about the commencement of the present century, a period of about two hundred years, it was almost the only escapement used. It is now rarely met with, in Australia at least, except in the form of the old, thick, double-cased watch—the well-known "turnip" as it is somewhat irreverently called. I see, however, according to Saunier, that more than 300,000 of watches with verge escapements are annually made in one of the cantons of Switzerland. Very few of these, however, find their way out here. In this escapement the plane of the scape wheel is at right angles to those of the other wheels, so that when the watch is laid flat it stands vertical. Hence the name. This necessitates the watch being of considerable thickness, as well as the use of either bevelled or crown wheels. The principal advantage of the verge escapement seems to be that the impulses are given so directly that the pallets require no oil. It seldom requires cleaning, so that the watch will go with an amount of dirt that would be fatal to the action of most others. Its disadvantages are that the impacts are so severe and so applied as to cause a recoil action of the train. This causes it to wear out rapidly. At the same time it so hampers the free motion of the balance spring that, notwithstanding the presence of the fusee to equalise the action of the motive power, which is absolutely necessary with this escapement, it is a very poor timekeeper. Sully, a celebrated English watchmaker of the last century, found that in the verge watches of his day an increase of one-half in the motive power caused a variation of six hours a day. Captain Cuttle's watch, immortalised by Dickens, had undoubtedly a verge escapement.

The duplex escapement derives its name from the double set of teeth on the scape wheel—a short set to give the impulse to the balance, and a long set to keep the train at rest, except at the moment of escape. It was invented near the end of the seventeenth century. Its inventor is not known with certainty. It was claimed, however, by the celebrated Robert Hooke, the contemporary, and in some degree the competitor, of the great Newton, many of whose discoveries he claimed for himself. He was undoubtedly one of the greatest inventors that ever existed. We owe to him the first investigation of and discovery of the isochronal properties of springs, and their application to regulate the motions of a watch. This escapement is a very good one. It is one of the simplest in construction; at the same time, it requires the most delicate adjustment and first-class workmanship. The impulse is given directly, so that it goes without oil; but it never allows the balance to be perfectly free from the train, as the long tooth is always rubbing against the axis. It requires less frequent cleaning than the lever, and, with careful wearers, gives equally good results. Where, however, it is subjected to a rotatory motion, such as many people give to their watches in the action of winding them, it is liable to set—that is, to stop—owing to the motion communicated to it. It also occasionally trips—that is, allows two teeth to pass the notch instead of one—when the motion is such as to accelerate the balance. This escapement, owing to its inferiority to the lever for general use, was gradually dying out. It has, however, been lately made in large numbers of very cheap watches by the Waterbury Watch Company, in America.

The horizontal, as it was called, to distinguish it from the old vertical escapement, and now usually known as the cylinder escapement, was invented by the celebrated English watchmaker, Graham, about the year 1720. It was never largely used in the country of its birth, but it was so extensively adopted by the French and Swiss that at one time nearly all their watches were made with this escapement. Its principles have been so thoroughly investigated by the latter nation that it is still a favourite among them, though it is gradually being supplanted by the lever. It has the advantage of being compact, and the parts may be so proportioned that a sort of rough compensation for change of temperature can be produced with the ordinary balance; but it has the disadvantages of not being substantial, the impulses are given obliquely, rendering the use of oil a necessity, and the balance is never detached from the influence of the train. It also wants cleaning rather frequently. Saunier says that a cylinder watch, if small, should commence going with the second turn of the key, ordinary size at the third turn, and large ones on the fourth turn.

The lever escapement, otherwise called the detached or patent lever, is generally known on the continent of Europe as the anchor escapement. It seems to have been first conceived in France. It was invented, however, in its present shape by Mudge, of London, about ninety years ago. The English, as became their practical character, took kindly to this escapement, and for many years it formed one of the principal features of an English watch. It is now, however, in great use everywhere, and seems likely to supersede all the other forms, for watches which have to be worn. It has the advantages of being simple and substantial, and, above all, it leaves the balance quite free from the influence of the train during nearly the whole of its vibration. The impulses are given obliquely, so that it requires oil, and therefore more frequent cleaning than direct impulse escapements. It has proved itself capable, however, of giving results nearly equal to those of the chronometer escapement—indeed, when the watch is worn in the ordinary way, I think it will prove the better timekeeper of the two.

The chronometer, detent, or detached escapement is the one universally employed in the large class of watches, usually called chronometers, used for finding the longitude at sea. It is occasionally employed in the superior sort of watches known as pocket chronometers—indeed, many watchmakers maintain that only watches with this escapement are entitled to be called chronometers. They therefore term the superior class of lever watches furnished with a chronometer balance half-chronometers. In this escapement the impulses are given directly, and the balance is completely free from the influence of the train. It works without oil, and though delicate in construction, it gives the best results as a timekeeper where the watch is kept in one position, as in marine chronometers. In pocket watches, however, it is, in my opinion, a mistake, and is not so trustworthy as the lever.

Although many other escapements have been proposed and constructed—indeed, scarcely any year passes without a new one being invented—yet the five just mentioned are now the only ones in common use. We will therefore pass on to the consideration of the hairspring and balance.

As mentioned before, Hooke was the first to study the action of springs. He found that the amount of bending of a spring was proportional to the weight that produced it, or, as he expressed it in the learned language of the time, "*ut tensio sic vis.*" From this property, then, when a spring is set vibrating, all the vibrations, whether long or short, ought to be isochronal—that is, performed in the same time. If Hooke had carried out his experiments more carefully, he would have found that in practice this did not strictly apply. The complete investigation was carried out by the celebrated French horologist, Pierre Le Roy, who, in the year 1766, announced his discovery in the following terms:—"There is in every spring, providing it be long enough, a length that causes all the vibrations, whether long or short, to be isochronal. Having fixed upon this length, if you shorten the spring the long vibrations will be quicker than the short. If, on the other hand, you lengthen it, the short arcs will occupy less time than the long." The great object in a good timekeeper, therefore, is to secure a good spring, determine its isochronal point, fix it there, and attach to it a balance of the proper weight and size, so that its inertia, combined with the elasticity of the spring, may cause them to vibrate in the interval of time required by the train, generally one-fifth of a second in a watch and one-fourth of a second in a marine chronometer. No alteration in the length of the spring should be made after this. Any change of rate that may be required should be brought about by changing the weight or dimensions of the balance. In marine and some pocket chronometers this procedure is strictly observed. In watches, however, change of rate is generally made by altering the length of the spring, as any interference with the balance of a watch that has to go in all positions would be likely to produce much larger errors than would result from a slight deviation from the isochronal length of the spring; and here it may be remarked that the usual way of making this alteration by means of a lever, containing two curb pins, which works radially round the spring, is by no means delicate enough. Some of the Waltham watches have very beautiful arrangements for this purpose, so that very minute alterations may be easily effected. Yet, strange to say, I find only their watches in hunting cases so provided; the similar grades of open face watches have the ordinary radial arm. The usual form of balance spring for watches is the well known flat spiral. In marine chronometers the heliacal spring is used, and for lever watches of the best class, especially those that have large arcs of vibration, amounting occasionally to 540 degs., a flat spring, with the outer end bent over and fixed not far from the centre coil, is preferred. Such a spring is known among the English as a Breguet, or overcoil, spring. The French call it *spiral coudé*. Many other forms of springs are sometimes found, but, judging from the results of the severe timing contests that take place among the Swiss manufacturers, no one form of spring is certain of proving itself superior to another. From what has been said above it will be seen that the selection of a proper spring for a watch demands great care, for unless the spring be isochronal great variations of rate would take place during the day, as the arc of vibration diminished with the uncoiling of the mainspring. This diminution, according to the observations of M. Phillippe, amounts to from 65 to 112 degrees. The English have endeavoured to evade this difficulty by the use of a fusee to equalise the force of the mainspring. This, however, considerably complicates the mechanism. It also renders rather difficult the application of the keyless mechanism, which is fast superseding the old style of winding, and worthily so, for, independently of its great convenience, the winding is done in a plane at right angles to that of the watch, so that there is no fear of disturbing the arc of vibration, as is done by those careless persons who, when they wind with a key, turn the watch as much, or even more, than the key itself. Keyless watches also keep clean longer than others. It has been remarked that the introduction of the keyless watch will be the death blow to the fusee. Strictly speaking every mainspring should have its own proper fusee, a point that was generally attended to in the best class of old verge watches; but

I suppose that it is owing to want of attention to this that I frequently find expensive English watches, furnished with a fusee, showing a greater variation of rate during the twenty-four hours than a Waltham watch without fusee and without stopwork. Very likely the Swiss going barrel watches would go as well, but I have not had the opportunity of testing high class Swiss watches. Those that were officially tested at the Observatory during the Exhibition trials were only timed once in twenty-four hours. In these circumstances this variation would not show itself. As a matter of fact, I have in my possession a Waltham watch purchased in Melbourne four years ago. It has such a long mainspring and runs so easily that it will go forty-eight hours without stopping. I have on three or four occasions forgotten to wind it, so that at the end of the two days I have found it moving very sluggishly, barely escaping, yet the greatest difference of rate I have found from this cause has been only nine seconds a day. It is sometimes less. The last occasion was on the 8th of the present month, when it was not wound. The two previous rates had been 5·7 secs. and 5·5 secs. losing, and between the 6th and the 8th the rate was 1·7 secs. losing.

Supposing the watch to be now put together in good condition and the balance perfectly poised, we will consider the causes that will make it change its rate. First and foremost will be change of temperature; and unfortunately its effects will be all in one direction, an increase of temperature will weaken the elasticity of the balance spring, increase its length, and also enlarge the diameter of the balance, each of which makes the watch go slower, so that the whole effect will be the sum of these partial ones. A decrease of temperature will act in a contrary direction, and cause the watch to gain. By far the principal cause of variation is the alteration of the elasticity of the spring; according to experiments made by Berthoud, and confirmed by Mr Dent, the effect of this amounts to more than four times that of the enlargement of the balance, and that the total effect will be to make an ordinary watch lose 63 seconds a day for an increase of 10° Fahr.; whereas an ordinary clock with an iron rod to the pendulum would only lose 3 seconds a day for the same increment of heat. To obviate this difficulty, the first chronometers were supplied with an apparatus that moved the curb pins, and thus shortened the effective part of the balance spring as the temperature increased; as this plan interfered with the isochronal quality of the spring, it was soon abandoned in favour of the compensation balance invented by Julien Le Roy, and afterwards much improved by Arnold and Earnshaw, who left it in very nearly the form it has retained ever since. According to this construction, the balance, instead of being a complete circle, consists of a steel cross bar, to each end of which is fixed a nearly semi-circular strip. These strips are composed of two metals, brass on the outside and steel on the inside. The old makers used to connect these metals by a number of very fine rivets. The modern practice is to melt one on the other. Screws called timing screws are fixed at the end of the cross-bar; any motion of these simply alters the inertia of the balance, without interfering with the compensation. They are therefore used for changing the rate. Heavy screws or weights are also attached to the bi-metallic strips. These are moved further from or nearer to the cross-bar, as we want to increase or diminish the effect of change of temperature. This balance acts in the following manner:—An increase of heat will cause the brass on the outside to expand more than the steel on the inside. This will cause the strips to curve inwards, and carrying the weights with them they thus diminish the inertia of the balance and compensate for the diminished elasticity of the spring; a decrease of heat will in a similar manner make them open outwards, and increase the inertia of the balance. This is still the style of balance most generally used. It is called simply a compensation balance. Its action, however, is not perfect. This was first explained by Mr. Dent, in 1833, though its defect had been a matter of observation in good chronometers for some time before. It was found that while the chronometer would go very well for a moderate range of temperature, yet it always lost above or below these limits when the range was considerable; or, if it went right at two extreme temperatures, it always gained at the mean one. The explanation is this: The effects of temperature on the spring would cause changes in its strength proportional to the changes of temperature. To compensate for this the moments of inertia of the balance ought to change in the same proportion. Instead of this, however, equal variations of heat will cause the compensating weights to alter their distances from the centre of the balance by equal variations of space; but the moments of inertia of the balance are proportional, not to the distances of the weights from the centre, but to the squares of these distances, so that while graphically the effect on the spring would be represented by a straight line, that on the balance would be a curve, which, near the point of contact with the straight line, would nearly coincide with it for a moderate distance, or would cut it in two points with a moderate deviation half-way between them. It is in the latter way that the chronometer is generally adjusted, so that it goes right at 55° and 85°, and it then gains about six-tenths of a second a day at 70°, the mean temperature. Various methods have been proposed for getting rid of this secondary error. The most successful seems to have been Kulberg's, which was exhibited in his marine chronometers at our late Exhibition. Another plan, invented by the superintendent of the Waltham factory, was used in some of their watches tested at the Observatory. The watches, however, were in very bad order, so that its efficiency was not made apparent. Watches that are carried in the pocket by day and placed under the pillow at night are in a great measure guarded from extreme changes of temperature. Carriage and similarly governed clocks are generally, however, exposed to great and sudden variations, so that, if not well compensated, their going must be greatly inferior to that of a common pendulum clock. From records kept at the Observatory I find that the maximum temperature of my room there, which has thick walls and a room above it, during the last ten years has been 90°, and the minimum 47°. This would cause a difference of four and a-half minutes a day in an uncompensated watch. In a weatherboard-lined room at my quarters, without a fire-place, the maximum has been 102°, and the minimum 31·5°. I have also carried a delicate thermometer in my watch pocket, to ascertain the temperature a watch is ordinarily submitted to. Sitting in my room where the thermometer indicated 59·3°, the temperature of the pocket was 82·4°. Another time the room was 58·0°; pocket, 80·0°. Open air, 55·5°; pocket, 70·4°. Air, 57·5°; pocket, with back to the sun, 72·0°; facing the sun, 81·0°. Bedroom, 63·0°; under pillow, 71·5°. Air 91·0°; pocket, 85·1. Room, 74·0°; pocket, 85·0°. Bedroom, 77·0°; under pillow, 81·8°. Air, 101·0°; pocket, in shade, 96·4°. Bedroom, 52·0°; under pillow, 59·0. Air, 50·0°; pocket, 71·0°. According to the above observations, the watch had been kept in temperatures varying from 59·0° under the pillow to 96·4° in the watch pocket while walking in the open air. This would correspond to a variation of nearly four minutes a day for a common watch, and shows how utterly useless all such refinements as finish, jewelled holes, &c., are to the timekeeping qualities of a watch if it is not provided with a compensation balance. One objection I have heard urged against the compensated balance is that, necessarily being heavy to get sufficient change of inertia, it is not suited for riding or other violent exercise. If this objection has a real foundation, it may be met by reverting to the old compensation curb, when the balance might be made as light as possible. It would also have the advantage of not being put out of poise by the alteration of the compensating weights. Decided objections might be raised to this in the case of the highest class watches, where the spring is firmly fixed to the collet and stud, and has no curb pins; but where a lever and curb pins are already fixed, as in most watches, I do not see why they should not be moved automatically as well as by hand.

A marine chronometer, properly adjusted for temperature as above, ought now to be in a condition to perform very well, as it is only kept in one position, except during the few seconds while it is being wound. A pocket watch, however, which is expected to go equally well in any position, needs very delicate adjustment in the poising of the balance and the regulation of the friction of the pivots. It will, I expect, surprise many persons when they know the high ratio the adjusting of a watch bears to its first cost. From an official return I find that the average price of the English watches sent to Australia is £5 8s. Of the foreign ones that come here *viâ* England the average price of the gold ones is £8 15s., and the silver ones 27s. Now, I am informed that in Geneva, where labour is not at all highly paid, an adjuster at the factories gets 25 francs, equal to £1 for each watch, and I see, from a discussion in the *English Mechanic*, that the principal London makers charge from 50s. to 60s. for adjusting a watch in temperature and position. To show the large errors even expensive watches are sometimes afflicted with, I append the following table, and I may state that I have only selected new watches for this purpose :—

DAILY RATES OF WATCHES IN SIX DIFFERENT POSITIONS.

POSITIONS.	*a.*	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*
	s.	s.	s.	s.	s.	s.	s.
Pendant up -	4·00	5·71	0·00	5·19	10·37	9·00	9·3
,, right	2·14	4·69	1·61	2·98	6·58	7·05	7·3
,, down	0·00	0·00	0·14	0·99	0·00	0·37	0·0
,, left -	2·27	4·12	2·99	4·60	2·58	0·00	11·6
Face up - -	3·89	1·21	2·29	0·99	7·32	9·38	0·0
,, down -	6·69	1·49	4·06	0·00	4·45	10·20	19·3

POSITIONS.	*h.*	*i.*	*j.*	*k.*	*l.*	*m.*
	s.	s.	s.	s.	s.	s.
Pendant up -	40·1	2·2	83·0	0·0	0·0	253·1
,, right	13·0	0·0	165·0	117·2	86·5	0·0
,, down	0·0	58·5	4·0	175·5	254·7	372·3
,, left -	21·2	36·3	0·0	76·6	202·0	526·0
Face up - -	25·5	50·3	111·0	118·0	155·0	349·4
,, down -	31·3	58·9	119·0	91·0	156·9	350·0

The above numbers are not the actual rates, a constant having been added to each rate to make them all positive or gaining, and zero for the least rate.

a was the watch that came out best at the official testing; it had a pivoted detent escapement, called by the Swiss who made it, a bascule, and a heliacal spring. Melbourne retail price, about £50.

b was the best lever watch, it was English, Breguet spring. Price, in gold case, about £60.

c was the second best Swiss watch, lever escapement, Breguet spring.

d was the second best English lever, flat spring. Price, £64.

e was the best German watch, lever, Breguet spring, cost, £26 in gold case.

f was the second best German watch, lever, Breguet spring, cost, £10 18s. in silver case.

g was a cheap Waltham, purchased in Melbourne for £4 near the end of 1878.

h was a third grade Waltham, cost, £20 in gold case.

i was a fine finished London watch with a fusee, cost, £9 in silver case.

j was a fine finished London fusee watch, selected from the exhibition, cost, £9 10s. in silver case.

k was one of the cheapest Swiss cylinder watches, in nickel case, cost, retail, 25s.

l was one of the cheapest Swiss levers, in nickel case, cost, retail, 27s. 6d.

m was a machine made English lever, in silver case. Price, about 80s.

The Melbourne retail prices given above are estimated as nearly as possible from information supplied, the costs are given from actual sales.

RATES OF WATCHES CARRIED IN THE POCKET, A MARINE CHRONOMETER, AND AN ASTRONOMICAL CLOCK.

h.	*h.*	*h.*	*g.*	*g.*	*e.*	*e.*	*e.*	*i.*	*Marine Chronometer.*		*Astronomical Clock.*		
s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
+ 3·6	+ 2·4	+ 1·7	− 2·6	+ 0·5	− 3·3	− 1·6	− 3·0	+ 34·5	− 0·5	+ 0·4	− 0·39	− 0·24	+ 0·05
+ 4·0	+ 3·3	+ 4·7	− 2·6	− 1·6	− 3·3	− 2·2	− 2·3	+ 15·5	− 0·7	+ 0·3	− 0·37	− 0·16	+ 0·12
+ 2·2	+ 1·5	− 0·8	− 1·9	− 2·2	− 2·7	− 3·8	− 2·9	+ 33·5	− 0·2	− 0·2	− 0·47	− 0·22	+ 0·07
− 1·8	+ 1·0	− 0·5	− 4·3	− 1·2	− 2·2	− 3·8	− 3·3	+ 32·3	− 0·1	0·0	− 0·35	− 0·21	+ 0·05
+ 1·2	− 1·0	+ 5·0	− 3.8	− 2·6	− 1·1	− 3·7	..	+ 30·7	+ 0·5	− 0·3	− 0·42	− 0·36	+ 0·01
+ 0·9	+ 1·3	+ 1·2	− 4·5	+ 0·6	− 4·8	− 3·4	..	+ 24·5	+ 0·3	− 0·3	− 0·30	− 0·16	+ 0·06
+ 0·8	+ 2·3	+ 3·1	− 1·3	− 0·6	− 3·0	− 2·0	..	+ 30·4	+ 0·2	− 0·3	− 0·45	− 0·16	+ 0·15
− 0·3	+ 0·3	+ 0·5	− 3·3	− 1·8	− 1·2	− 3·5	..	+ 30·2	− 0·1	+ 0·1	− 0·24	− 0·19	+ 0·16
− 0·2	+ 0·7	+ 4·8	− 1·8	− 1·1	− 1·8	− 3·0	..	+ 24·1	− 1·3	− 0·2	− 0·31	− 0·19	+ 0·06
+ 2·3	− 0·7	+ 4·8	− 2·6	− 1·5	− 2·1	− 2·9	..	+ 35·4	− 0·8	0·0	− 0·40	− 0·30	+ 0·03
− 1·9	+ 2·2	+ 3·2	− 2·0	− 2·9	− 3·1	− 3·5	..	+ 30·1	− 0·3	− 0·3	− 0·39	− 0 27	− 0·06
− 1·7	+ 0·8	+ 2·3	− 2·4	− 0·1	− 2·8	− 3·7	..	+ 25·6	− 1·1	− 0·6	− 0·17	− 0·26	+ 0·02
− 0·9	− 1·6	+ 4·4	+ 0·7	+ 2·3	− 1·6	− 3·5	..	+ 30·1	− 0·5	+ 0·5	− 0·11	− 0·20	− 0·05
− 0·8	+ 3·4	+ 3·8	− 3·0	− 0·5	− 3·9	− 4·2	..	+ 33·2	− 0·3	− 0·6	− 0·18	− 0·22	+ 0·06
+ 1·8	+ 3·3	+ 4·2	− 0·5	− 1·6	− 1·8	− 2·7	..	+ 29·1	− 0·3	− 0·5	− 0·04	− 0·25	+ 0·10
+ 1·3	+ 2.4	+ 2·0	− 2·0	− 2·1	− 1·3	− 3·2	..	+ 30·9	+ 0·2	0·0	− 0·11	− 0·15	+ 0·09
− 1·3	+ 3·8	− 4·4	− 1·1	− 2·2	− 3·4	− 3·5	..	+ 34·2	0·0	− 0·4	− 0·19	− 0·02	+ 0·15
− 2·1	+ 2·8	+ 0·2	− 1·6	− 1·6	− 4·0	− 4·5	..	+ 34·0	− 0·4	− 0·1	− 0·11	+ 0·09	+ 0·16
− 5·9*	+ 0·3	+ 0·4	− 1·8	− 1·1	− 2·4	− 4·0	..	+ 25·5	0·0	0·0	− 0·19	+ 0·02	+ 0·26
− 0·9	+ 2·6	− 0·1	− 3·3	+ 0·6	− 2·9	− 3·3	..	+ 9·1	+ 0·3	+ 0·5	− 0·09	− 0·06	+ 0·19
− 0·7	+ 3·6	− 2·5	− 4·2	− 2·2	− 3·4	− 4·0	..	+ 38·7	+ 0·3	0·0	− 0·15	+ 0·08	+ 0·34
+ 0·1	+ 3·2	− 0·3	− 3·7	− 1·5	− 2·7	− 2·7	..	..	− 0·4	0·0	− 0·24	+ 0·04	+ 0·27
+ 3·0	− 1·6	+ 2·6	− 5·7	− 0·9	− 2·5	− 3·3	..	..	− 0·3	0·0	− 0·16	+ 0·08	+ 0·27
+ 0·2	+ 2·2	+ 0·1	− 5·3	− 0·4	− 4·9	− 3·4	..	..	− 0·1	0·0	− 0·25	+ 0·01	..
+ 1·2	+ 0·6	− 5·1	− 3·4	− 0·7	− 2·0	− 4·1	..	..	− 0·2	0·0	− 0·24	+ 0·01	..
+ 1·1	+ 1·5	− 1·0	− 1·8	− 2·1	+ 0·4	− 2·7	..	..	− 0·1	− 0·4	− 0·39	− 0·01	..
+ 1·1	+ 1·9	+ 0·2	− 2·8	− 0·2	− 3·5	− 4·8	..	..	− 0·2	− 0·7	− 0·21	+ 0·09	..
+ 1·2	+ 1·7	+ 2·0	− 1·2	− 1·4	− 1·3	− 3·0	..	..	− 0·1	− 0·4	− 0·25	+ 0·02	..

* Not wound for 38 hours.

In referring to the above list of watches, it may be mentioned, that *a, b, c, d, e,* and *f* were specially selected and adjusted by the makers for exhibition and competitive trial, the others were purchased from ordinary stock. The marine chronometer is a very fine one by George Timewell, of Liverpool, which has not been cleaned for four years, and the astronomical clock is the celebrated Frodsham 991, which, when its rates were examined by the horological jury of the Paris exhibition of 1867, was pronounced to be one of the best in existence, its rates are found by celestial observations, generally taken every second or third day. Those given in the above list extend from near the beginning of February to the end of August in the present year, they, therefore, include the hottest and coldest periods, the gradual change of rate is owing to the clock being slightly under-compensated. The iron jar containing the quicksilver is only 8½ inches long inside; this has proved to be not quite enough. The rates of the watches and chronometer have been determined by means of daily comparisons with the standard mean time clock of the observatory, they have all been obtained from trials made during the last few months, with the exception of watch *g,* whose rates are given for November and December 1879, as I have not often worn it since. All the errors of position have been determined since the beginning of last year. It should be stated also that the rates of the astronomical clock have been corrected for the variations of atmospheric pressure, as it has been found for this particular clock, that a rise of one inch of the barometer causes it to lose half a second per diem.

On examining the above table of rates, it will be seen at once to what enormous dimensions the error of position sometimes attains; in watch *m,* the English machine-made watch, it amounts to a daily difference of eight minutes and forty-six seconds between pendant right and pendant left; while in the Waltham, costing the same money, and also a machine-made watch, the greatest difference is only nineteen seconds. Again, in watch *j,* a finely-finished London fusee watch, the error reaches two minutes forty-five seconds a day. Comparing these with the two high-class expensive London watches *b* and *d,* whose largest errors of position are only somewhat over five seconds, it shows what English watchmakers can do when they are well paid for their work; their ordinary watches, however, are very badly adjusted, and if they do not improve in this particular, they are likely to lose their trade. According to a notice in the *Horological Journal,* Australia is England's best customer for watches, still the manufacture has lately fallen off to such an extent, that England does not now export one watch per head of her watchmaking population. The competition the English have to contend against is shown in the case of watch *g,* whose rates were given before, which came into my possession in a very ordinary way. On passing down Swanston-street I saw it in Mr. Joseph's window; it was simply marked "Waltham," with the price, four guineas, attached. I went in on the afternoon of December 4th, 1878, purchased it, and took it home with me. I compared it with our standard clock, and got the following results :—

DATE.				ERROR.	DATE.				ERROR.
	d.	h.	m.	s.		d.	h.	m.	s.
Dec.	4.	5	26	12 slow	Dec.	8.	21	0	13·5 slow
"	4.	21	0	13 "	"	9.	1	0	12·5 "
"	5.	21	0	12·0 "	"	9.	5	5	11·2 "
"	6.	1	0	13·0 "	"	9.	21	3	11·3 "
"	6.	4	0	12·5 "	"	10.	1	0	10·5 "
"	6.	21	0	12·5 "	"	10.	4	0	10·5 "
"	7.	7	23	12·0 "	"	10.	9	35	10·5 "
"	7.	20	31	12·5 "	"	10.	22	12	12·0 "

I was fairly astonished at such a result. On the last mentioned day I left Melbourne for New Zealand. During the voyage I used the watch as a chronometer for finding the longitude, as I had carried a small sextant with me for my amusement. On reaching Dunedin I found that in seven days the watch had altered its error about half a minute, having lost more in the much colder temperature at sea, than in Melbourne. I subsequently found by direct experiment that it was over-compensated to the extent of gaining twelve seconds a day for an increase of ten degrees Fahr. About a year ago I had the screws shifted, and the compensation is now nearly perfect. I still occasionally wear it, and it goes as well as ever; the improvement in the compensation being partly neutralised by an increase in the position error. Mr. Dent says that an adjusted going barrel lever may be expected, with an ordinary wearer, to have a daily variation of rate from 2 to 4 seconds. The above watch did not profess to be adjusted, yet it is within those limits; I consider myself, however, a careful wearer.

To dispense with the tedious and expensive process of adjustment for position, an arrangement has been introduced by the Swiss, called a "tourbillon." In this system the escapement and balance are mounted on a frame which makes a complete turn in the watch every two or three minutes. Some of these tourbillons have given very good results. The method does not seem, however, to be growing into favour, owing, perhaps, to its being less stable than the ordinary construction. A somewhat similar plan is found in the Waterbury watches, mentioned before in connection with the duplex escapement, where the whole movement turns in the case once in an hour.

As a final remark to the purchasers and owners of watches, I would say to the former, buy your watches from trustworthy men—those whose words are as good as their bonds. Do not be led away by surface appearances, the number of jewels, &c. Saunier remarks that—"In a vast number of modern watches, and, unfortunately, even in many of those which pretend to be of superior quality, the jewels are rather a blind than in any sense beneficial. Badly worked and of insufficient hardness, these are less serviceable than good, carefully hammered brass." Watch jewels are by no means so valuable as is usually supposed. The cost of a jewelled hole of good average quality, ready for fixing in the plate, is, I am informed, in Geneva, only one shilling. The Swiss occasionally put a glass back to their watches in place of the usual metal dome, so that the works may be seen without opening and exposing them to dust, &c. It is a very bad style, however, for should the glass get fractured the particles fall at once into the movement, and do great damage. I am told that one of the fine Swiss watches that came out highest at our Observatory testing has been lately irretrievably ruined owing to this. Compensation balances also, unless carefully made, are worse than plain ones, for, independently of their never having been adjusted, the arms oftentimes move unequally with change of temperature, and thereby cause great errors of position. As a general remark, it may be stated that good watches are seldom unsightly. To the owners of good watches I would say, treat them with the greatest care and gentleness, for they are most delicate machines, and worthy of being treasured as specimens of man's intelligence and manipulative skill. Never allow them to go so long as to stop of themselves from the drying of the oil and the accumulation of dirt, for excessive wear results from this. As a general rule two years is the longest time a good watch should go without cleaning, especially if it is wound with a key, which conveys most of the dirt into the interior, as may easily be seen by an inspection of the winding square. Dust proof cases and keyless winding may enable a watch to perform well for a longer period than two years, but it will be found bad economy in the end to allow them to do so. Above all, never trust good watches with inferior workmen. A good watch is easily ruined, but restored with great difficulty. In the present state of the watch manufacture, where the division of labour is so minutely carried out, the watch repairer, or jobber, as he is sometimes contemptuously called, requires more science and skill in his work than the watchmaker. In conclusion, I would recommend to those engaged in practical watchwork the large treatise by Saunier, an English edition of which has been lately issued; and to those who only take an interest in the matter, the little book in Weale's series by Sir Edmund Beckett, Bart., on clocks and watches, where diagrams will be found of the different escapements, &c., mentioned in this paper, and where the subject is treated in such a charming and popular manner that, although the work is full of information, it is as entertaining as a novel.

ART. XVI.—*Experiments on Model Girders.*

BY W. C. KERNOT, M.A., C.E.

[Read 14th September, 1882.]

IT has been the practice for several years past, in connection with the Engineering School of the University, to try various experiments upon the strength of model girders and frames, representing to scale existing or proposed structures. These experiments have, until recently, been made on wooden or cardboard models only. The desirability of testing iron models riveted together in the same manner as the actual structures, has all along been recognised, but practical difficulties in the way of obtaining the proper sections of metal in sufficiently small sizes, have hitherto prevented anything being done in this direction. Recently, however, a quantity of very small angle iron has been obtained, and this has removed the obstacle.

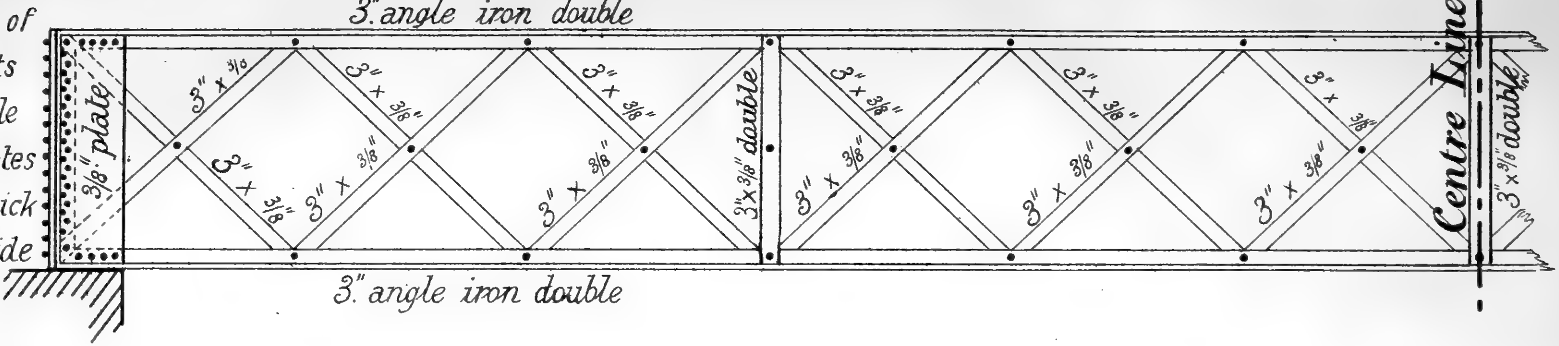
The first case chosen for experimental investigation was that of a small bridge for pedestrian traffic, crossing the lines of railway in the large goods station at Spencer-street. This structure is as a rule very lightly loaded, it rarely occurring that more than two or three persons are upon it at once, but, at the same time, it is quite within the bounds of possibility for a dense crowd to assemble upon it, testing its endurance to the utmost, and rendering any weakness a matter of most serious importance. The reasons why this particular bridge was selected were, first, that its construction being comparatively simple, the labour of making the model was but moderate; and, second, that calculation based upon established dynamical laws led to the conclusion that some parts were considerably deficient in strength, while others were needlessly lavish, both in material and the amount of riveting employed. The former criticism applies to the compression diagonals, which consist merely of thin flat bars, while the latter refers to the end vertical pieces, which are of comparatively masssive and complex construction, containing many times the quantity of iron theoretically necessary.

The model marked A represents accurately to a scale of one-twelfth full size one of the girders of this structure. That marked B is constructed according to an amended design, characterised by the strictest adherence to the indications of mathematical calculation compatible with simplicity of construction. In general appearance, girder B is hardly distinguishable from A; a close inspection reveals the following differences—(1) The replacing of the massive ends, each of which consists of five separate pieces of metal united by numerous rivets, by a single angle iron; (2) The omission of certain minor vertical members, upon which there is no calculable load; (3) The introduction of angle irons instead of the plain flat bars for the compression diagonals. The time taken in construction was carefully noted, also the weight of metal, number of rivets, and other particulars, for which see subjoined tabular statement. The great reduction in the amount of time expended in the case of girder B was due mainly to the simplification in the construction of the end vertical pieces.

In testing, the girders were supported and loaded exactly as in the actual structure, the top members being braced to prevent lateral deflection. The difference in strength, and the mode and nature of the fracture in each case, was in accordance with what was predicted on theoretical grounds.

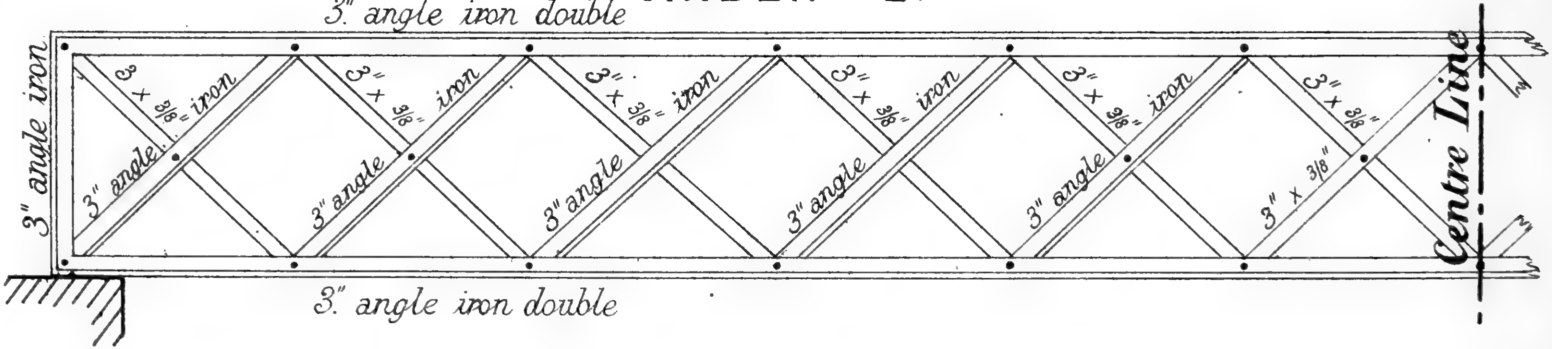
	GIRDER A.	GIRDER B.
Weight of metal ...	1 lb. 9 oz.	1 lb. 5 oz.
Time occupied in making	14 hours 10 minutes	5 hours 30 minutes.
Actual breaking load	208 lbs.	771 lbs.
Calculated ditto	182 lbs.	800 lbs.
Ratio of breaking load to weight of girder	133 to 1	587 to 1.
Nature and position of fracture	Buckling of compression diagonals, leading to general collapse of structure	Terminal tension diagonal torn across through rivet hole.

GIRDER A.



Note.—End of girder consists of two 3" angle irons, two plates 12" wide, & 3/8" thick one plate 8" wide 7/8" thick, and 40 rivets.

GIRDER B.



N.B. – The load was distributed uniformly along the lower member.

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ART. XVII.—*Descriptions of New, or Little Known, Polyzoa.*

PART III.

BY P. H. MACGILLIVRAY, M.A., M.R.C.S., F.L.S.

[Read 12th October, 1882.]

Membranipora serrata, M'G. Fig. 5.

IN a paper communicated in December, 1881, I figured this species which I had previously described, and also described and figured a seemingly distinct form as *M. acifera.* I have since then dredged a specimen at Port Phillip Heads, which shows them to belong to the same species. In some parts at the centre and circumference of the colony the cells are wide, the margins either unarmed or with one or more sharp uncinate spines; in other cells the spines are forked, or broad and serrated, and in many so large that those of opposite sides interdigitate, and occasionally coalesce.

Cribrillina setirostris, n. sp. Fig. 3.

Cells distinct, elongated; surface thickly covered with round or pyriform white-bordered pores, frequently arranged in irregular single or double transverse rows; mouth arched above, nearly straight below, with a slightly thickened margin; an avicularium at the base of the cell with a very long setiform mandible directed close up one margin of the cell.

Port Phillip Heads. Dredged by Mr. J. B. Wilson and myself.

Schizoporella Ridleyi, n. sp. Fig. 1.

Polyzoary encrusting; cells rhomboidal or elongated, in radiating linear series, separated by slightly raised margins; surface when young smooth; when older deeply areolated at the edges; mouth semi-circular above, straight below, with a small rounded sinus; below the mouth a small vertical elliptical avicularium on an elevated part of the cell; ovicell rounded.

Port Phillip Heads.

In a paper in the *Proceedings of the Zoological Society*, of June, 1881, Mr. Stuart O. Ridley describes this species, from a specimen dredged during the voyage of the "Alert," in the Strait of Magellan, as *S. marsupium*, M'G. Unfortunately, when I drew up my original description of *Lepralia marsupium*, the specimens I had were worn and imperfect, so that the exact structure of the mouth was not distinctly seen. Consequently the present and the true species, of which I have since procured numerous perfect specimens, have been confounded. In the present paper I give a more correct figure and fuller description of *L. marsupium*.

In young specimens of *S. Ridleyi* the mouth, with its semicircular upper margin and straight lower lip with rounded sinus, is well seen, as well as the small elliptical suboral avicularium, situated on the raised semilunar portion of the cell. In older and more calcified cells this raised portion frequently becomes so developed as to obscure the view of the mouth and avicularium; in these also there is usually a series of deep grooves, converging from the margin to the raised suboral portion.

Schizoporella arachnoides, n. sp. Fig. 4.

Polyzoary encrusting; cells oval, distinct, convex, smooth; mouth arched above, with a deep rounded notch in the straight lower lip; a series of (usually) seven stiff spines, several of which, especially the lower, are situated at a distance from the mouth; ovicell rounded, smooth, the margin usually sculptured.

Port Phillip Heads.

This very beautiful species is at once distinguished by the arrangement of the oral spines. These are usually seven in number. The lowest on each side is situated below and to one side of the angle of the mouth, and several others are frequently situated at a little distance from the mouth margin. The edge of the ovicell is usually sculptured, as in *Microporella Malusii;* sometimes, however, it is smooth.

Porella marsupium, M'G. Fig. 2.

Cells elongated, distinct, arranged in linear series, surface smooth, minutely punctured or areolated at the margin;

mouth in young specimens nearly round with a projecting mucro below; in old specimens contracted downwards, and usually with a squared denticle in the lower lip, which is also slightly thickened; below the mouth is a small elliptical avicularium on the upper part of a bullate projection; ovicell small, globular, smooth, with faint radiating lines.

Common.

As already stated, this species was originally described from bad specimens, and I have, therefore, given a more correct figure and an amended description. Hincks had already (Annals & Mag. Nat. His., 1881) given a figure, and noticed the oral denticle (which is frequently absent) and suboral avicularium.

Cellepora exigua, M'G. Fig. 7.

The figures represent a common form which I described in 1860. I now think that it is probably identical with the very variable *Rhynchopora bispinosa,* and shall, in a future communication, give additional figures and a full description.

Rhynchopora profunda, n. sp. Fig. 8.

Polyzoary encrusting; marginal cells oval, smooth or areolated at the edges; in the youngest the mouth arched above, slightly hollowed below; when a little older one side becomes enlarged, and from it projects an unciform process, the point of which is turned slightly upwards; as growth advances a calcareous deposit, at first arranged in a reticulate manner on the margins of the cells, increases in bulk until the original cell is much thickened, and the mouth is buried at the bottom of a deep cavernous opening; in these cells the upper lip is sometimes minutely crenulate; the uncinate process is always plainly seen deep down, and has an avicularium in the front with a broadly triangular mandible opening forward; the surface of the raised calcareous parts is irregularly nodulated, and there are a good many large avicularia with more or less spatulate mandibles scattered over it.

Port Phillip Heads; Mr. J. B. Wilson.

I refer this species doubtfully to Hinck's genus *Rhyncopora.* The characteristics are the triangular mandible of the avicularium on the uncinate process opening directly forward, and the extraordinary calcareous growth which originates on the margins of the cells, and increases to such an extent as to leave the mouth buried at the bottom of a deep cavern. The figures are taken from different parts of the same small colony.

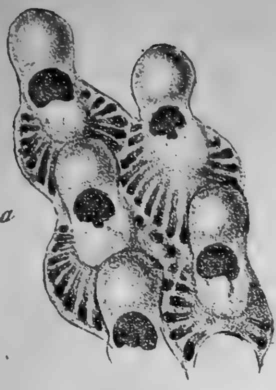
Lekythopora, n. genus.

Polyzoary erect, branched; cells arranged round the branches, more or less flask-shaped or elongated, oblique or erect, and crowded together; mouth irregularly rounded; peristome thickened and becoming produced into a long tube, on one side of the orifice of which is a small avicularium; ovicell forming a projection on the side of the cell below the mouth, the summit deficient in calareous matter, and formed by an oval lens-shaped membrane.

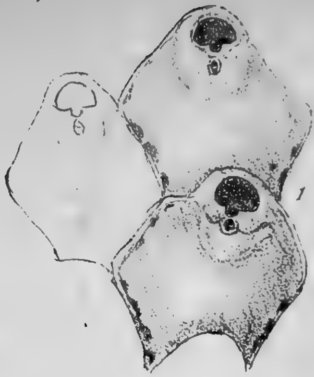
L. hystrix, n. sp. Fig. 6.

Of this, the only species, I have procured several specimens at the Heads. Mr. Wilson, I believe, has also found it. My specimens form small branching rigid tufts, like some of the small erect *Celleporæ.* The cells are very much crowded together, and, where not too much compressed by their neighbours, may be seen to be flask-shaped; the surface is nearly smooth, or granular and pitted. The primary orifice seems to be nearly circular, but the peristome in all the cells is thickened, and in most is produced into a very long slightly prismatic tube. On one side of the summit of this peristome there is a small horizontal avicularium, with a bluntly triangular mandible opening directly upwards. From this avicularium a minute tube can be traced, extending in a spiral manner downwards. There are also a few large avicularia, with large spatulate mandibles, scattered among the cells. The ovicell is peculiar. It is an enlargement on the front of the cell below the mouth. The summit is not calcareous, but consists of an elliptical convex chitinous membrane. The genus evidently belongs to the *Celleporidæ.*

Plate I.



1a



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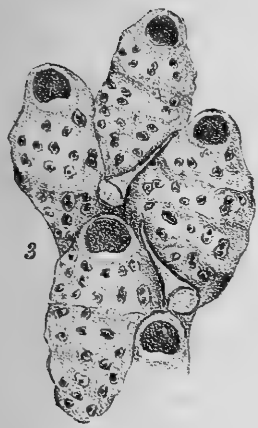
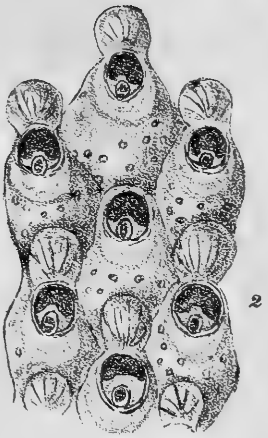


3

2a



2

4

5

$\frac{1}{100}$ inch

P.H.McG. del & lith.

C. Troedel & Co. imp.

Plate II.

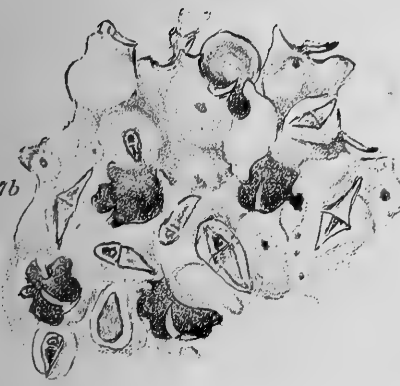
6d

6b

6a

6

6c

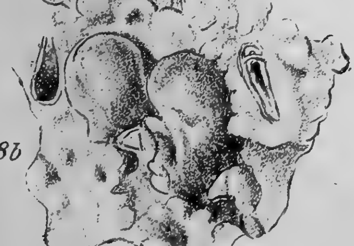


7b

7a

7

8a



8b

8

1/100 inch.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Schizoporella Ridleyi*, young cells. Fig. 1*a*. Older group, showing the converging grooves and ovicells.

Fig. 2. *Porella marsupium.* Fig. 2*a*. Young cell.

Fig. 3. *Cribrillina setirostris.*

Fig. 4. *Schizoporella arachnoides.*

Fig. 5. *Membranipora serrata.* Two of the cells, showing the condition described as *M. acifera.*

PLATE II.

Fig. 6. *Lekythopora hystrix*, natural size. Fig. 6*a*. Outline of portion magnified. Fig. 6*b*. Two cells showing roughened and pitted surface, membranous covering of ovicell, oral and separate large avicularia. Fig. 6*c*. Part of peristome, showing avicularium and spiral tube. Fig. 6*d*. Profile of cell to show situation and projection of ovicell.

Fig. 7. *Cellepora exigua*, showing oral avicularia and ovicells. Fig. 7*a*. Young cells from growing margin. Fig. 7*b*. Portion of older colony, showing scattered avicularia.

Fig. 8. *Rhynchopora profunda.* Cells from growing margin, showing the commencement of the calcareous growth. Fig. 8*a*. More advanced stage of this growth. Fig. 8*b*. Two cells with calcareous overgrowth, showing scattered avicularia and commencing development of ovicells.

ART. XVIII.—*On Electric Railways.*

BY MR. PETER BEHRENDT.

[Read 12th October, 1882.]

ART. XIX.—*Methods of Election.*

BY PROFESSOR E. J. NANSON.

[Read 12th October, 1882.]

IF there be several candidates for an office of any kind, and the appointment rests in the hands of several persons, an election is held to decide who is to receive the appointment. The object of such an election is to select, if possible, some candidate who shall, in the opinion of a majority of the electors, be most fit for the post. Accordingly, the fundamental condition which must be attended to in choosing a method of election is that the method adopted must not be capable of bringing about a result which is contrary to the wishes of the majority. There are several methods in use, and none of them satisfy this condition. The object of this paper is to prove this statement, and to suggest a method of election which satisfies the above condition.

Let us suppose, then, that several persons have to select one out of three or more candidates for an office. The methods which are in use, or have been put forward at various times, may be divided into three classes.

The first class includes those methods in which the result of an election is arrived at by means of a single scrutiny.

The second class includes those in which the electors have to vote more than once.

The third class includes those in which more than one scrutiny may be necessary, but in which the electors have only to vote once.

In describing these methods, the number of candidates will in some cases be supposed to be any whatever, but in other cases it will be assumed, for the sake of simplicity, that there are only three candidates. The case in which there are only three candidates is the simplest, and it is of frequent occurrence. I propose, therefore, to examine, for the case of three candidates, the results of the methods which have been proposed, and to show that they are erroneous in this case. This will be sufficient for my purpose, for it will be easily seen that the methods will be still more liable to error if the number of candidates be greater than three. I shall then discuss at some length the proposed method in the case of three candidates, and afterwards consider more briefly the case of any number of candidates.

METHODS OF THE FIRST CLASS.

In the first class three methods may be placed, viz., the single vote method, the double vote method, and the method of Borda. In these methods the electors have only to vote once, and the result is arrived at by means of a single scrutiny.

THE SINGLE VOTE METHOD.

This is the simplest of all methods, and is the one adopted for Parliamentary elections in all English-speaking communities in the case in which there is only one vacancy to be filled. As is well known, each elector has one vote, which he gives to some one candidate, and the candidate who obtains the greatest number of votes is elected. This method is used for any number of candidates; but in general the larger the number of candidates the more unsatisfactory is the result.

In this method, unless some candidate obtains an absolute majority of the votes polled, the result may be contrary to the wishes of the majority. For, suppose that there are twelve electors and three candidates, A, B, C, who receive respectively five, four, and three votes. Then A, having the largest number of votes, is elected. This result, however, may be quite wrong; for it is quite possible that the four electors who vote for B may prefer C to A, and the three electors who vote for C may prefer B to A. If this were the case, and the question

That A is to be preferred to B

were put to the whole body of electors, it would be negatived by a majority of two, and the question

That A is to be preferred to C

would also be negatived by a majority of two. Thus the single vote method places at the head of the poll a candidate who is declared by a majority of the electors to be inferior to each of the other candidates. In fact, if A and B were the only candidates B would win; or if A and

C were the only candidates C would win; thus B and C can each beat A, and yet neither of them wins. A wins simply because he is opposed by two men, each better than himself.

Thus the single vote method does not satisfy the fundamental condition. It appears also not only that the best man may not be elected, but also that we are not even sure of getting in the second best man. It is clear that if any candidate obtain an absolute majority of the votes polled this error cannot occur. All we can say, then, about the single vote method is that if any candidate obtain an absolute majority the method is correct, but if no one obtains such a majority the result may be quite erroneous.

These results are well known, and consequently in elections under this plan great efforts are generally made to reduce the number of candidates as much as possible before the polling day, in order to avoid the return of a candidate who is acceptable to a small section only of the electors. This reduction can, in practice, be made only by a small number of the electors, so that the choice of a candidate is taken out of the hands of the electors themselves, who are merely permitted to say which of two or more selected candidates is least objectionable to them.

THE DOUBLE VOTE METHOD.

In this method each elector votes for two candidates, and the candidate who obtains the largest number of votes is elected. This method is erroneous, for it may lead to the rejection of a candidate who has an absolute majority of votes in his favour, as against all comers. For suppose that there are twelve electors, and that the votes polled are, for A, nine; for B, eight; for C, seven, then A is elected. Now, in order to show that this result may be erroneous it is merely necessary to observe that it is possible that each of the seven electors who voted for C may consider C better than A and B; that is to say, an absolute majority of the electors may consider C to be the best man, and yet the mode of election is such that not only does C fail to win, but in addition he is at the bottom of the poll. This is an important result; we shall see presently the effect it has on other methods of election.

In the case in which there are only three candidates this method is, in fact, equivalent to requiring each elector to vote against one candidate, and then electing the candidate who has the smallest number of votes recorded against him.

BORDA'S METHOD.

This method was proposed by Borda in 1770, but the first published description of it is in the volume for 1781 of the *Memoirs of the Royal Academy of Sciences.* For some remarks on the method see Todhunter's *History of Probability*, p. 433, where the method is described. In the case of three candidates, it is as follows. Each elector has three votes, two of which must be given to one candidate, and the third vote to another candidate. The candidate who obtains the greatest number of votes is elected.

In order to show that this method may lead to an erroneous result, suppose that there are twelve electors, of whom five prefer A to B and B to C, whilst two prefer A to C and C to B, and five prefer B to C and C to A. Then the votes polled will be, for A, fourteen; for B, fifteen; for C, seven. Thus B is elected. It is clear, however, that this result is wrong, because seven out of the whole twelve electors prefer A to B and C, so that, in fact, A has an absolute majority of the electors in his favour. Hence, then, Borda's method does not satisfy the fundamental condition, for it may lead to the rejection of a candidate who has an absolute majority of the electors in his favour.

It may be observed that the result of the poll on Borda's method may be obtained, in the case of three candidates, by adding together the corresponding results in the polls on the methods already described.

If there be n candidates, each elector is required to arrange them in order of merit; then for each highest place $n-1$ votes are counted; for each second place, $n-2$ votes, and so on; $n-r$ votes being counted for each r^{th} place, and no votes for the last place. The candidate who obtains the greatest number of votes is elected.

Borda does not give any satisfactory reason for adopting the method. Nevertheless he had great faith in it, and made use of it to test the accuracy of the ordinary or single vote method, and arrived at the extraordinary conclusion that in any case in which the number of candidates is equal to or exceeds the number of electors, the result cannot be depended upon unless the electors are perfectly unanimous. This in itself is sufficient to show that Borda's method must be capable of bringing about a result which is contrary to the wishes of the majority.

There is, however, another objection which is of great importance. Borda's method holds out great inducements to the electors to vote otherwise than according to their real views. For if an elector strongly desires the return of a particular candidate, he not only gives his two votes to that candidate, but he also takes care to give his remaining vote to the least formidable of the other candidates. The effect of this is to give a great advantage to second-rate candidates. Thus not only does Borda's method fail to interpret the true wishes of the electors, supposing that they vote honestly, but it holds out great inducements to them to vote otherwise than according to their real views.

Laplace discussed the question of the best mode of electing one out of several candidates, and by an analytical investigation was led to Borda's method.* He states distinctly that this method is the one indicated by the theory of probabilities. He then proceeds to point out the objection just stated, and expresses the opinion that the method would, without doubt, be the best if each elector would write the names of the candidates in what he thinks the order of merit. We have seen, however, that this is far from being the case.

METHODS OF THE SECOND CLASS.

The simplest method of the second class is the French method of double elections. In this method each elector has one vote, as in the single vote method, already described. If, however, no candidate obtain an absolute majority of the votes polled, a second election is held. For this second election only the two candidates who obtained the largest number of votes at the first election can be candidates. The result is that the successful candidate is returned by an absolute majority of those who vote at the second election, so that it would appear, at first sight, that the successful candidate represents the views of a majority of the electors. We must not lose sight, however, of two facts, first, that all the electors who vote at the first election may not vote at the second election; second, that those who do so vote merely have to choose between the two remaining candidates, and that, consequently, they may not be repre-

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* *Journal de l'Ecole Polytechnique*, cahiers vii. and viii., pp. 169, 170; *Théorie Analytique des Probabilités*, pp. 101, 299; Todhunter's *History of Probability*, pp. 547, 548.

sented in any sense by the candidate they vote for; they may merely be in the position of having a choice of evils.

This plan has frequently been proposed for adoption in England, and quite recently it has been proposed by more than one speaker in the Legislative Assembly of Victoria. The method is indeed a great improvement on the present system of single voting, and if the election be merely a party contest, and neither side runs more than two candidates, the result cannot be wrong. But if these conditions be not satisfied, the method may easily lead to an erroneous result. The method may be used whatever be the number of candidates; but it is sufficient to show that it is erroneous in the case of three candidates only. This is at once done by a further consideration of the example already given in discussing the single vote method. For in that example C is at the bottom of the poll, and, according to the present system, he is rejected, and a second election is held to decide between A and B, because no one has an absolute majority at the first election. The result of the second election is, for A, five votes; for B, seven votes; so that B wins. In order to show that this result may be erroneous it is only necessary to suppose that the five electors who voted for A prefer C to B. For then, if the question

That C is to be preferred to B

was put to the whole body of electors, it would be carried by a majority of four. Now, we have already seen that the question

That C is to be preferred to A

would be carried by a majority of two. Hence, then, this method leads to the rejection of a candidate who is declared by a majority of the electors to be superior to each of the other candidates. This method, then, clearly violates the condition that the result must not be contrary to the wishes of the majority.

We may consider this example from a slightly different point of view. In discussing it under the single vote method, the important result arrived at was that A was inferior to each of the other candidates, and, therefore, ought to be at the bottom of the poll, instead of being at the top, as he was, in consequence of his being opposed by two good men, B and C. Thus, instead of excluding C, as in the French method, A is the one who ought to be excluded. Having arrived at the result that A is to be excluded, the whole of the electors have now a right to decide between B and C. On putting this question to the issue, we find that C is preferred by the electors.

We see, then, that the French method may lead to error through throwing out the best man at the first election. And this is the only way in which it can err; for if there be a best man, and he survive the ordeal of the first election, he must win at the second, seeing that he is, in the opinion of the electors, better than each of his competitors.

Comparing the French method with the single vote method, we see that in the case of three candidates the worst candidate may be returned by the single vote method, but that it would be impossible for such a result to be brought about by the French method. By that method we are at least sure of getting the second best man, if we fail to get the best.

There is, however, a grave practical objection to this method. It is that a second polling may be necessary. This is of great importance; for in the case where the number of electors is large, as in a political election, great expense has to be incurred, not only by the authorities in providing the necessary machinery, but also by the electors themselves in coming to the poll again. Besides this, the excitement of the election is kept up much longer than it would be if the whole matter could be settled by a single polling. There can, I think, be little doubt that this objection has been one of the chief obstacles with which the advocates of this method have had to contend. Accordingly, we find that the single vote method is employed, as a rule, in those cases in which there are some hundreds of electors, and it would be inconvenient to hold a second election. On the other hand, when the number of electors is small, so that they can all meet together, and remain till a second or third election has been held, the number of candidates is generally reduced to two by means of a preliminary ballot or ballots. This very fact shows that the defects of the single vote method are recognised, because in those cases in which it is considered to be practicable to do so a preliminary election is held, so as to try to avoid the glaring defect of the single vote method—that is, to avoid returning a candidate who is acceptable to a small section only of the electors. It is a mistake, however, to suppose that it is not practicable to hold one or more preliminary elections when the number of electors is large. It is generally thought that in order to do so a fresh set of voting papers must be used for the second election, and that this second election cannot be held till the result of the first is known, so that the electors have the expense and trouble of going to the poll a second time. This, at all events, appears to be the practice in France, Germany, and Italy. This, however, is not necessary; for, by a very simple expedient, any number of preliminary elections, on any plan whatever, may be held by means of a single set of voting papers, and without troubling the electors to vote more than once. The expedient is to require each elector to indicate his order of preference amongst all the candidates. Once get this information from the electors, and we can tell how any elector will vote on any question that may be put as to the merits of the candidates. It is here assumed that an elector will not change his opinion during the course of the election. This expedient of making each elector indicate his order of preference amongst all the candidates is necessary in order to carry out Borda's method, which has been described above; indeed, it was suggested by Borda himself. But Borda does not appear to have noticed that it might be made use of for a series of elections without requiring the electors to vote again; this appears to have been first pointed out by Condorcet. The idea of a preferential or comparative voting paper is one of the fundamental ones in Hare's system of proportional representation. We are not concerned with this subject here, as the only question under consideration is that of filling a single vacancy. It is, however, worthy of notice that the preferential voting paper which is such an important feature in Hare's system, is of such old origin, and that it was suggested by Condorcet as a means of filling several vacancies, which is the very question considered by Hare. The method of Condorcet, however, is quite different to that of Hare.

If the expedient here described were adopted, the French system would be free from the practical objection which has been indicated. It would still, however, be open to the objection that the result of the election might be contrary to the views of the electors. Notwithstanding this, the method would be a good practical one for elections on a large scale; it would be very suitable for party contests, and if neither side ran too many candidates, the result could not be wrong. The method, however, would be altogether unsuitable if there were three distinct parties to the contest. Under any circumstances, however, the method would be very little more complicated than the present system of single voting, and it would give much better results. If, however, it be considered desirable to reform the present electoral system so far as to introduce this French system of double elections, it would be as well to at once adopt the method of Ware, described below. This is the same, in the case of three candidates, as the French method, but in other cases it is a trifle longer. No difference whatever would be required in the method of voting, but only a little more labour on the part of the returning officer. The results of this method would be much more trustworthy than those of the French method.

OTHER METHODS OF THE SECOND CLASS.

Before passing on to the methods of the third class, it may be stated that each of the methods described under that heading may be conducted on the system of the second class. In order to do so, instead of using a preferential voting paper, as in the methods of the third class, we must suppose a fresh appeal made to the electors after each scrutiny. This, of course, would make the methods needlessly complex, and, in the case of a large number of electors, totally impracticable. This, however, is not the only objection to the methods of the second class. For if the electors be allowed to vote again after the result of one of the preliminary elections is known, information is given which may induce an elector to transfer his allegiance from a candidate he has been supporting to another candidate whom he finds has more chance of success. A method which permits, and which even encourages, electors to change their views in the middle of the contest cannot be considered perfect. This objection does not apply to those cases in which there are only three candidates, or to any case in which all but two candidates are rejected at the first preliminary election, as in the French system.

There is another objection, however, which applies to all cases alike; it is that, at the first preliminary election, an astute elector may vote, not according to his real views, but may, taking advantage of the fact that there is to be a second election, vote for some inferior candidate in order to get rid, at the first election, of a formidable competitor of the candidate he wishes to win. If this practice be adopted by a few of the supporters of each of the more formidable competitors, the result will frequently be the return of an inferior man.

On account of these objections, I consider it unnecessary to enter into any further details as to the methods of the second class.

METHODS OF THE THIRD CLASS.

In the methods of the third class each elector makes out a list of all the candidates in his order of preference, or, what comes to the same thing, indicates his order of preference by writing the successive numbers 1, 2, 3, &c., opposite the names of the candidates on a list which is supplied to him. Thus one voting only is required on the part of the electors. These preferential or comparative lists are then used in a series of scrutinies; and the methods of the third class differ from one another only in the way in which these scrutinies are conducted. Three different methods, which may be called Ware's method, the Venetian method, and Condorcet's practical method, have been proposed for use, and these will now be described.

WARE'S METHOD.

This method is called Ware's method because it appears to have been first proposed for actual use by W. R. Ware, of Harvard University.* The method was, however, mentioned by Condorcet,† but only to be condemned. This method is a perfectly feasible and practicable one for elections on any scale, and it has recently been adopted by the Senate of the University of Melbourne. It is a simple and obvious extension of the French system, and it is obtained from that system by two modifications, viz.:—

(1.) The introduction of the preferential or comparative method of voting, so as to dispense with any second voting on the part of the electors.

(2.) The elimination of the candidates one by one, throwing out at each scrutiny the candidate who has fewest votes, instead of rejecting at once all but the two highest.

In the case in which there are three candidates only, the second modification is not necessary. It will, perhaps, be convenient to give a more formal description of this method. The mode of voting for all methods of the third class has already been described; it remains, therefore, to describe

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* See *Hare on Representation*, p. 353.

† *Œuvres*, 1804, vol. xiii., p. 243.

the mode of conducting the scrutinies in Ware's method.

At each scrutiny each elector has one vote, which is given to the candidate, if any, who stands highest in the elector's order of preference.

The votes for each candidate are then counted, and if any candidate has an absolute majority of the votes counted he is elected.

But if no candidate has such an absolute majority, the candidate who has fewest votes is excluded, and a new scrutiny is proceeded with, just as if the name of such excluded candidate did not appear on any voting paper.

Successive scrutinies are then held until some candidate obtains on a scrutiny an absolute majority of the votes counted at that scrutiny. The candidate who obtains such absolute majority is elected.

It is obvious that this absolute majority must be arrived at sooner or later.

It is clear, also, that if on any scrutiny any candidate obtain a number of votes which is greater than the sum of all the votes obtained by those candidates who each obtain less than that candidate, then all the candidates having such less number of votes may be at once excluded.

Ware's method has been shown to be erroneous for the case of three candidates in the remarks on the French method, of which it is in that case a particular form. It is easy to see that if there be more than three candidates the defects of this method will be still more serious.

The objection to this method, concisely stated, is that it may lead to the rejection of a candidate who is considered by a majority of the electors to be better than each of the other candidates. At the same time, the method is a great improvement on the single vote method; and the precise advantage is that whereas the single vote method might place at the head of the poll a candidate who is considered by a majority of the electors to be worse than each of the other candidates, it would be impossible for such a candidate to be elected by Ware's method.

To illustrate fully the difference between the two methods and the defects of each, suppose that there are several candidates, A, B, C, D, . . P, Q, R, and that in the opinion of the electors each candidate is better than each of the candidates who follow him in the above list, so that A is clearly the best, B the second best, and so on, R being the worst. Then on the single vote method R may win; on Ware's method A, B, C, D, . . P, may be excluded one after another on the successive scrutinies, and at the final scrutiny the contest will be between Q and R, and Q, of course, wins, since we have supposed him better than R in the opinion of the electors. Thus the single vote method may return the worst of all the candidates; and although Ware's method cannot return the worst, it may return the next worst.

A great point in favour of Ware's method is that it is quite impossible for an astute elector to gain any advantage for a favourite candidate by placing a formidable competitor at the bottom of the list. On account of its simplicity, Ware's method is extremely suitable for political elections. In cases of party contests, the strongest party is sure to win, no matter how many candidates are brought forward. The successful candidate, however, will not always be the one most acceptable to his own party.

THE VENETIAN METHOD.

For the sake of simplicity, I describe this method for the case of three candidates only. Two scrutinies are held; at the first scrutiny each elector has two votes, which are given to the two candidates, one to each, who stand highest in the elector's order of preference. The candidate who has fewest votes is then rejected, and a final scrutiny is held between the two remaining candidates. At the final scrutiny each elector has one vote, which is given to that one of the remaining candidates who stands highest in the elector's order of preference. The candidate who obtains most votes at the final scrutiny is elected.

This method is very faulty; it may lead to the rejection of a candidate who has an absolute majority of the electors in his favour. For we have seen, in discussing the double vote method, that such a candidate may be rejected at the first scrutiny. In fact, unless the candidate who has fewest votes at the first scrutiny has less than N votes, where 2N is the number of electors, we cannot be sure the result is correct. For, for anything we can tell, the candidate who is rejected at the first scrutiny may be, in the opinion of an absolute majority of the electors, the best man for the post. If, however, the candidate who has fewest votes on the first scrutiny has less than N votes, then the method will certainly give a correct result. For, since there are only three candidates, to require an elector to vote for two candidates comes to exactly the same thing as to ask him to vote against one candidate. Now, if with the two votes any candidate get less than N votes, it is clear that there are more than N votes against him, for each candidate must be marked first, or second, or third on each paper. Thus, in the opinion of an absolute majority, the candidate is worse than each of the other candidates, and, therefore, ought not to be elected. Unless, therefore, the lowest candidate has less than N votes, this method violates the fundamental condition.

I do not know that the method has ever been used in the form here described; but in the still more objectionable form of the second class, which differs from the one just described only by dispensing with the preferential voting paper, and allowing the electors to vote again after the result of the first scrutiny is known, it is exceedingly common, and is frequently used by committees. An instance which was fully reported in the Melbourne papers occurred some time ago in the selection of a candidate to stand on the constitutional side at the last election for Boroondara. It is fair, however, to say that the result of the method appears to have been correct in that case; but that was due to accident, and not to the method itself.

If there be more than three candidates the method is very complicated, and the defects are more serious. It seems, however, hardly worth while going into any details in these cases.

CONDORCET'S PRACTICAL METHOD.

This method was proposed in 1793 by Condorcet, and appears to have been used for some time at Geneva. It is described at pp. 36—41 of vol. xv. of Condorcet's collected works (edition of 1804), and may be used in the case of any number of candidates for any number of vacancies. We are at present concerned only with the case of a single vacancy; and for the sake of simplicity I describe Condorcet's method for the case in which there are only three candidates.

Two scrutinies may be necessary in order to ascertain the result of the election in this method. At the first scrutiny one vote is counted for each first place assigned to a candidate, and if any candidate obtains an absolute majority of the votes counted he is elected. But if no one obtain such an absolute majority a second scrutiny is held. At the second scrutiny one vote is counted for each first place, and one vote for each second place, exactly as in the first scrutiny on the Venetian method, and the candidate who obtains most votes is elected. At first sight we might suppose that this method could not lead to error. Comparing it with the Venetian method, described above, we see that Condorcet supplies a remedy for the obvious defect of the Venetian method—that is to say, the rejection of a candidate who has an absolute majority is now impossible. A little examination, however, will show, as seems to have been pointed out by Lhuilier,* that the method is not free from error. For, let us suppose that there are sixteen electors, of whom five put A first and B second, five put C first and B second, two put A first and C second, two put B first and A second, and two put C first and A second. Then the result of the first scrutiny will be, for A, B, C, seven, two, seven votes respectively. Thus, no one having an absolute majority, a second scrutiny is necessary. The result of the second scrutiny will be—for A, B, C, eleven, twelve, and nine votes respectively. Thus B, having the largest number of votes, is elected. This result, however, is not in accordance with the views of the majority of the electors. For the proposition, "B is better than A," would be negatived by a majority of two votes, and the proposition, "B is better than C," would also be negatived by a majority of two votes, so that in the opinion of the electors B is worse than A and also worse than C, and, therefore, ought not to be elected.

Summing up the results we have arrived at, we see that each of the methods which have been described may result in the return of a candidate who is considered by a majority of the electors to be inferior to each of the other candidates. Some of the methods—viz., the double vote method, the method of Borda, and the Venetian method—may even result in the rejection of a candidate who has an absolute majority of votes in his favour as against all comers. It would, however, be quite impossible for such a result to occur on the single vote method, or the methods of Ware and Condorcet.

METHOD PROPOSED.

Having pointed out the defects of the methods in common use, it now remains to describe the method proposed for adoption, and to show that it is free from these defects. It

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* See Montucla's *Histoire des Mathématiques*, vol. iii., p. 421.

consists merely in combining the principle of successive scrutinies with the method of Borda, and at the same time making use of the preferential voting paper, so that the proposed method belongs to the third class. I propose, first, to describe and discuss the method for the case of three candidates, and then to pass on to the general case in which there may be any number of candidates.

Let us suppose, then, that there are three candidates, A, B, C. Each elector writes on his voting paper the names of two candidates in order of preference, it being clearly unnecessary to write down a third name. If we prefer it, the three names may be printed on the voting paper, and the elector may be required to indicate his order of preference by writing the figure 1 opposite the name of the candidate of his first choice, and the figure 2 opposite the name of the candidate of his second choice, it being clearly unnecessary to mark the third name. In order to ascertain the result of the election two scrutinies may be necessary.

At the first scrutiny two votes are counted for each first place and one vote for each second place, as in the method of Borda. Then if the two candidates who have the smallest number of votes have each not more than one-third of the whole number of votes, the candidate who has most votes is elected, as in Borda's method. But if one only of the candidates has not more than one-third of the votes polled (and some candidate must have less), then that candidate is rejected, and a second scrutiny is held to decide between the two remaining candidates. At the second scrutiny each elector has one vote, which is given to that one of the remaining candidates who stands highest in the elector's order of preference. The candidate who obtains most votes at the second scrutiny is elected.

The method may be more briefly described as follows:—Proceed exactly as in Borda's method, but instead of electing the highest candidate, reject all who have not more than the average number of votes polled. If two be thus rejected, the election is finished; but if one only be rejected, hold a final election between the two remaining candidates on the usual plan.

In order to show that the proposed method is free from the defects above described, it is necessary and it is sufficient to show that if the electors consider any one candidate, A, say, superior to each of the others, B and C, then A cannot be rejected at the first scrutiny. For if A be not rejected at the first scrutiny he cannot fail to win at the second scrutiny. Let therefore the whole number of electors be 2N, and let the number who prefer B to C be $N + a$, and consequently the number who prefer C to B be $N—a$; similarly, let the number who prefer C to A be $N + b$, and therefore the number who prefer A to C be $N — b$, and let the number who prefer A to B be $N + c$, and therefore the number who prefer B to A be $N — c$. Then it is easy to see that the numbers of votes polled by A, B, C at the first scrutiny will be

$$2N — b + c, 2N — c + a, 2N — a + b$$

respectively. For if the compound symbol A B be used to denote the number of electors who put A first and B second, and similarly for other cases, it is clear that A's score at the first scrutiny will be

$$2AB + 2AC + BA + CA.$$

Now this expression can be written in the form

$$(AB + AC + CA) + (AC + AB + BA),$$

and it is clear that the three terms in the first pair of brackets represent precisely the number of electors who prefer A to B, which number has already been denoted by $N + c$. In the same way the remaining three terms represent the number of electors who prefer A to C, which number has been denoted by $N — b$. Hence the score of A on the first scrutiny is $2N — b + c$. In exactly the same way it may be shown that the scores of B, C are $2N — c + a$ and $2N — a + b$ respectively. The sum of these three numbers is 6N, as it ought to be. Thus 2N is the mean or average of these three numbers, and consequently the highest of the three candidates must have more than 2N votes, and the lowest must have less than 2N votes. Now, let us suppose that a majority of the electors prefer A to B, and likewise that a majority prefer A to C; then c must be positive, and b must be negative. Hence the score of A, which has been shown to be $2N — b + c$, is necessarily greater than 2N, for it exceeds 2N by the sum of the two positive quantities $— b$ and c. Thus A has more than 2N votes, that is, more than one-third, or the average of the votes polled. He cannot, therefore, be rejected at the first scrutiny, so that B or C or both must be rejected at the first scrutiny. If either of the two, B and C, be not rejected, A must win at the second scrutiny, for there is a majority for A against B, and also against C. Hence, then, it has been demonstrated that if the opinions of the electors are such that there is a majority in favour of A as against B, and likewise a majority in favour of A as against C, the method of election which is proposed will certainly bring about the correct result; whereas it has been shown by the consideration of particular examples that the methods in ordinary use may easily bring about an erroneous result under these circumstances. Thus the proposed method cannot bring about a result which is contrary to the wishes of the majority, so that the proposed method satisfies the fundamental condition.

The method which is proposed has, I think, strong claims. It is not at all difficult to carry out. The result will, as often as not, be decided on the first scrutiny. We simply require each elector to put down the names of two of the three candidates in order of preference. Then for each first name two votes are counted, and for each second name one vote is counted. The number of votes for each candidate is then found. The third part of the sum total may be called the average; then all candidates who are not above the average are at once rejected. The lowest candidate must, of course, be below the average. The second is just as likely to be below as above the average. If he is below, the election is settled; but if he is above the average, a second scrutiny is necessary to decide between him and the highest candidate.

CASES OF INCONSISTENCY.

We have now to consider what is the result of the proposed method in those cases in which there is not a majority for one candidate against each of the others. The methods which have been described have been shown to be erroneous by examining cases in which either one candidate has an absolute majority of the electors in his favour, or a candidate A is inferior to B and also to C, or a candidate A is superior to B and also to C. Now it is not necessary that any of these cases should occur. If a single person has to place three candidates in order of preference he can do so, and it would be quite impossible for any rational person to arrive at the conclusions

B is superior to C ... ... (1)
C is superior to A ... ... (2)
A is superior to B ... ... (3)

When, however, we have to deal with a body of men, this result may easily occur, and no one of the candidates can be elected without contradicting some one of the propositions stated above. If this result does occur, then, no matter what result any method of election may give, it cannot be demonstrated to be erroneous. We have examined several methods, and all but the one now proposed have been shown to lead to erroneous results in certain cases. It may fairly be urged, then, that that method which cannot be shown to be erroneous in any case has a greater claim to our consideration than any of the other methods which can be shown to erroneous. On this ground alone I think the method proposed ought to be adopted for all cases.

We can, however, give other reasons in favour of the method proposed. We have seen that it gives effect to the views of the majority in all cases except that in which the three results (1), (2), (3) are arrived at. In this case there is no real majority, and we cannot arrive at any result without abandoning some one of the three propositions (1), (2), (3). It seems most reasonable that that one should be abandoned which is affirmed by the smallest majority. Now, if this be conceded, it may be shown that the proposed method will give the correct result in all cases. For it is easily seen that the majorities in favour of the three propositions (1), (2), (3) are respectively $2a$, $2b$, $2c$. Hence, then, in the case under consideration, a, b, c, must be all positive. Let us suppose that a is the smallest of the three. Then we abandon the proposition (1), and consequently C ought to be elected. Now let us see what the proposed method leads to in this case. B's score at the first scrutiny is $2N - c + a$, and this is necessarily less than 2N, because c is greater than a, and each is positive. Again, C's score is $2N - a + b$, and this is necessarily greater than 2N, because b is greater than a, and each is positive. Thus B is below the average, and C is above the average. Therefore, at the first scrutiny B goes out and C remains in. If A goes out also, C wins at the first scrutiny. But if A does not go out, C will beat A at the second scrutiny. Thus C wins in either case, and, therefore, the proposed method leads to the result which is obtained by abandoning that one of the propositions (1), (2), (3) which is affirmed by the smallest majority. We have already seen that in the case in which the numbers a, b, c are not all of the same sign, the proposed method leads to the correct result. Hence, then, if it be admitted that when we arrive at the three inconsistent propositions (1), (2), (3) we are to abandon the one which is affirmed by the smallest majority, it follows that the proposed method will give the correct result in all cases.

We have, then, arrived at two results. First, that if the electors affirm any two of the propositions (1), (2), (3) and affirm the contrary of the remaining one, and so affirm three consistent propositions, then the result of the method of election which is here proposed, will be that which is the logical consequence of these propositions, whilst the methods in ordinary use may easily give a different result. Second, that if the electors affirm the three propositions (1), (2), (3) which are inconsistent, then the result of the method proposed is that which is the logical consequence of abandoning that one of the three propositions which is affirmed by the smallest majority.

ANOTHER WAY OF APPLYING PROPOSED METHOD.

The method may be stated in another form, which may sometimes be more convenient. For each first place count one vote; then, if any candidate has an absolute majority, elect him. But if not, count in addition one vote for each second place; then, if the lowest candidate has not got half as many votes as there are electors, reject him, and proceed to a final scrutiny between the remaining two. But, if not, take the aggregate for each candidate of the results of the two counts; then reject all who have less than one-third of the votes now counted, and, if necessary, proceed to a final scrutiny.

This process will give the same final result as the method already described. This is readily seen as follows:—1st. If any one has an absolute majority on the first places, the election is settled at the first scrutiny, and the result is manifestly correct, and therefore the same as that of the proposed method. 2nd. If no one has an absolute majority on the first places, but some one has on first and second places less than half as many votes as there are electors, it is manifest that more than half the electors consider that candidate worse than each of the others, so that he ought to be rejected, and hence the result of the final scrutiny will be correct, and therefore in accordance with that of the proposed method. 3rd. If neither of the above events happen, we take the aggregate. Now (as has already been remarked) the result of taking the aggregate is to give us exactly the same state of the poll as in the first scrutiny of the proposed method. Thus the second way of applying the method will give the same final result as the proposed method. This second way is very convenient, for if there be an absolute majority for or against any candidate, it is made obvious at the first or second count, and the election is settled with as little counting as possible. The two counts are conducted on well known plans, and if the circumstances are such that either of these necessarily gives a correct result, that result is adopted. But if it is not obvious that a correct result can be arrived at, then we take the mean, or what comes to the same thing, the aggregate of the two counts. This might appear to be a rule of thumb, and on that account may perhaps commend itself to some persons. This is not the case, however; and it is remarkable that that which might suggest itself as a suitable compromise in the matter should turn out to be a rigorously exact method of getting at the result in all cases. The view of the proposed method which has just been given shows exactly what modifications require to be made in Condorcet's practical method in order tomake it accurate.

LAPLACE'S OBJECTION.

It may be said that the proposed method is open to the objection raised by Laplace to the method of Borda. To this I think it a sufficient answer to say, that if we have a method which will truly interpret the wishes of the electors, as expressed by their voting papers, we need not trouble ourselves whether they vote honestly or not; that is their own concern. If we provide a method which will bring out a correct result for honest electors we need not try to go further, and endeavour to construct a method which will force dishonest electors to vote honestly. Nevertheless, it may be pointed out that Laplace's objection is not of so much force in this case as in the case of Borda's method. For if an elector vote otherwise than according to his real views it will be at the risk of having his vote at the final scrutiny counted against the candidate whom he considers most fit for the office to be filled. This risk would be sufficient to deter most electors from voting otherwise than according to their real opinions. If, in spite of this risk, an elector persists in voting otherwise than according to his real views we must take him at his word. To illustrate this objection, let us suppose that B and C are two formidable candidates, and that A is in reality inferior to each of them, but that the voting is as follows, BA = 5, CA = 4, AB = 1, AC = 1; so that B's supporters, in their anxiety to defeat C, put A second, and C's supporters, in their anxiety to defeat B, put A second. The result at the first scrutiny is A 13 votes, B 11 votes, C 9 votes. Thus C is rejected and A wins in the final scrutiny. A wins because the whole of C's supporters put him second. Had one of C's supporters voted according to his real views, and put B second, the result would have been different.

If the preferential mode of voting were not employed, this objection would be of great force; for then the supporters of each candidate would put his most formidable opponent at the bottom of their list at the first scrutiny, knowing that they would have at the second scrutiny an opportunity of reviewing their vote.

A MODIFICATION OF PROPOSED METHOD.

It may be mentioned that there is another, but in general a more tedious, method of getting at a result, which cannot be shown to be erroneous in any case. This method has been adopted by the Trinity College Dialectic Society. It is as follows:—In the method proposed above, instead of rejecting all the candidates who are not above the average, reject the lowest only. It is obvious from what has been said above that this cannot lead to error. But a second scrutiny will always be required, whereas in the proposed method one scrutiny only may be necessary. There is another disadvantage: the result will not in all cases agree with that of the proposed method. For, let us suppose that a, b, c are all positive, and that a is the least of the three, and at the same time that $2c$ is less than $a + b$. On the method proposed, as we have already seen, C would be elected, but on the method now under discussion B would be elected. For the scores of A and B at the first scrutiny are $2N—b+c$, $2N—c+a$, respectively, and the first of them is the smallest, because $2c$ is less than $a + b$, and therefore $c—b$ is less than $a—c$. Thus A would be thrown out at the first scrutiny, and a second scrutiny would be held to decide between B and C, and B would win because a is positive. Thus the result is that which would follow from abandoning the proposition "A is better than B," which is affirmed by a majority of $2c$, whereas the result of the proposed method is that which would follow from abandoning the proposition

"B is better than C," which is affirmed by a majority of $2a$, which is smaller than the former majority.

There is, however, one point in favour of the modified method. The first scrutiny will at once give us the values of the three differences $b—c$, $c—a$, $a—b$. From these, of course, we cannot find a, b, c. In the modified method, however, a second scrutiny is always necessary, and this will at once give us the value of one of the three a, b, c. Having already found the three differences, we can at once find each of the quantities a, b, c, and hence we can ascertain if the result is demonstrably correct. Thus if the modified method be used, we can always ascertain, by a simple calculation, whether the result is perfectly satisfactory or not. The same remark applies to the proposed method in those cases in which two scrutinies are necessary.

ALGEBRAIC ANALYSIS.

Before leaving the case in which there are three candidates only, it may be of interest to give a short algebraical analysis of the question. As before, let the compound symbol AB stand for the number of electors who put A first and B second, and similarly for other cases. Let us suppose, as is clearly possible, that six quantities, a, b, c, α, β, γ, are found from the following equations:

$$\begin{array}{lll} AB=\beta+c & BC=\gamma+a & CA=\alpha+b \\ AC=\gamma-b & BA=\alpha-c & CB=\beta-a \end{array}$$

Also let us suppose that 2N denotes the whole number of electors, which is clearly equal to $2(\alpha+\beta+\gamma)$, then the states of the poll on the different modes of election which have been discussed are as shown in the following table:—

Analysis of Votes.	Single Vote.	Double.	Borda.	Condorcet.		
A $\left\{\begin{array}{l} AB=\beta+c \\ AC=\gamma-b \end{array}\right\}$	$\beta+\gamma-b+c$	$N+\alpha$	$2N-b+c$	*	$N-b$	$N+c$
B $\left\{\begin{array}{l} BC=\gamma+a \\ BA=\alpha-c \end{array}\right\}$	$\gamma+a-c+\alpha$	$N+\beta$	$2N-c+a$	$N+a$	*	$N-c$
C $\left\{\begin{array}{l} CA=\alpha+b \\ CB=\beta-a \end{array}\right\}$	$\alpha+\beta-a+b$	$N+\gamma$	$2N-a+b$	$N-a$	$N+b$	*
$2N=2(\alpha+\beta+\gamma)$	2N	4N	6N	2N	2N	2N

In the first column is set out an analysis of the votes. In the second is the result of the poll on the single vote method. For instance, in the first line we have the quantity $\beta+\gamma-b+c$, which is the sum of AB and AC, *i.e.*, it denotes the number of electors who put A first. In the third column is the result of the poll on the double vote system, in which each elector has two votes. For instance, in the first line we have $N+\alpha$, or what is the same, $2\alpha+\beta+\gamma$, and this is equal to AB+AC+BA+CA, *i.e.*, it denotes the number of electors who put A first or second. In the fourth column is the result of the poll on Borda's method. For instance, in the first line we have $2N-b+c$, and this is equal to 2AB+2AC+BA+CA, as it ought to be. It is also seen at once that $2N-b+c$ is the sum of the two numbers in the first line in the second and third columns. This shows the truth of what was stated above, viz., that the poll on Borda's method is the aggregate of the polls on the single and double vote systems. In the fifth, sixth, and seventh columns, under the heading Condorcet, are set down the states of the poll on the supposition that each of the candidates, A, B, C, is excluded in turn. Thus, if A be supposed excluded for a moment, we have $N+a$ votes for B in preference to C, and consequently $N-a$ for C in preference to B. For $N+a$ is equal to AB+BC+BA, as it ought to be. Thus it is clear that $2a$ is the majority for B as against C, so that the letters a, b, c, have the same meaning as in the previous part of this paper. It is clear too, as has been proved before, that the number in any row in the column headed Borda, is the sum of the two numbers in the same row in the columns headed Condorcet.

The result of the method of election proposed in this paper depends solely upon the numbers a, b, c. The same is true of the method of Borda. On the other hand, the result of the double vote method depends solely on the values of α, β, γ. Consequently, whatever be the result of the proposed method or of Borda's method we can clearly construct cases in which the result of the double vote method shall be what we please. The same is true of the single vote method; for although the result of the single vote method depends upon a, b, c as well as upon α, β, γ, it is easy to see that we can choose α, β, γ so as to eliminate the effect of the quantities a, b, c, whatever may be the values of the latter. The results of the Venetian method and of Ware's method depend on the values of a, b, c as well as upon those of α, β, γ, so that although for given values of a, b, c we cannot bring about any result we please, still we can choose α, β, γ so as to bring about a result different from the true one. This, of course, is to be done by choosing α, β, γ, so that the best candidate is thrown out at the first scrutiny. We have already seen that this is possible.

It is clear that no one of the quantities $\beta + \gamma, \gamma + \alpha, \alpha + \beta$ can be negative. For we have $\beta + \gamma =$ BC + CB, and BC, CB can neither of them be negative. Again, $\beta + \gamma =$ N $- \alpha$; thus α cannot be greater than N. So also β, γ can neither of them exceed N. Since $\beta + \gamma$ cannot be negative, β and γ cannot both be negative; thus one only of the three α, β, γ can be negative. If α be negative it is clear that the numerical value cannot exceed N, for $\alpha + \beta$ cannot be negative, and β cannot exceed N. So for β and γ. Thus no one of the three α, β, γ can numerically exceed N, and one at most can be negative.

The limits between which a, b, c must lie are at once found from the consideration that AB, AC, &c., must none of them be negative. Thus $a + \gamma, \beta - a$ can neither of them be negative; thus a cannot be less than $- \gamma$ nor greater than β. Hence, *a fortiori*, no one of the three a, b, c, can be numerically greater than N. This last result is obvious from the fact that no one of the numbers in the columns headed "Condorcet" can be negative.

Formal demonstrations will now be given of a few results.

(i.) If any candidate have less than N votes on the double vote method, he ought not to be elected.

This has already been seen, but the following proof is given. Suppose A has less than N votes; then α must be negative, and therefore c must be negative and b positive. Thus A is worse than B, and also worse than C.

(ii.) Even if every elector put A in the first or second place it does not follow that A ought to be elected.

For if A has no third places we must have BC = O and CB = O, thus $a = \beta = - \gamma$. Suppose β positive and therefore γ negative. Then by preceding case C ought to go out and A or B ought to win as c is positive or negative. Now c may be negative so that B may win; for the only conditions with reference to c are that c must be greater than $- \beta$ and less than α, and as β is positive it is clear that c may be negative.

(iii.) It is impossible to arrive at the true result by merely counting the number of first places, the number of second places, and the number of third places for each candidate.

This result seems obvious enough after what has been given. It may, however, be formally proved as follows.

Let A_1, A_2, A_3 denote the numbers of first, second, and third places respectively for A, and let corresponding meanings be given to B_1, &c., C_1, &c. Then we have

$$
\begin{aligned}
A_1 &= \beta + \gamma - b + c \\
A_2 &= 2a + b - c \\
A_3 &= \beta + \gamma
\end{aligned}
$$

with corresponding equations for B's and C's. We see at once from these equations that it is impossible to find a, b, c even if A_1, A_2, A_3, B_1, &c., be all given. We can, however, find α, β, γ and the three differences $b - c$, $c - a$, $a - b$, viz., the results are

$$\alpha = N - A_3,\ \beta = N - B_3,\ \gamma = N - C_3$$

$$b - c = A_3 - A_1,\ c - a = B_3 - B_1,\ a - b = C_3 - C_1,$$

where $2N = A_1 + B_1 + C_1 = A_3 + B_3 + C_3$ . . . . (i) thus any five of the quantities A_1, B_1, C_1, A_3, B_3, C_3, may be chosen at pleasure; the sixth and N are then determined by the conditions (i) and A_2, B_2, C_2 are then given by the equations

$$A_2 = 2N - A_1 - A_3, \text{ \&c.}$$

(iv.) If there be a demonstrably correct result, say A better than B and B better than C, so that c, a, are positive and b negative, then if Ware's method be wrong, Venetian method is right, and if Venetian method be wrong, Ware's method is right.

For if Ware be wrong A must be lowest on the single vote method, and therefore we must have

$$
\begin{aligned}
&\alpha + \beta - a + b > \beta + \gamma - b + c \\
&\text{or } \alpha > \gamma + a + c - 2b
\end{aligned}
$$

i.e., *a fortiori* $\alpha > \gamma$ because a, c are positive and b negative. Thus A cannot be lowest on double vote method, so that A will win on the Venetian method. Again, if Venetian be wrong, A must be lowest on double vote method, and therefore we must have $\gamma > \alpha$ and therefore $\beta + \gamma - b + c > \alpha + \beta - a + b$ because a, c are positive and b negative. Thus A cannot be lowest on single vote method, so that A will win on Ware's method.

(v.) If we agree to accept the proposed method as correct in all cases, then the conclusions of the last proposition will be true in all cases.

For, in the demonstration of the last proposition, the essential condition is that $a + c - 2b$ should be positive. Now, if we suppose as before that the accepted result is A better than B, and B better than C, we must have a, b, c all positive and b the smallest of the three, so that it is clear that $a + c - 2b$ is positive.

Comparing then Ware's method with the Venetian method, we see that both may be right, or one wrong and one right, but both cannot be wrong; so that, if these two methods agree, the result cannot be shown to be wrong. If, however, they do not agree, we cannot tell which is right without in effect having recourse to the proposed method.

(vi.) If $a = b = c$, single and double vote methods give different results.

For A's scores on the two methods will be respectively $N - \alpha$ and $N + \alpha$. Thus, if $\gamma > \beta > \alpha$, the candidates are in the order A, B, C on the single vote method, and in the order C, B, A on the double vote method. In this case Borda's method leads to a tie, and consequently the proposed method also. Ware elects A or B as c is positive or negative, and Venetian method elects C or B as a is negative or positive. Thus, in this case, Ware and Venetian method give different results.

(vii.) If $\alpha = \beta = \gamma$, double vote method, and therefore also Venetian method, gives a tie; single vote method and Borda lead to same result; but Ware and proposed method will not necessarily lead to same result. If one only of the three, $b - c$, $c - a$, $a - b$, be negative, Ware and proposed method will lead to same result; but if two be negative the results may or may not agree.

(viii.) If AB = AC, BC = BA, CA = CB, all the methods will give the same result, and that result will be demonstrably correct.

This is the case in which the strong supporters of each candidate are equally divided as to the merits of the remaining candidates. In this case we have

$$a = \beta - \gamma,\ b = \gamma - \alpha,\ c = \alpha - \beta,$$

and A's scores on the single, double, and Borda's method are respectively 2α, $N + \alpha$, $N + 3\alpha$. Thus, if $\alpha > \beta > \gamma$, it is obvious that each of these methods will put A first, B second, and C third, and it is clear that this result is correct, for a, c are positive and b negative. It is at once seen that all the methods which have been discussed will lead to the same result in this case.

(ix.) If we suppose that

$$\alpha = \frac{N}{3} + p\,(b - c),\ \beta = \frac{N}{3} + p\,(c - a),\ \gamma = \frac{N}{3} + p\,(a - b),$$

then A's scores on the single, double, and Borda methods will be respectively

$$\frac{2N}{3} - (p + 1)\,(b - c),\ \frac{4N}{3} + p\,(b - c),\ 2N - (b - c).$$

Hence we see that

If $p < o$ and > -1, the results of all three methods will be the same.

If $p < -1$, double and Borda methods will give the same result, which will be opposite to that of single method.

If $p > o$, single and Borda methods will give the same result, which will be opposite to that of double method.

Thus, if $p > o$ or < -1, single and double methods will give different results. If we suppose that b, c are positive and a negative, and also that $2b < c + a$, then it may be shown that these different results will both be wrong.

CASES OF MORE THAN THREE CANDIDATES.

It remains now to state and examine the method proposed for the case in which there are more than three candidates.

A series of scrutinies are held on Borda's system of voting, and all candidates who on any scrutiny have not more than the average number of votes polled on that scrutiny are excluded. As many scrutinies are held as may be necessary to exclude all but one of the candidates, and the candidate who remains uneliminated is elected.

The method proposed cannot lead to the rejection of any candidate who is in the opinion of a majority of the electors better than each of the other candidates, nor can it lead to the election of a candidate who is in the opinion of a majority worse than each of the other candidates. These results are an extension of those already proved for the case of three candidates, and they may be proved as follows:— As before, let 2N be the number of electors, and let the candidates be denoted by A, B, C, D, &c. Let the compound symbol ab denote the number of electors who consider A better than B, and let corresponding meanings be given to ac, ad, ba, &c., so that ba will denote the number of electors who prefer B to A, and we shall, therefore, have $ab + ba$

$= 2\mathrm{N}$. Now suppose that at the commencement of any scrutiny the unexcluded candidates are A, B, C, ... P, then the score of A on that scrutiny will be

$$ab + ac + ad + \ldots\ldots + ap.$$

For suppose that there are n unexcluded candidates, and consider a voting paper on which A now occupies the rth place. For this A gets $n - r$ votes. Now on this paper A stands before $n - r$ other candidates. Thus the $n - r$ votes which A receives may be considered each as due to the fact that A stands before one of the following $n - r$ candidates. Thus we see that on any one voting paper A receives one vote for every candidate placed after him. Summing up for all the voting papers, we see that A receives one vote for each candidate placed after him on each paper. Now ab denotes the number of times B is placed after A on all the papers, and similarly for ac, ad, &c. Thus it is clear that A's score is

$$ab + ac + ad + \ldots\ldots + ap.$$

This result was stated by Borda,* but proved only for the case of three candidates.

The whole number of votes polled is

$$2\mathrm{N}\,(1 + 2 + 3 + 4 \ldots + n-1)$$

or $\mathrm{N}n\,(n-1)$. Thus the average polled by all the candidates is $\mathrm{N}(n-1)$. Now let us suppose that there is a majority for A as against each of the other candidates, then each of the $n-1$ numbers ab, ac, ad, ... ap is greater than N; thus the sum of these numbers, which is equal to A's score, is necessarily greater than $(n-1)$ N, that is, greater than the average score. Thus A will be above the average on every scrutiny, so that he must win on the proposed method.

Next, let us suppose that there is a majority for each of the other candidates against A. Then each of the numbers ab, ac, . . . ap is less than N, and therefore their sum, which is equal to A's score, is less than $(n-1)$ N, that is, less than the average score. Thus A is below the average, and will, therefore, be excluded at the first scrutiny.

The results which have just been proved are particular cases of a more general theorem, which may be enunciated as follows :—

If the candidates can be divided into two groups, such that each candidate in the first group is, in the opinion of a

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* *Mémoires de l'Académie Royal des Sciences*, 1781, p. 663.

majority of the electors, better than each of the candidates in the second group, then the proposed method cannot lead to the election of a candidate of the second group.

The results which have just been proved are obtained from the above by supposing, first, that the first group contains one candidate, and the second group all the rest; and second, that the first group contains all but one of the candidates, and the second group the remaining candidate.

Let the first group consist of the l candidates, A, B, C, &c., and let the second group consist of the m candidates, P, Q, R, &c., and let $l + m = n$, so that n is the whole number of candidates. Because each of the candidates A, B, C, &c., is better than each of the candidates P, Q, R, &c., each of the numbers ap, aq, ar, &c. . . . bp, bq, &c. . . . &c., is greater than N. Now the scores of A, B, C, D, &c., at the first scrutiny are respectively

$$\begin{array}{llllllll}
* & ab + ac & + ad & + \;\&c. \ldots\ldots & + ap & + aq & + ar & + \;\&c. \\
ba & * \;\; + bc & + bd & + \;\&c. \ldots\ldots & + bp & + bq & + br & + \;\&c. \\
ca + cb & * & + cd & + \;\&c. \ldots\ldots & + cp & + cq & + cr & + \;\&c. \\
da + db + dc & & * & + \;\&c. \ldots\ldots & + dp & + dq & + dr & + \;\&c. \\
\quad \&c. & \&c. & & & \&c. & & \&c. &
\end{array}$$

If we add together all these numbers, we shall get the sum of the scores of A, B, C, D, &c. Now the numbers in the first l columns can be arranged in pairs, such as ab, ba, and $ab + ba = 2\text{N}$, and then are $\frac{1}{2}\, l\, (l - 1)$, of these pairs; thus, the sum of the first l columns is $\text{N}l(l - 1)$. Again, the numbers in the last m columns are each greater than N, and there are lm of these numbers; thus, the sum of the last m columns is greater than $\text{N}lm$. Thus, the sum of all the numbers is greater than $\text{N}l(l - 1) + \text{N}lm$; that is, than $\text{N}l(l + m - 1)$; that is, greater than $\text{N}l(n - 1)$. Thus the sum of the scores of the l candidates of the first group is greater than $\text{N}l(n - 1)$. Hence the average score of the candidates of the first group is greater than $\text{N}(n - 1)$. Hence the candidates of the first group cannot all be rejected at the first scrutiny. By the same reasoning it follows that those of the first group who survive cannot all be rejected at the second scrutiny; and so on. Thus some candidate of the first group must win on the proposed method; or, in other words, no candidate of the second group can be elected.

If the candidates can be divided into two groups in the manner just indicated, it is quite clear that no candidate of the second group ought to win. At the same time, whichever of the candidates of the first group wins, the result cannot be shown to be erroneous. If the division into groups can be made in more than one way it is clear that the last statement applies only to the smallest group of the first kind. Now in the proposed method the successful candidate must belong to the smallest group of the first kind. Hence then it is clear that the result of the proposed method cannot be shown to be erroneous in any case.

It is clear that no candidate can have more than $N(2n - 2)$ votes on any scrutiny, n being as before the number of unexcluded candidates at the commencement of that scrutiny. For a candidate could only have this number by obtaining the first place on each voting paper.

Again, if any candidate obtain $N(2n - 3)$ votes on any scrutiny, there is an absolute majority in his favour, so that we can at once elect him. For if a candidate were not put first on half the papers, he could not have so many as $(n - 1)N + (n - 2)N$ votes, this being the number he would have if he were put first on one half of the papers and second on the other half. It is clear, too, that if any candidate has less than N votes there is an absolute majority against him; for if a candidate has less than N votes, he must be last on at least half of the papers. These results are not of much use except in the case of three candidates; for if there be more than three candidates, it is only in cases of remarkable unanimity that a candidate can have so many as $N(2n - 3)$, or so few as N votes. If, however, there be three candidates only, the above results may be stated as follows:—The average is 2N; the largest number of votes any one candidate can have is 4N; if any candidate has 3N votes, or more, there is an absolute majority for him, and we can elect him at once, no matter whether the second candidate is above the average or not; if any candidate has less than N votes, there is an absolute majority against him, so that the result of the proposed method is demonstrably correct.

In the case of any number of candidates it will sometimes save a great deal of trouble if we first examine if there be an absolute majority for or against any candidate. This is easily done, and the results arrived at in the inquiry will be of use in carrying out the proposed method, if such be found necessary. For let A_1, A_2 . . . A_n denote the numbers of papers on which A occupies the first, the second . . . the last or nth place, and let similar meanings be given to B_1, B_2, &c., C_1, &c. If A_1 be greater than N, there is an absolute majority for A, and we may at once elect him. If A_n be greater than N, there is an absolute majority against A, and we may at once exclude him. If neither of these results hold good for any candidate, we must use the proposed method in its general form. Now A's score on that method is

$$(n-1)A_1 + (n-2)A_2 + \ldots + (n-r)A_r + \ldots + A_{n-1}.$$

Thus to find A's score we must find $A_2, A_3 \ldots A_{n-1}$. Now to find these it is not necessary to count all the votes for A. For we have

$$A_1 + A_2 + A_3 + \ldots + A_n = 2N,$$

and A_1, A_n having been already found, we see that it is sufficient to calculate any $n-3$ of the $n-2$ quantities, $A_2, A_3 \ldots A_{n-1}$, and the remaining one can then be found from the above equation.

It would, however, in practice be better to calculate each of the n quantities, $A_1, A_2 \ldots A_n$, and then to use the above equation as a test of the accuracy of the counting of the votes. Similar remarks apply to the numbers $B_1, B_2 \ldots B_n$, $C_1, C_2 \ldots C_n$, &c.

We have also n equations of the former

$$A_r + B_r + C_r + \ldots = 2N$$

where r may have any one of the values $1, 2, 3 \ldots n$. This gives us n independent tests of the accuracy of the enumeration of the votes. In fact, if we arrange the n^2 quantities, $A_1, A_2 \ldots A_n$, B_1, &c., in the form of a square array

$$\begin{array}{llll} A_1, & A_2, & A_3, & \&c. \\ B_1, & B_2, & B_3, & \&c. \\ C_1, & C_2, & C_3, & \&c. \\ \&c., & \&c., & \&c. & \end{array}$$

the sum of every row and of every column ought to be 2N, so that we have altogether $2n-1$ independent tests of the accuracy of the enumeration of the votes.

The proposed method is not so laborious as might appear at first sight. The number of scrutinies will not usually be large; for we may reasonably expect to halve the number of candidates at each scrutiny. At each scrutiny we reject all who are not above the average. Now in the long run we may expect to find as many below as above the average on a poll. Thus, if there be eight candidates we should not, on the average, require more than three scrutinies. There can be no doubt, however, that the method would be tedious if the number of electors were very large, unless the number of candidates was very small indeed. In cases where the number of electors is large Ware's method has great practical advantages; for in that method we only require to count one vote for each paper examined at each scrutiny, and at every scrutiny except the first the number of papers to be examined is but a small fraction of the whole number of papers.

CONDORCET'S THEORETICAL METHOD.

A method of election was described by Condorcet in 1785, but on account of its complexity it was never proposed for actual use. On this account, and in order to distinguish it from Condorcet's practical method (which has been already described), I propose to call it Condorcet's theoretical method. This method is described by its author in the following terms:—

"There exists but one rigorous method of ascertaining the wish of the majority in an election. It consists in taking a vote on the respective merits of all the candidates compared two and two. This can be deduced from the lists upon which each elector has written their names in order of merit."

"But, in the first place, this method is very long. If there are only twenty candidates, in order to compare them two and two we must examine the votes given upon one hundred and ninety propositions, and upon seven hundred and eighty propositions if there are forty candidates. Often, indeed, the result will not be as satisfactory as we could wish, for it may happen that no candidate may be declared by the majority to be superior to all the others; and then we are obliged to prefer the one who is alone judged superior to a larger number; and amongst those who are judged superior to an equal number of candidates, the one who is either judged superior by a greater majority or inferior by a smaller. But cases present themselves where this preference is difficult to determine. The general rules are complicated and embarrassing in application." (*Œuvres de Condorcet*, vol. xv., pp. 28, 29.)

By this method Condorcet showed that the single vote method and the methods of Ware and Borda are erroneous. I do not think however, that any one has hitherto noticed that Borda's method may lead to the rejection of a candidate who has an absolute majority of the electors in his favour as against all comers. It has also been shown above by the help of this theoretical method that Condorcet's practical method is erroneous. Thus it will be seen that the theoretical method is of use in testing the accuracy of other methods. From the description which has been given above, however, it is not clear what the result of the theoretical method is, even in the simplest cases, when discordant propositions are affirmed, for if there be three candidates only, and with the notation already used, we have $a = 1$, $b = 2$, $c = 3$, each candidate is superior to one other candidate, and A is superior by most, whilst C is inferior by least. Thus, according to the above description, it is not certain which of the two, A or C, wins. In another passage, however,* Condorcet explains how he deals with any case of three candidates, and the process he adopts in the case of inconsistent propositions is to reject the one affirmed by the smallest majority. This is exactly the process which has been described above, and which was shown to be in accordance with the method proposed. Thus it is clear that in the case of three candidates the result of the proposed method will always be the same as that of Condorcet's theoretical method.

The general rules for the case of any number of candidates as given by Condorcet† are stated so briefly as to be hardly intelligible. Moreover, it is not easy to reconcile these rules with the statements made in the passage quoted above, and as no examples are given it is quite hopeless to find out what Condorcet meant.

COMPARISON OF PROPOSED METHOD WITH CONDORCET'S THEORETICAL METHOD.

Comparing the method proposed in this paper with Condorcet's theoretical method, we see that, so far as any conclusion can be drawn from the votes of the electors the two methods always agree. In those cases in which no conclusion can be drawn from the votes the results of the two methods will not always be the same. It is equally impossible to prove either of these results wrong. Con-

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* *Œuvres*, vol. xiii., p. 259.

† *Essai sur l'application de l'analyse à la probabilité des decisions rendues à la pluralité des voix*, pp. 125, 126.

dorcet's method always shows whether the result is incapable of being proved wrong or not, but the proposed method gives us no information on this point. With the proposed method, however, there is no difficulty in arriving at the result in any case, whereas Condorcet's method is, by his own admission, so complicated as to be quite impracticable. Condorcet returns the candidate who is superior to the largest number of other candidates, without reference either to the numbers of votes by which the candidate is superior to those other candidates, or to the number of votes by which the candidate is inferior to the remaining candidates. Now in the proposed method both these elements are taken into consideration. Each candidate is, in fact, credited with the numbers of votes by which he beats all candidates he is superior to, and is debited with the numbers of votes by which he is beaten by all candidates he is inferior to. All candidates who have the balance against them are excluded, and the election then proceeds as if the remaining candidates were the only ones eligible.

It seems clear, then, that the proposed method is quite as rigorous as that of Condorcet. It gives the same result as Condorcet's in the case of three candidates, and it agrees therewith in all cases so far as any conclusion can be drawn from the votes. In those cases in which no valid conclusion can be drawn from the votes the two methods may not agree, and although nothing can be proved one way or another in these cases, the principles on which the proposed method is founded seem quite as sound as those of Condorcet's method. The proposed method has, however, great practical advantages over Condorcet's method, for the process of arriving at the result is the same in all cases; the operations throughout are of the same kind. The number of numerical results which have to be arrived at is much smaller than in Condorcet's method. For instance, if there be sixteen candidates we should expect, in the long run, to have four scrutinies, involving thirty numerical results, whereas Condorcet's method would require the computation of the votes for and against one hundred and twenty different propositions. When the numerical results are arrived at there is not the slightest difficulty in applying them, whereas in Condorcet's method the rules are very complicated. It may be claimed, then, that the proposed method has all the rigour of Condorcet's method and none of its practical difficulties.

INCOMPLETE VOTING PAPERS.

There is a point of some practical importance to be considered in connection with the proposed method. If the number of candidates was large, some of the electors might not be able to make out a complete list of the candidates in order of preference. We have then to consider how voting papers, on which the names are not all marked in order of preference, are to be dealt with. Such a voting paper may be called incomplete. In order to examine this question, let us first suppose, for the sake of simplicity, that there are only three candidates A, B, C, and that the votes tendered are of one of the forms AB, BA, C, that is to say, that all the electors who put A first put B second, that all who put B first put A second, and that all who vote for C mark no second name. In accordance with the proposed method, for each paper of the form AB, two votes would be given to A and one to B; and for each paper of the form BA, two votes would be given to B and one to A. The question arises, however: is a paper of the form C, that is, a plumper for C, to be counted as one vote or as two votes for C? If it be counted as one vote only, it is clear that C might be defeated even if he had an absolute majority of first votes in his favour. For if we suppose $AB=BA=a$, and $C=c$, it is clear that the scores of A and B will each be equal to $3a$, and that of C to c. Thus C will be defeated unless $c > 3a$; but if $c > 2a$, there is an absolute majority for C. Hence, then, we may be led into error if each plumper for C be counted as one vote only. If, on the other hand, a plumper be counted as two votes, it is clear that C might win even if there were an absolute majority against him. For the score of C will now be $2c$, and C will win if $2c > 3a$. But if $2c < 4a$, there is an absolute majority against C. Thus we should also be led into error if each plumper be counted as two votes. If, however, we agree to count a plumper as three halves of a vote, neither of these errors could occur. This course is readily seen to be the proper one in any case of three candidates, for it clearly amounts to assuming that the electors who plump for C are equally divided as to the merits of A and B. For if a^1, b^1, c^1 denote the numbers of plumpers for A, B, C respectively, and if we agree to consider all the electors who plump for A as being equally divided as to the merits of B and C, the effect of the a^1 plumpers for A would be to give $2\,a^1$ votes to A, and $\frac{1}{2}\,a^1$ each to B and C. Now, as we are only concerned with the differences of the totals polled for each candidate, we see that the result of the first scrutiny will be the same if we take away $\frac{1}{2}$ a^1 votes from each candidate. Thus the result will come out the same if we give $\frac{3}{2}$ a^1 votes to A, and none to B or C, so far as the plumpers are concerned. Similarly the result will not be altered if the b^1 plumpers for B be counted, as $\frac{3}{2}$ b^1 votes for B and nothing for C and A, and so for C's plumpers. Thus the final result will be in accordance with the views of the electors, if each plumper be reckoned as three halves of a vote

The assumption that the electors who plump for A are equally divided as to the merits of B and C, appears to be perfectly legitimate, for the electors have an opportunity of stating their preference, if they have one, and as they have, in the case supposed, declined to express any, it may be fairly concluded that they have none.

At the final scrutiny (if held), all plumpers for the candidate who has been rejected will have no effect.

If there be more than three candidates, and incomplete papers are presented, we should have to make a similar assumption, viz., that in all cases where the preference is not fully expressed, the elector has no preference as regards the candidates whom he has omitted to mark on his voting paper. Thus, for example, if there be four candidates, A, B, C, D, a plumper for A ought to count as two votes for A and none for B, C, D. Again, a voting paper on which A is marked first and B second, and on which no other names are marked, ought to count as two and ahalf votes for A and three halves of a vote for B. If there be more than four candidates the varieties of incomplete papers would be more numerous, and the weights to be allotted to each would be given by more complicated rules. Practically it would be best to count one vote for each plumper in the case in which only one candidate is marked on a voting paper; one for the last, and two for the first, when two names only are marked on a voting paper; one for the last, two for the next, and three for the first, when three names only are marked on a voting paper, and so on, giving in all cases one vote to the candidate marked lowest on any paper, and as many votes to the candidate marked first as there are names marked on the paper. By this means the rules for computing the votes would be the same in all cases and at all scrutinies. We have seen, it is true, that this method may lead to error. The error has the effect of decreasing the votes for the candidates who are marked on any incomplete paper, and it arises solely in consequence of the papers being incomplete. Thus, if the electors do not fully express their preference, the effect is to injure the chances of their favourite candidates. If, then, we adopt the plan just described for incomplete papers, it will be sufficiently simple for practical purposes, and its use will tend to elicit from electors a full statement of their various preferences.

CASES OF EQUALITY.

No case of equality can occur in the proposed method except when all the candidates poll exactly the same number of votes on a scrutiny, for if less than the whole number of candidates have the same number of votes in any scrutiny, if that common number be not greater than the average, all the equal candidates are excluded. If it be greater, no one of them is excluded; and in either case we pass on to another scrutiny.

If on any scrutiny all the candidates poll exactly the same number of votes, that number, of course, must be the average, and it is necessary that some one should have a casting vote. If it is thought proper to do so, one casting vote can then be made to settle the election, by allowing the casting vote to decide who is to win. But if it is thought that this is giving too much weight to the casting vote, then we may permit the casting vote to decide who is to be excluded, and then proceed to a fresh scrutiny between the remaining candidates. It will be observed, however, that the chance of a casting vote being required at any scrutiny except the last, when only two candidates remain, is very minute, seeing that it depends upon all the candidates polling exactly the same number of votes on a scrutiny.

STATEMENT OF METHOD.

It is convenient to give here a formal statement of the method which it is proposed should be used when incomplete papers are presented.

Each elector is furnished with a list of the candidates in alphabetical order, upon which he indicates his preference amongst the candidates by placing the figure one opposite the name of the candidate of his first choice, the figure two opposite the name of the next in order of preference, the figure three opposite the next, and so on, to as many names as he pleases.

It is, of course, unnecessary to mark all the names; it is sufficient to mark all but one. In what follows, if all the names be marked, it is unnecessary to pay any attention to the name marked lowest in order of preference.

The mode of dealing with the papers is as follows:—For the lowest candidate marked on any paper count one vote, for the next lowest two votes, for the next three votes, and so on, till the highest is reached, who is to receive as many votes as there are names marked on the paper. The total number of votes for each candidate is then to be ascertained; and thence the average number polled. All candidates who have not polled above the average are then to be excluded. If more than one candidate be above the average, then another scrutiny must be held as between all such candidates.

In counting up the votes for the second, or any subsequent scrutiny, no attention must be paid to the names of any candidates who have been excluded.

As many scrutinies as may be necessary must be held, so that finally all the candidates but one are excluded, and the last remaining candidate is elected.

PRACTICAL DETAILS.

In order to show precisely the amount of labour which would be required to carry out the proposed method, it may be as well to state what appears to be the most convenient way of making up the result. As in the ordinary methods, it would be necessary to have a poll-book in which to keep a tally of the votes. In this book the names of the candidates should be printed from the same type as the ballot papers are printed from. Each ballot paper should be placed with the names in a line with the corresponding names in the poll book, and the numbers written opposite to the names on each ballot paper should then be copied into the successive columns of the poll-book. In this way the risk of error in transcription would be exceedingly small, and any error which was made would be at once detected on placing the ballot paper side by side with the column in which its numbers are recorded. When this is done many of the columns would contain vacant spaces. In every vacant space in each column write a number greater by unity than the largest number copied from the voting paper into that column. After doing this add up the figures in each row; then find the mean or average of the sums. Every candidate who has a sum *equal* to or *greater* than the average is to be excluded. A little consideration will show that this process will give the same result as the method described above. When the papers have once been copied into the poll-book as just described, all subsequent scrutinies that may be necessary can be conducted without handling the voting papers again.

CASES OF BRACKETING.

Under the head of "Incomplete Voting Papers" we have considered a case in which an elector does not fully express his preference. There is, however, another way in which an elector may fail to fully express his preference. An elector may have no difficulty in putting a number of candidates at the bottom of his list, and yet he may have considerable difficulty in deciding as to the precise order in which to place the candidates at the top end of his list. In such a case an elector might wish to put two or more candidates equal for the first, second, or some other place on his list. This may be called a case of bracketing. It is now to be shown that this system of bracketing can be permitted without causing any difficulty in the practical working of the system. Let us suppose that an elector brackets m_1 candidates for the first place, m_2 for the second place, and so on; so that $m_1 + m_2 + m_3 + \ldots = n$, the case in which one candidate only is put in the r^{th} place being provided for by supposing $m_r = 1$. Then in the poll-book already described enter the number one for each of the m_1 candidates in the first bracket, the number two for each of the m^2 candidates in the second bracket, the number three for each of the m_3 candidates in third bracket, and so on. Suppose, for example, that there are seven candidates, A, B, C, D, E, F, G, and that an elector wishes to bracket B, E for the first place and A, D, F for the second place, and that he does not care to say anything about C, G. Then he would mark his paper as shown in the margin. As nothing is said about C, G, we should consider them as bracketed for the third or last place. Now in order to record this vote in the poll-book it is merely necessary, as before, to copy the column of numbers on the

2A
1B
C
2D
1E
2F
G

voting paper into a column of the poll-book, taking care to write in two 3's in the two blank spaces opposite the names C, G. After copying the numbers from each ballot-paper into the poll-book and filling up all the vacant spaces, we should add up the different rows and proceed exactly as before to ascertain the result of the election. Thus it is clear that the method of dealing with the papers is exactly the same no matter how many or how few names be marked, nor how many are bracketed in the various brackets, and that there is very little risk of error in the process.

If this system of bracketing be permitted we at once get rid of the objection that the proposed method could only be used in a highly educated constituency, because it is only highly educated electors who can possibly arrange the candidates in order of merit. The method can easily be used by the most ill-informed electors. In fact, an elector, if he so pleased, could vote in exactly the same manner as in elections under the common "majority" system of voting in cases where there are several candidates—that is, the elector may simply cross out the names of all the candidates he objects to and leave uncancelled as many names as he pleases. In such a case the uncancelled names would all be considered bracketed for the first place, and the cancelled ones as bracketed for the second or last place.

Exactly as in the case of incomplete papers previously discussed, it is easy to see that the method just given is not strictly accurate, that the strictly accurate method would be too complicated for practical purposes, and that the error has the effect of decreasing the chances of success of the favourite candidates of the elector who resorts to bracketing. In fact it may be shown that the numbers which ought strictly to be entered in the poll-book for the candidates in the successive brackets are

$$0,\ \frac{m_1}{2}+\frac{m_2}{2},\quad \frac{m_1}{2}+m_2+\frac{m_3}{2},\ \ldots\ldots \qquad (1)$$

$$\frac{m_1}{2}+m_2+m_3+\ldots+m_{r-1}+\frac{m_r}{2},\ \&c.$$

Now the plan just described comes to the same thing in the end as entering instead of these the numbers

$$0,\quad 1,\quad 2,\quad \ldots\ldots\quad (r-1),\ \&c. \qquad (2)$$

and as no one of the numbers m_1, m_2, m_3, &c., can be less than unity, it is easy to see that no one of the numbers (2) can be greater than the corresponding one of the numbers (1), that when no bracketing occurs the two sets (1), (2), are the same, and that the two sets agree until the first bracket is reached. Now observe that the numbers entered in the poll-book are in reality negative votes, and we see at once that the moment an elector begins to bracket, he diminishes the influence of his own vote on the result of the election, and also decreases the chances of success of all candidates who on his own list are placed higher than the bracket. Each additional bracket will have precisely the same effects. Thus it is clear that the effect of the proposed method will be to discourage the practice of bracketing. If we do not wish to discourage this practice we must resort to the accurate method, and use the numbers (1) instead of (2). This is not very difficult to do, but as it introduces a new method for the bracketed votes, it would give considerable extra trouble to the officers who make up the poll-books. The most convenient way of stating the accurate method would be as follows:—For each first place count one negative vote, for each second place count in addition $\frac{1}{2}(m_1 + m^2)$ negative votes, for each third place count in addition to the last $\frac{1}{2}(m_2 + m_3)$ negative votes, for each fourth place count in addition to the last $\frac{1}{2}(m_3 + m_4)$ negative votes, and so on. As before remarked, the numbers for the successive places would be the natural numbers 1, 2, 3, 4, &c., until a bracket was arrived at. When brackets do occur we shall in general have to deal with half-votes, but no smaller fraction could occur.

ANOTHER METHOD FOR CASES OF BRACKETING.

Another plan might also be adopted for dealing with cases of bracketing. It is as follows. For each candidate in the first place count one vote; for each candidate in the second place count $m_1 + 1$ votes; for each candidate in the third place count $m_1 + m_2 + 1$ votes; for each candidate in the fourth place count $m_1 + m_2 + m_3 + 1$ votes; and so on. The plan now under consideration comes to the same thing as counting for the successive places the numbers $0, m_1, m_1 + m_2, \; . \; . \; . \; . \; m_1 + m_2 + \; . \; . \; . \; + m_{r-1}$, &c. instead of the proper numbers (1). Thus the errors for the successive places are

$$0, \quad \frac{m_1 - m_2}{2}, \quad \frac{m_1 - m_3}{2}, \quad . \; . \; . \; . \; . \; \frac{m_1 - m_r}{2}, \quad \&c.$$

Hence we see that

(i.) If the same number of candidates be bracketed for each place, the plan is accurate.

(ii.) If m_1 be greater than each of the numbers m_2, m_3, &c., that is, if more candidates are bracketed for the first place than for any other place—then the errors will be all positive, and the effect will be to give the elector more negative votes than he is entitled to, and, consequently, to increase unduly the chances of the candidates bracketed for the first place.

(iii.) If m_1 be less than each of the numbers m_2, m_3, &c.—that is, if fewer candidates are bracketed for the first place than for any other place—then the errors will be all negative, and the effect will be to give the elector fewer negative votes than he is entitled to, and, consequently, to decrease unduly the chances of the candidates placed at the top end of the elector's list.

(iv.) If m_1 be equal to the mean of the numbers m_2, m_3, &c., the elector will have just as many votes as he ought to have, but he will give more negative votes to some candidates and less to others than they ought to have.

(v.) If m_1 be not equal to the mean, then the elector will have more or less votes than he is entitled to, according as m_1 is greater or less than the mean.

The results just given apply to each scrutiny; but the numbers m_1, m_2, m_3, &c., will generally be altered at each scrutiny. Thus it is in general impossible to tell at the commencement of an election what will be the effect of different modes of bracketing. Sometimes the elector will get too many votes, sometimes too few. At some scrutinies the candidates at the top end of his list will get too many votes, and at others those at the lower end will get too many votes.

If there be one candidate only in each place except the last, or, in other words, if the only bracket be for the last place, we have the case of incomplete papers discussed above. In this case the plan just described, and the method adopted above, agree; and the effect is, as has already been pointed out, to give the elector too few votes; and this would be the case at each scrutiny, until all but one of the candidates in the bracket are rejected.

If, however, an elector bracket a number of candidates for the first place and arrange all the rest in order of merit, he would get more votes than he is really entitled to and this would be the case at each scrutiny until all but one of the candidates in the bracket are rejected. Electors would very soon find this out. Each elector would ask himself the question, How must I vote in order to get as much electoral power as possible; and the answer would very soon be seen to be—I must bracket all the candidates I don't object to for the first place, and I must arrange all the rest in numerical order. Thus, instead of encouraging the electors to arrange all the candidates in order of merit, this plan would lead to each elector trying all he could to defeat objectionable candidates without expressing any opinion as to the relative merits of those he does not object to.

RULE FOR FORFEIT.

If the method which is proposed were adopted for parliamentary elections, it is clear that the number of candidates would be very much greater than at present. In order to prevent the number becoming so great as to make the election unmanageable, it is necessary to provide some method for keeping the number of candidates within reasonable bounds. Such a provision exists for the method now in use. It is that any candidate who fails to obtain one-fifth of the number of votes polled by the lowest successful candidate forfeits the deposit which he has lodged with the returning-officer. This rule is, of course, purely empirical, and we must fix upon some rule of the same kind for the proposed method. I will first state a rule for the method as first described—*i.e.*, when positive votes are used. This rule is as follows:—

If at the first scrutiny any candidate has a number of votes which is less than half the number of votes polled by the candidate who is highest at the first scrutiny, he shall forfeit his deposit.

In the mode of applying the method which is most convenient in practice this rule takes a somewhat more complicated form, as follows:—

If at the first scrutiny any candidate has a number of votes which, together with a number which is equal to half the number of electors, exceeds half the number of votes polled by the candidate who has the smallest number of votes by the average for the first scrutiny, he shall forfeit his deposit.

CASE OF SEVERAL VACANCIES.

Hitherto we have supposed that there is only one vacancy to be filled. If there be more than one vacancy we have to settle a most important question before we can consider what method of election is to be adopted. This question is as follows:—Is the majority of the electors to fill the whole of the vacancies, or are the successful candidates supposed to represent the different sections of the electoral body? The first case is that of the selection by a board of governors of officers to fill various offices. No question of representation is involved, but simply the selection of those persons most fit, in the opinion of the whole electoral body, to fill the different offices. The second case is that of the selection of representatives by a large electoral body. In the first case the whole electoral body has to decide for itself once for all, and the majority must rule. In the second case the electoral body has to select representatives, who are to decide and act for it in a variety of matters; and in order that the decision may be as far as possible in accordance with the views of the electoral body, it is necessary that all the different sections thereof should, as far as possible, be represented.

In the first case there is only one method of arriving at the correct result, and the method is to fill each vacancy separately. Thus one person must be elected by the method described above; then by means of the same set of voting papers we must proceed to a second election for the next vacancy, and so on till all the vacancies are filled. After each vacancy is filled we must of course suppose the name of the successful candidate erased from all the voting papers.

The second case—that of the selection of representatives—has been considered by Hare, Andræ, and other writers. It is not proposed here to discuss this question beyond pointing out that it follows from the principles which have been established in this paper that the process of "elimination" which has been adopted by all the exponents of Hare's system is not satisfactory.

Art. XX.—*The Oceanic Languages Shemitic: a Discovery.*

By Rev. D. Macdonald.

[Read 16th November, 1882.]

(A list of abbreviations will be found at the end.)

Under the name Oceanic I do not include the Australian languages, for though there are undoubtedly Oceanic words in the Australian vocabularies, the grammar seems essentially different. Cardwell, in his *Dravidian Grammar* ("Introduction," p. 53) says:—The grammatical structure of the Australian dialects exhibits general agreement with the languages of the Scythian group. In the use of post-positions instead of prepositions; in the use of two forms of the first person plural, one inclusive of the party addressed, the other exclusive; in the formation of inceptive, causative, and reflective verbs, by the addition of certain syllables to the root; and generally in the agglutinative structure of words, and in the position of words in a sentence, the dialects of Australia resemble the Dravidian, as also the Turkish, the Mongolian, and other Scythian languages, and in the same particulars, with one or two exceptions, they differ essentially from the dialects which are called Polynesian." "The Malagasi," says Latham, "is essentially a Malay language. . . . Of African elements in the Malagasi none have been pointed out, . . . which, as a phenomenon in the distribution and dispersion of languages, is the most remarkable on all the earth's surface" (Latham, *Comp. Phil.*, p. 294). Oceanic stands out quite distinct from the languages of America. This was known as early as the time of Captain Cook's discoveries. According to Crawford (*Dissertation*, p. 285), in 1000 words of Javanese there are 110 of Sanscrit, but 50 in the same number of Malay, and none in Polynesia; yet this Sanscrit was in Javanese and Malay probably before the Christian era, and introduced with Hinduism. Mohammedanism has been introduced along with modern Arabic, of which there are 52 words in 1000 of Malay, and none in Polynesia. The same great authority on this subject (*Dissertation*, p. 287), speaking of the languages of South-eastern Asia generally, the continental languages nearest geographically to Malaysia, says:—"The languages of these countries are generally monosyllabic and the Malayan polysyllabic. They refuse to amalgamate or intermix, of which we have some striking proofs. The Chinese have been settled in great numbers throughout the Archipelago for many centuries, and intermarried with the native inhabitants, yet there are certainly not a dozen words of any Chinese language in Malay, Javanese, or any other native tongue of the Archipelago."

The Oceanic is described by Professor Whitney (*Life and Growth of Languages*, ch. xii., International Scientific Series), following Muller, as "a vast and perfectly well-developed family, the Malay-Polynesian," comprising the Malagasy, Malayan, Polynesian, and Melanesian, better called the Papuan. By Latham (*Comp. Phil.*, ch. 54) the Oceanic is divided into two great branches, the one of which may be called the Malay, if we include under that name, for convenience' sake, the Malagasy, Micronesian, and Polynesian proper; the other is the Papuan, which prevails in New Guinea, the New Hebrides, and intervening islands. The Oceanic languages are more widely diffused than any other. Between Madagascar and Easter Island there are two hundred degrees of longitude. The family thus widely diffused over two oceans, and having no apparent connection* with those of the adjacent mainlands of Africa, Asia, and America, some have suggested, by way of accounting for its existence, that the isles in which it is spoken may be the hill-tops of an ancient submerged continent; others that this so-called family is not really a family, but a multitude of heterogeneous indigenous languages, with a number of common Malay words added to them by Malayan immigrants. The former of these suggestions never attracted much attention, and the latter, though elaborately asserted by Crawford in his dissertation prefixed to his Malay dictionary, has always had the great majority of scholars against it, and may be

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* From what central point (says Whitney the migrations of the tribes and their dialects took place it is not possible to tell. The family is strictly an insular one.—*Life and Growth of Language*, p. 242. London, 1880, International Scientific Series.

regarded as a mere crotchet. The affinity of the Malagasy to the Malay was known two centuries ago; that, also, of the Polynesian to the Malay has been known since the time of Captain Cook's discoveries. The common theory first stated by Forster in 1778, to the effect that "all these languages were derived from one very ancient tongue now lost," has been effectively supported by Marsden, who calls (*vide* his *Malay Grammar*, "Introduction," p. xviii.) the original language the Polynesian, and maintains that one of its dialects stands in the same relation to the Malay as the Saxon to the English.

The relation, then, between the Shemitic and Oceanic is, generally speaking, that of an ancient to a modern language, as Latin to French, Saxon to English. This implies that we shall find the Oceanic, as compared with the Shemitic, characterised by phonetic and grammatical decay, the abbreviation and corruption of words by a principle of voice economy, and the substitution of separate auxiliary words or particles for the inseparable forms of declension and conjugation; and that allowance must be made for the existence of ancient vulgar dialects, in addition to the literary, just as is done in tracing the Romance to the Latin. In the Shemitic we find that this process of decay had been operating; in the Oceanic we find it carried further, but on the same lines. Gesenius *(Heb. Gr.*, "Introd.," sec. 16), glancing over the Shemitic field, says:—"The Aramæan dialects exhibit the earliest and greatest decay, and next to them the Hebrew-Canaanitish. The Arabic was the longest to maintain the natural fulness of its forms, being preserved undisturbed among the secluded tribes of the desert until the Mohammedan revolution, when it suffered considerable decay. It was not till so late a period as this that the Arabic reached nearly the same point at which we find the Hebrew, even as early as the times of the Old Testament." "This," he adds, "accounts for the facts (erroneously considered so very surprising) that the ancient Hebrew in its grammatical structure agrees more with the modern than with the ancient Arabic." It is the Aramæan, with its "simplicity, occasioned, in fact, by derangement of structure and curtailing of forms," that the Oceanic most resembles.

According to Latham *(Comp. Phil.*, ch. 66) the Shemitic languages are essentially dialects of a single language from which is to be inferred either the comparatively recent diffusion of the Shemitic forms of speech, which he thinks the more likely, or a great indisposition to change. Latham *(Ib.*, ch. 54), encountering a similar phenomenon in Polynesia, interprets it in the same way, saying of the Polynesian dialects that "they have spread both recently and rapidly;" the sole foundation for his theory being the uniformity of these island dialects, and the consequent difficulty of conceiving of them as existing separately for ages, and still preserving that uniformity. Of the fact no one doubts; but Latham is, perhaps, almost alone in his inference from it. "The unity of the Polynesian dialects," says Alexander ("Introduction" to *Hawaiian Dictionary), "* is still an astonishing fact. Tribes like the Hawaiians and New Zealanders, separated from each other by one-fourth of the circumference of the globe in space, and thousands of years of time, speak dialects of one language, and have the same customs and mythology. The laws of euphony in the several dialects which regulate the changes of consonants are so fixed and uniform that, a New Zealand or Samoan word being given, we can generally tell with certainty what its form will be in each of the other dialects." "It was the belief of Wm. Humboldt," he adds, "that the Polynesians exhibit the original state of civilisation of the Malay race, when they first settled in the Indian Archipelago, and before they had been changed by foreign influence." The one fact which is truly wonderful and unparalleled is the substantial sameness of the language whose varieties are spoken in the numberless isles of Oceania. As this cannot by any possibility be accounted for by recent diffusion, the only other alternative is that of a peculiar inherent permanency or indisposition to change. This peculiarity, which is also Shemitic, is as such thus referred to by Whitney (ch. xii.):—"The scale of dialectic differences is much less in Semitic than in Indo-European; all the great branches, even, are, as it were, the closely related members of a single branch. This is not necessarily because their separation has been more recent than that of the branches of our family; for Semitic speech has shown itself much more rigid and changeless than Indo-European, or, it is believed, than any other variety of human speech."

In comparing Oceanic and Shemitic it may be necessary to say a few words at the outset as to phonesis.

Speaking of the Malay, Crawford points out that "there are a good many monosyllabic words; . . . the great majority of radical words are bisyllables." This is true of Oceanic universally, whose radical words, as Whitney says, "are prevailingly dissyllabic;" and it is true, also, in like manner of Shemitic.

As was to be expected, there is no Oceanic language that has retained all the Shemitic consonants; the Malagasy has perhaps retained more than any other. There is much less difference between the Malagasy and Hebrew or Arabic than there is between the Polynesian and Malay or Malagasy. For, as Crawford remarks, "the dialect of the Sandwich Islands wants no fewer than thirteen, that of the Marquesas twelve, and that of New Zealand eleven consonants of the Malayan system." As used here, the vowels have the continental sound; and it has to be borne in mind that the short sounds of i and e are almost identical, and somewhat like that of short u or y. As in Shemitic so in Oceanic, vowel sounds are peculiarly interchangeable. In what follows the consonants have the English powers. The Shemitic words are transliterated as nearly as possible, according to the system of Gesenius, set forth in the comparative table of alphabets prefixed both to his grammar and dictionary. Cheth is hh or ch; in Efatese, as there is no h or ch, cheth is either k or quiescent. Efatese has but the one sibilant, s, that can represent the Shemitic z, sh, and s. Tzade or tz can only be t or s as pronounced by an Efatese native; koph (q), k, and g can only be k; and d, t, and th can only be t. In Efatese k and ng are very frequently interchanged, and in the vast majority of instances ng is merely dialectic for k; p (or b) and v (or f) are frequently interchanged for the sake of euphony. What may be called double euphonic consonants are somewhat common in Oceanic, as mb or mp for b or p, and tr or nr for r. In Oceanic the vowel at the end of a word is often euphonic. The same rules for the commutation and omission of letters apply as well to the Oceanic as to the Shemitic. As in Assyrian (Sayce and Norris) so in Oceanic, ayin is a vowel or quiescent, and is here denoted by a comma, thus (,). In what follows when the third person singular preterite of a Shemitic verb is given with certain of its letters italicised the letters not italicised are the radicals of the "stem-word."

Dr. Thomas Young "has calculated by the theory of probabilities that if three words were identical in two languages, the odds would be more than 10 to 1 that in both cases they must have been derived from a common parent tongue; that for 6 words the chances would be 1700 to 1; and for 8 words in common, 100,000 to 1; so that in the two latter cases the evidence would be little short of certainty that the languages in question, and consequently the natives who speak them, had a common origin. But according to the more learned modern ethnographers, the affinity of languages is not so much to be sought in the coincidence of words as in the grammatical structure." So says Mrs. Somerville. "The philologue," says Latham (ch. 1.), "who looks upon languages from the historical point of view has, in most cases, to infer the relationship from the likeness. . . . For historical purposes, the important parts of a language are the details—the details in the way of its words, glosses, roots, and vocables; its nouns and verbs; its adverbs and pronouns. Where these are common to two languages the chances are that the actual relationship is in proportion to the extent of the community."

The parts of Oceanic words italicised are non-radical, and explained in the part treating of grammar.

VOCABULARY.

(Any word without the name of the language to which it belongs prefixed is Efatese.)

1. Father; ava, ap. My., pa; Ch., aba.
2. Strong; bur; Heb., abir.
3. To walk in a rolling manner, or backwards and forwards, banga; Syr., abak.
4. Wing, avar; Heb., abar, a wing feather.
5. A reward; keroa; Syr., agroa, *cf.* Heb., agorah, a silver coin.
6. To gather together; kur, ngur; Heb., gur.
7. To gather together; kuruk; Ch., gareg.
8. To take in, draw in (i.e., lay up, to put in store for oneself); kar, ngaru, ngarukaru, *ta*garu; Heb., gar'a.
9. Heb., gar'a, also means to diminish; Ef., kir, small. My., korang; Java, kirang; *ma*kur, thin, lean; My., kuru. My., karu*t*, kari*k*, kukur, &c., are all belonging to the same root.
10. The radical meaning of Heb. gar'a and cognates, as garr, is to scrape, scratch; Ef. ngura, v. and s., and My. garu, v. and s. Ef., kar, ngarakar.

11. An article. Ef., e or a; Heb., he, ha; Phen.,* a.

12. To put together in a bundle, tar; Heb., tzarr.

13. A shadow; ate; Po., ata; Heb., ad, exhalation, vapour. From the same root (Heb., aid; Arb., ada, to bend, be strong, heavy, &c.), we have—Ef., ate, a spirit, the soul; My., ati, heart, mind; Po., aitu, a ghost, and atua, a god; also, Ef., Po., My., and Mg., ate, ati, the liver.

14. Male; anoi; Tah., oni; My., inu; Heb., on (aon), virile and genital power.

15. To spin or weave, sel, (Fiji., sulu, cloth); Heb., azal. Like the Heb. and Ch., this Ef. word sel or sal also means to go, depart, and sela is a way or road; *mi*sal is separate (departed), cf., Arb., cognate, 'azal.

16. To creep, slip; sol, sosol; Sam., solo (transitive, sol*i*; Sam., solo*i*, to wipe); Heb., zahhal. Like the Arb. and Arm., which, however, substitute d for z, the Sam. sola, solo, means also to run, run away.

17. To bind around; ser; Heb., azar; Arb., zarra. Ef., *ma*seri, woman's waist dress. My., saru*ng*, the cloth wrapped or girded round the loins of men and women.

18. A kinsman, ak, ek; Heb., ach.

19. To howl, cry out; au (aw'); Arb., 'awi.

20. Narrow; wos; Heb., autz (wutz).

21. A mark; wot; Heb., aoth (woth).

22. A pot; Fiji., yawe. Heb., ahh, a pot or furnace. Ef., ua (uwa), the native oven.

23. To take; us, wis, was; Heb., ahhaz.

24. Tail; nger; My., ekor; Heb., achor, hinder part, rear end.

25. Not; e; (Heb., ai, i); Api., i, like Eth. i, prefixed to verbs.

26. Empty, vain; lala; Heb., elil.

27. Sam., ngali, to gnaw; (Heb., akal, to eat, bite); Ef., ngol, lips.

28. To say, li; (le or lo, voice, speech); Arb., alla, to cry out; Amh., ala, to say, speak.

29. Hand, arm, *l*ima; Po., id; Api., ma; Heb., amah, the forearm.

30. To languish, hang down the head (be ashamed, weak); mal; My., malu; Heb., am*a*l.

31. To be strong; met, mat*ua*; Fiji and Po., mat*ua*; Heb., ametz.

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* Phenician.

32. Sav.—Heb., as*a*f; cognates, suf, s*a*f*a*h, y*a*s*a*f; meanings common to Ef. and Heb., to scrape, scrape off, together, surpass (be great), collect, take, take off, away. Causative, cause to go away; passive (modern), *mi*sav, taken away, separated; and (ancient) siv; cf. Heb., ps. part., asuf, to be gathered together, to vanish, perish.

33. To bind to anything; sera; Heb., as*a*r.

34. Weak; pwel (pel), wel; Heb., af*i*l, ap*i*l.

35. End; abis; My., abis; Heb., apes.

36. To surpass; bong, pong; Arb., paq; hence,

37. Extremity; pango, pang (much used in names of places throughout Oceania); Arb., pauqon or pauq.

38. To go round; ova or epa; Heb., aff or app.

39. To weave, intertwine; rav; Heb., ar*a*v.

40. To go; arowo, aroo, *p*orou; My., *p*erga; Heb., ar*a*ch or ar*a*hh.

41. A time; rak, rang; Arb., ar*a*ch, to appoint a time.

42. To delay; *f*irak; Arb., Heb., ar*a*ch.

43. A foundation; isi (issi); Ch., Arb., ash (osh, ush).

44. To come (dialect); da (nda); My., data*ng*; Heb., ath*a*h.

45. Food, a present; vang; Erom., vang; An., hang; Mg., faha*na*. In Bible, only in Ez. and Dan., bag or vag.

46. To cut; bit; (knife, bīt); Heb., badd or padd.

47. Quickly, swiftly, tremblingly; bile, bele; Heb., b*a*hel; Ch., beh*a*l, hence,

48. Bile, file; to flash, lighten, and s., lightning; Po., id. Fiji., vula; My., bula*n*, moon.

49. To shut, cover; bon, won, fun, bun; Heb., b*a*h*a*n. The secondary meanings in Ef. are, to finish (from closing or sealing), to blot out, kill; and the word is widely used in Oceania. Ef., bunu; My., bunoh; Mg., vono; Ef., bunu*ta*; Java, bun*tu*; Sam., pupuni. Ef., fona; Mg., fono, cloth covering, or wrapper. Ef., fonu; Java, panu, a turtle (because covered). With auxiliary m.—Ef., *m*ono, *m*unu; Mg., *m*amono (for mafono); this change on prefixing auxiliary *m* to verbs beginning with a labial takes place invariably in Mg., and only occasionally in other Oceanic languages.

50. To come in, come upon, enter, to go; pa, va, pa*n*, va*n*; also bua, fua (hence *na* pua, a road, way); Heb., ba, (bua). Bua, to procure, bring; My., bawa; Heb., bua, ba. Pa to, or pa ta; My., pada; even, equal; Heb., ba'ad. Baki; My., bagi; to, unto; Heb., ba ki. Baka; My., bagai; Fiji, baka;

Maori, whaka—as, like, as if; Heb., ba k, ba ka. Ba, va, baka, vaka; (Fiji, vaka; Sam., faa), prefixed to verbs in Papuan and Polynesian languages forms a kind of causative; Heb., ba; Arb., ba; to be equal (My., baya), to make equal, to come to pass, cause to come to pass. The ka in baka means *as*; Heb., ka; hence vakamauri, to save, is literally not to cause to live, but to cause to be as alive. Modern causative ba*i*, to bring in, insert; ancient causative ova, or ava, to carry; Heb., Hiphil, hevia (avi), which means in Hebrew also, to put in; Ef., to entomb, bury. With m or um (49) we have umai (dialect), mai; to come; also used widely in Papuan and Polynesian as a particle to denote direction towards the speaker, and like the prep. from. Fa, be, pa be, (usually va*n mai*), to come; Heb., ba bo, or va bo, (Dan. xi. 10).

51. To tread with the feet, trample on; pas; Heb., bus (bas)

52. To snatch away; bass; Syr., baz, hence,

53. A prey; bes; Heb., baz or bizah.

54. To confide in; fafatu, (fatu); Heb., b*a*t*a*hh, prt., batuahh.

55. Principal or public house; fare; Tah., fare; Maori, ware; Fiji, bure; Heb., Ch., birah, palace. Eth., nabar, to dwell.

56. This, that; nin, nen; My., nun, nin, nen, inun; Syr., enun, enen.

57. To be not, empty, worn out, without anything; bol, buel, bal, wol; Api., buel; Heb., b*a*l*a*h.

58. A wave (swell); peau; Sam., id.; Ch., be'aa, to swell, boil up.

59. To burn up; *tu*bara; Heb., ba'ar: to kindle an oven, bouria, būria; Heb., prt., bo'erah, Hos., 7-4.

60. Stupid, brutish; bär; Heb., ba'ar.

61. Precipice; patir; Heb., batzir, inaccessible, high.

62. To strike; baka, boka, buka, puka; Heb., p*a*g'*a*.

63. To inquire into, examine; bous; Ch., b*i*hh*a*sh.

64. Bora, wora, bara; to beget; Heb., b*a*ra; hence,

65. Offspring; wor; Heb., bar, and

66. Fat; barua; Heb., baria.

67. To make a humming sound; buruma; Arb., b*a*r*a*m.

68. To raise up, *ra*kai; *ta*kai; Heb., gaah. In Ef. and Heb. it also means to adorn.

69. To be polluted, defiled; ngolo*pa*; Heb., g*a*al.

70. To thunder; kat, ngat; Eth., redupl, gidgad.
71. To cut; kut, ngut; Heb., gadd.
72. To cut, break; koto, ngoto; Heb., gad’a.
73. To pluck off, break off; kotev; Heb., q*a*t*a*v.
74. To cleave, cut; kob, ngob; Heb., gub.
75. A dog; kuria; Syr., guroa.
76. To shear, cut off; kosi; Syr., g*a*zi.
77. To shave, shear; kosum; Heb., kasam.
78. A slender stem; kusou; Syr., guz’o.
79. To hide; kor, ngor; Heb., gahhar.
80. To bind; kat, ngat; Arb., qad.
81. A wave; ngalu; Sam., id. Syr. galo.
82. Husk, peel; ngalu; Syr., gelo.
83. To bind together, tie; kela; Arb., ’*a*q*a*l.
84. To be bent, twisted; *ma*ngal, *ta*kel, *ta*kelkel, *ta*ngelengele; Heb., ’*a*q*a*l.
85. To absorb; kumi, ngumi; Heb., g*a*ma.
86. A wing; Santo, kave, kav; Ch., gaf.
87. To call, cry out; kua, ngua; Syr., g’oa, q’oa.
88. To feel, explore; kis, ngis; Syr., gas.
89. This; te, to, tu; Ch., do, dā.
90. To fear; *mi*taku; My., taku*t*; Heb., dag.
91. To cover; tak; Heb., d*a*g*a*h.
92. Breast; My., dada; Heb., dad.
93. To pound, beat; tuk; Heb,, duk.
94. To roll, round, &c.; tal; Heb., tzall; Arb., dd*a*ll’*a*.
95. To incline to one side; tale; Heb., tz*a*l’*a*; Arb., dd*a*l’*a*; hence,
96. A side; tale; Heb., tzel’a.
97. Fatigued,wearied; *ta*ngiengi,(angi); Heb.,y*a*gi’*a*,yagi’a.
98. A heap of stones; *ta*ngur; Ch., ygar.
99. To delay; *t*aleale, (āle); Sam., *t*ali, wait for; Heb. y*a*hh*a*l.
100. To push; tō; Heb., d*a*hh*a*h.
101. To thrust, push; tōv; Heb., d*a*hh*a*f.
102. To thrust, push; tak; Heb., d*a*hh*a*q.
103. To thrust out, expel, drive away; tīa; Heb., hidīahh, Hiph. of n*a*d*a*hh.
104. To be many; et (dialect); Arb., adi.
105. Lord; tui, ti; Po., id; My., tua*n*; Arb., dzu, or thu, thí.
106. That, so that, because, he who, that which; t, te; Ch., d, dī, de.

107. This; tik, tuk; Ch., dek.

108. To disturb water; tuletul, (tule); Heb., d*a*l*a*hh.

109. This; tun; Ch., den.

110. To thrust, push, strike; tiba, tuba, tapa; Heb., d*a*p*a*h, tapp; Arb., dabba.

111. To knock; tavangk; Heb., d*a*f*a*q.

112. To sing, cry (as a child), speak, &c.; kei, ngei; Heb., h*aga*h. Kī, to squeak; Heb., Hiphil; Sam., ’i’i (kiki). An., eka; Fiji, kaya, to speak.

113. To break, utter sound; at; Heb., h*a*dd; Arb., h*a*dd*a*.

114. To beat with a club; watu, atu; Heb., y*a*t*a*hh; Arb., w*a*t*a*hh.

115. This, he, she, it; wa (ua), ia (ia); Heb., hua, hia.

116. To be; pi, bi, vi, ba, pa, bu, vu, bo, pu; future, fo, wo, o. Heb., h*a*v*a*h. Ch., h*a*v*a*h, h*a*v*aa*.

117. To go away; Sam., alu; Arb., halla: hence, a road, Ef., lel; Po., ala; Mg., lala.

118. To walk, go; Santo, Fiji, lako; My., laku; Heb., h*a*l*a*k, y*a*l*a*k: to pour out; lingi; Heb., Hiphil, id.

119. To be brilliant, glorious; *m*iel; Heb., h*a*ll; Arb., halla: hence, elo, or al, the sun; Abyssinian, aloh; ali, day; li*n*, light; aliati, (for aliali), day; to dawn.

120. Multitude, riches; mān; Heb., hamōn.

121. They; mai, máne; Ch., himō, himōn.

122. To wander in perplexity; bingo; Heb., buk.

123. Crooked, twisted; pangpang*oa*; Heb., hapakpak.

124. A star; *ma*sei, *ma*sai, (*what* shines); Arb., z*a*ha, or z*a*y*a*i, to shine.

125. To be filthy, loathsome; samasama*na* (sam); Heb., z*a*h*a*m.

126. To flow out, go out; tav; Heb., davv; Syr., duv; Sam., tafe, flow; tafe, a flood, Ef., id.

127. To deceive, lie; sur; Arb., zar; zur, a lie.

128. Milk, breast; sus; Mg., My., Sam., id.; Heb., ziz, zuz.

129. To draw out; tila; Heb., d*a*l*a*h; Syr., dela.

130. To scatter; siri; Heb., z*a*r*a*h.

131. Bosom, inside; kob, kupu; Heb., chob; Ch., chuba.

132. Fire; kap; cf. Syr., ch*a*b, to burn; My., afi; Arb. wafi, to cook.

133. To tie; ut; Heb., hhud; Arb., hhad.

134. To returu; liliu, (liu, lyu); Arb., ala.

135. To dance; wul; Heb., hhul.

136. House; *s*uma, um; My., *r*umah; Java, umah; An., *ne*om; Heb., hhomah, wall of a town or house.

137. To be; ka; Heb., chayah, to live; hence,

138. Ika, a fish; Po., id.; Heb., chayah, (water) animal.

139. War; *fa*kal; My., kalahi; Heb., chayil.

140. To do with ardour, be earnest; kara; Heb., ch*a*r*a*h.

141. To scrape, scratch; karas; Arb., ch*a*r*a*s.

142. To be dried; kara; Arb., charra.

143. To be bright, clean; tär; Heb., t*a*h*e*r.

144. To twist; taui, tawi; Arb., t*a*wi.

145. To be long; tali; Arb., tal*a*: hence, tali, a rope; Po., My., id.

146. Clay, earth; tano, tan; Po., My., Mg., id.; Ch., tin.; Syr., tino.

147. To cover, or soil with clay or earth; tan, tun; Arb., tan.

148. An egg; tole; Arb., tala, a young animal of any sort. My., tulo*r*; Mg., *a*tody; egg.

149. To be heavy, laden; *mi*ten; Syr., t'en.

150. To cast down; toro; Heb., tarahh, be cast down, wearied; Ch., terahh: hence, to sleep, *ma*turu; My., tidor; Mg., *ma*tory.

151. To pour over (smear); bulu; Arb., b*a*ll*a*; Heb., b*a*ll.

152. A cutting instrument; karab; Heb., chereb.

153. To know; atai, tai; My., tau; Heb., yad'a; Ch., yd'a.

154. To tread; us; Arb., wahass; Heb., yahatz.

155. A day; ma, (mei, me); Ch., emphatic, yomā.

156. A shoot; niko, or iniko; Heb., ynikah.

157. Beautiful, good; pia, wia, wi; Heb., yapeh. My., ba*ik*; Arb., baha, to be beautiful.

158. To go out, forth; sei; Eth., wasza.

159. To go out, forth, cause to go out, forth; tou; Heb., yatza; Hiph., hotzia or hotziya; hence,

160. Gate, fountain, origin; mita; Heb., motza; which also in Ef. means, (after the analogy of Heb., 'yn), the eye; Po., My., mata; Mg., maso; hence, also,

161. Excrement; tai; Sam., tae; My., tai; Heb., tzah tzeah, and,

162. To be filthy; *m*ota; Sam., oteota; Syr., Heb., tzoah. Cf. Syr., tzaa, to stain; tzoa, filthy; hence, also,

163. To spring forth, up; as in Heb.; then, to become, exist, continue; Ef., tou, or tau; Fiji, Sam., id.; (cf. My., jadi. Java, dadi. Ef., tou and tu, offspring, like Heb. tzeetzayim; hence, also,

164. A year, season, (harvest); tou; My., tau*n*; Mg., tao*na*. A year in pigeon English is "one yam."

165. Established, firm; supe, sup; Ch., yatzib.

166. To dwell near, sit, be on; tab, tav; Heb., y*a*sh*a*b; Arm., ythib; Arb., w*a*th*a*b.

167. Like, so, as, as if; ke, ki, ka; Heb., ke, ka; My., ka.

168. Weak, faint-hearted, &c.; ki*n*, ka*n*; Heb., kah, and cognates.

169. So, thus, here, this; ku, kua, ko, ka; Heb., koh; Ch., kah; My., iki, iku.

170. A vessel, basket; kat, kot; My., water vessel, kandi (n euphonic); Heb., kad.

171. A pot; Fiji, kuro; Heb., kir.

172. To catch, seize, fall upon; karak; Heb., ch*a*r*a*k. (only in Prov. xii. 27).

173. A joining, the elbow; wusik; Heb., hhashuq; My., siku: Heb., hh*a*sh*a*q or hh*a*z*a*k; Hiphil, hehziq, to join to, adhere, take hold of, seize; Ef., siku.

174. To pierce, dig, cut round; kor; My., kore*k*. Heb., kur; My., kari*s*, kri*s*, a dagger.

175. To pant; ngaingai, (ngai); Syr., kahh; Arb., kahh, to overcome in battle; Heb., koahh; My., gagah, strength, might, valour; Fiji, ngu.

176. That, in order that; ki, ka, nga; Heb., ki; Arb., ka.

177. Clothing; kul; Heb., keli; My., kuli*t*, skin.

178. A vessel; My., kulah; Heb., keli.

179. To be covered, hid; kus; Heb., k*a*s*a*h, ps.

180. To bow down; kav; Heb., kaff.

181. To stoop; tak; My., *tu*nduk. Syr., v. Jno. xx. 5—11. (Adiq, to stoop, Aphel of daq, to look, look round, &c.)

182. A deep cavity; luk, lok; Heb., log.

183. To stick, adhere; liko; My., laka*t*; Arb., lahhiqa.

184. To be exhausted, languid, fade; li; My., layu; Heb., lah, l*a*ah.

185. A knife, (sword); lova; Heb., lahavh.

186. To be mad; elielia; Fiji., lialia; Heb., lahah.

187. To burn, flame; livaliva; Fiji., livaliva, lightning; Arb., l*a*hh*i*vh*a*; Samaritan, lavhlavh, to shine.

188. To shine, be bright; langa; Arb., lacha.

189. To be strong, firm; let; Arb., lath*a*.

190. A fissure or chasm; las; Arb., las'.

191. To bite; leti, lati; Arb., lat'a.

192. To be mild, gentle; *ma*ilum; Mg., *ma*lemy; My., lumah; Arb., hhaluma.

193. To cut off skin or bark; mulu; Heb., mul; also the word is used both in Ef. and Heb. in the sense of, to circumcise. Circumcision prevails among a part of the Efatese, very extensively in the New Hebrides, and in other parts of Oceania.

194. Defilement; mym, (mim); Heb., mum.

195. The Heb. word for eye, 'yn (160), literally means fountain; from 'in, to flow out. This word or root is found in Mg. as ony, river, and in Ambrym as un, in un miten, flowing of the eye, tears.

196. To die; mat, mate; My., Sam., id.; Mg., maty; Heb., muth, math.

197. To separate; mas; Arb., maza.

198. To strike upon, extend to; mau, (mawa); Heb., mahhah.

199. To chew; ma; Sam., mama; My., mamah; Syr., mahha, to bite.

200. To rub; mā; Heb., mahhah.

201. A hollow; mele, (const.); Heb., mĕhillah.

202. Who? Ero., me? Heb., mi?; (pl.) Ero., me ume? Heb., mi wami?; Who? (sing.). My., mana? Syr., man?

203. Feeble, soft; malua; Sam., malu, (Ef., malilua. Sam., malulu); Arb., malīhh.

204. To flee, (slip, glide away); mila; Heb., malahh.

205. To cut off, clear; mal; Heb., mall: hence the Po. malae or marae, (familiar to the readers of Cook, &c.), the open (clear) public place of the village; in Ef. mala or malla (or malel).

206. A beam; nerou; Syr., niroa.

207. Short; mwit; Heb., ma'at, to be diminished.

208. A covering; mwit; Heb., ma'ateh.

209. Treachery, perfidy; mal; Heb., ma'al.

210. Above (Ef. dialect); mahil; Heb., ma'al: (ayin here represented by h).

211. To be angry; maieto; Arb., ma'idda.

212. A hollow, cave; mōru; Heb., me'arah; (Ef. const., merite); Heb., me'arath: Ef. pl., moruta (name of a valley full of caves); Heb., me'aroth.

213. To come; masa; Eth., maza.

214. A gathering together, company; mikau (mikawa); Heb., miqeweh.

215. Man, lord; mera, mare; Ch., mare. In Mar-Saba, maranatha, &c.

216. To stroke with the hand, anoint; masa, masamaso; Heb., mashahh.

217. A portion; maso; Heb., mashhhah.

218. To show, declare, tell; tili, tule; Sam., tala; Arb., dalla.

219. To speak, say; nova, nowa, noa; Heb., navha, naba.

220. To speak, say; Ero., nam; Heb., nam.

221. To contend; Fiji, leti; Heb., l*a*dd.

222. Water; wai; Po., vai; Heb., naba' or bu'a, to well up, gush forth, (mabu'a, a fountain); Abyss., waha, water.

223. To rain; bowa, wa, bwa; Heb., naba', or bu'a, Hīph., to gush forth.

224. Rain, shower; us; My., uja*n*; Sam., ua; Arb., wadz'a, to flow, to run.

225. A wave; wa, (*v.* 222). This Shemitic root, or group of cognate words, as Heb. nub, napag, means also to swell up, to sprout, to produce (fruit); hence the word wa in Ef. is used to denote not only a wave, water, and to rain, but also

226. Fruit, and to fruit; Sam., fua; My., buwah; Mg., voa; of which last the verb is mamoa (49).

227. Hence, young shoots, offspring; pia; My., pia*t*; Sam., fua; and

228. Young; fau, or fou; Sam., fou; Fiji, vou; Mg., vaovao; and

229. To begin, be first; be, ve; Sam., fua; Fiji, vu; An., hu; My., püu*n*, beginning, source, foundation; Ef., bua, ancestor, progenitor; hence also,

230. Blossom, flower, bu*ma*; Mg., vo*ny*; Sam., fu*nga*; My., bu*nga*.

231. To rest, dwell; *ma*nak; Arb., nach.

232. Progeny, offspring; nan; Heb., nin.

233. To move to and fro; nua; Heb., nua'.

234. To sprinkle, scatter, shake forth; nopa; Heb., nup, Hiph., henif; hence Ef., nīvi, to shake (a fan), to fan, a fan.

235. To drop; tev, tetev; Heb., nataf.

236. Before, face, front; nako; Heb., nokahh.

237. To fall; bul; Heb., n*a*p*a*l.

238. To take up, carry, to suffer, to bear any one's sin; su; Heb., n*a*sa: Arb., to grow; nashā; Ef., *pi*sou; hence,

239. Height (top), sū; Heb., si, sya; and

240. Vapours which ascend from the earth; nsou; Heb., nasya.

241. To saw; sar; Heb., n*a*s*a*r.

242. To bite; kat; Ch., nekath. (The Heb. is nashak.)

243. To kiss; sung; Heb., nashaq.

244. Hill; tav; Abyss., debba; Arb., natab, to be lofty.

245. To cut; niti; Heb., Piel, nitahh.

246. To lift up; sela; Heb., s*a*la.

247. To kiss; sum: My., chyum, to kiss, to scent, to smell; Arb., shamma, to smell.

248. To be hid; bwei; Arb.. 'abiya.

249. To do, make; bat, pat; My., buat; Aram., 'bad; hence

250. A slave; viti; My., beta; Heb., 'ebed.

251. That, to, in order that; An., par; Ero., wor; Heb., ăbur.

252. (Sandy) shore, ground, land (opp. to sea); uta; My., uta*n*, a forest, as in Orang-utan; Bisaya, uta*n*, a garden of pot-herbs; Arb., 'uta, soft, sandy ground, irrigated with water and planted with trees.

253. To dwell, to be; ana; My., id.; Heb.,'un; Arb., ana.

254. To arise (as the wind); *ma*uri; Heb., 'ur.

255. To live; *ma*uri; My., idu*p;* Java, uri*p;* Tanna, *mu*ri*f*; Po., ora; Heb., 'ur, to be awake, alert.

256. To cover; My., tutup (tup): Ef., tove; Po., tapa, clothing. Heb., 'atap, to cover, be clothed; Syr., 'tap or 'taf, to be clothed; Arb., 'itap, a cloak.

257. To run; ur; Heb., 'ir.

258. As, for, because, on account of; oli; My., ulih; Heb., 'al.

259. To aid; ouli; Heb., ya'al.

260. To go up, &c.; liu; Heb., 'alah; hence,

261. Up, heaven (sky); le*n* or le*ng*, lang; Po., lang; My., langi*t;* Mg., lani*tra ;* Santo, lon; Ch., 'elyon.

262. To be; im, um, ma, mi; Ero., um; My., ma; Tanna, Mg., id; Arb., '*amma*, to be in common.

263. To dwell, to be; ne, no; Heb., nah, n*a*w*a*h.

264. To work, wiswis (wis); Mg., asa; Heb., 'asah.

265. To roll, twist; bulo, *m*ul (49); Po., *m*ilo; Mg., voly, *ma*moly; My., bali*t*, &c., &c.; v. Ges., Heb. Dict., pol.

266. To exhale odour; boa, *na*boa; Arb., pahh*a*.

267. To search out, elect; pili, *m*ili; My., pilih, *m*ilih (49); Syr., pela.

268. To ascend; sak; Arm, nesaq.

269. To roll, revolve; polos; Heb., p*a*l*a*sh.
270. Food; vinanga; Heb., Ezek, pannag, a cake.
271. To break; bor, por; Heb., p*a*rr.
272. Space between, middle; but, put; Heb., poth.
273. To part in pieces, divide; pot; Heb., p*a*thth.
274. To open; puka; My., buka; Heb., p*a*q*a*hh.
275. A flat dish; seloa; Heb., tzelahhah.
276. To cry out with a loud and clear voice; tare; Eth. t*a*ra.
277. To meet; ngara, kor; Heb., q*a*r*a*h.
278. Hard, strong; kasu*a*; My., kwasa; Heb., q*a*sh*a*h.
279. To make a noise; ra; Heb., ra'a'.
280. To love, pity; rum; Heb., r*a*hh*a*m.
281. To look at; sikō; Ch., sĭkā.
282. To rejoice; samasama (sama); Heb., samahh.
283. To sweep, rush, stand on end (hair); sara, sera; Heb., sa'ar.
284. To draw water; saov; Heb., sh*a*avh.
285. To make a noise; so; Heb., sh*a*ah.
286. To look at; sao; Heb., sh*a*ah.
287. To be evil, bad; sa; My., jaha*t*; Arb., sa.
288. To sink down; suk; Heb., shuach.
289. A cloud; sok; Heb., shahhaq.
290. To praise; surosuro (suro); Heb., shur.
291. To deceive; seli; Heb., sh*a*l*a*h.
292. To delineate, mark out; *mi*tir; Heb., t*a*ar.
293. To mark, cut; ta; Heb., taah.
294. To find; *ma*soko; Ch., shekahh.
295. Spittle; top; Ch., tup, to spit out.
296. To be, to dwell; to; Arb., tawa.
297. To remain; tok; Syr., tuk.
298. To be broken; *mi*tela; Arm., talahh.
299. To desire; *ma*sik; Heb., shuq.
300. To cry out; tangi; Sam., id.; My., tang*is*; Heb., tza'aq.
301. A place, ki. Assy., ki. (In Assy. Dict written ci.)
302. A land; mot; Oc. names of places—mota lapa, big land; pau motu, cloud of lands; Assy., matu; very frequently occurring in Assy., and, according to Sayce, of Accadian origin. (Sayce, Assy. Gr., Norris, Assy. Dict.)

It would be interesting, were this the place for it, to take the principal names of relationship, of members of the human body, of animals, and of the great objects of nature in all their variety as actually found in Oceania, and to show that they are Shemitic. One or two examples will indicate this: Bird—Cocos Island, ufa; Tagala, ibo*n;* Heb., ’of. Mg., vuro*na;* My., vurong; Heb., parahh, to fly. Ef., Api., Amb., Mallicollo, to; Heb., dah, to fly. Nest, *ne* kin; Mg., *a* kany; Heb., qen, qin.

Dog—Ef., kuri; Maori, kuri; Heb., Syr., gur, gura, a whelp, puppy.

Fish—Ef., Po., ika; My., ika*n;* Heb., chayah, an animal; My., ikan-ayar, water animal. Like Mg., haza-*ndrano;* Paama, New Hebrides, asa; Amharic, assa.

Water—Ef. (dialect), ra*n;* Mg., dra*no* or ra*no;* Arb., riy*on,* watering. Ef., ra*nu,* to pour fresh water over after a sea-bath; Fiji., dra*nu* id.; Fiji., dra*no,* a lake; Ef., ra, a lake or pool of fresh water. My., ayar; Java, er; Malo. (N.H.), reuh; Heb., r*a*w*a*h (to be full of), water. Ef., me (urine); Heb., Syr., me, id.; Ef., mua, to flow (the tide); Heb., mua, to flow.

Sea, salt—Ef., Sam., *t*asi; sea; Patos, asih; My., *t*asi*k*, literally the salt (water, *i.e.*); Mangarei, wae-tasik; Ende, ora-*m*asi*;* Java., ra*nu-m*asi*n;* Mg., ra*no-m*asi*na;* Asi, salt, very widely used, from Syr., ’az, to boil forth: Like My., gara*m;* Celebes and Tanna, gara, salt; Heb., gir, to boil up. And Mg., tsira; Matabello, sira, salt; Ef., sira (ferment); Heb., sir; to boil up. In Ef. salt is tas-men—*i.e.* the boiling up, foam, or ferment of the sea, men; Arb., yamon; Amboyna, met, mit; Syr., mata or ymata. Tagala, daga*t;* Ero., tok; sea; Heb., daki, "crashing, dashing (of waves)." Ef., lou or lau; My., lau*t;* Bouru, ola*t;* Api, ela; Arb., ’alla, to strike with repeated blows, &c. Celebes, lauduk, is a combination of these last two words.

Land; fanua, vanua, benua, so widely used in Oceanica for for district, country, is literally a house or building (a dwelling-place); Heb., b*a*n*a*h, to build. In Santo it still has this meaning. Ef., ure, land; Ch., ara’, (Heb., eretz).

Rain, Mg., ora*na.* Celebes, ura*n*, *n*aro; Abyss., heri, iro; Heb., yoreh.

GRAMMAR.—It will now be well to go over the principal points of grammar, and

§1. Demonstrative pronouns meaning this (here), or that, or simply calling attention to, or pointing out, or emphasising a word, simple or compound, separate or attached to a word, prefixed or postfixed—

Ma; Assy, ma; The Heb. mah mostly interrogative; √m.

Wa, ua; Heb., hua, hu; √ a, u, (ĭ, y̆, ĕ).

In, ini, ne, na; Heb., hen, henah, an, in, √ n.

Se, si, sa; Heb., zeh, √ s.

Tu, ta, te, to; Ch., da, √ t.

Eri, ru, ra, ri; Ch., aru, √ r.

Lu, la, li; Ch., alu; Heb., al, aleh; Arb., al, √ l.

If the two latter, l and r, were originally one in Sh., as Gesenius thinks, so in Oc.

Ko, ka, ki, ku, ke; Heb., kah (from kahu), √ k.

Fa, ba, be, pa, pe, va; Heb., pa, pah, fa (from bahu), √ b.

Compounds of these are very common in Sh. and Oc., thus (v. voc. 56.)

Nin, nen; My., nun, nen, nin; Syr., enun, enen.

Susa; Assy., sasa, sasu.

Rik, erik; Syr., hereka; My., ma*rika*.

Nanga (naka); Ch., henak.

Tuk; Ch., dek.

Thus, in Ef. we have nis, wis, kis, sin, wai, wan, netu; nai, Syr., hnu (used for third personal pronoun, singular); and nara (third plural). So—Mg., izato, (Heb., zath), izao, izany, ity, iroa, iny, ireto, ireny, &c.; and used as third personal pronoun, singular, izy; plural, izareo. Sam., lenei, sinei, lea, lena, lela, sea, sisi, ia, na, nei, &c.; used as third personal pronoun, singular, ia; plural, ila-tou. My., ini, tu, itu, nun or nen; and used as third personal pronoun, singular, iya; plural, marika.

Remarks.—The pronoun used for the third singular contains as its principal part the one used in all the Sh. languages for the same purpose: thus, Assy., su—(*i.e.*, √ s., above, and hu or u) is in Mg. izy (the y representing this u, sounding like short i or ü). The Amharie further compounds this word by adding √ r, thus, arsu. Ef., nai is the same i or y with na prefixed, as in Syr., instead of sa, as in Assy. Sam., ia or o—*i.e.*, ko ia. My., iya.

The one used for the third plural is like the Heb. al, aleh., "plural according to use, and not according to grammatical inflexion." Ef., nara (n. r.). Mg., izareo (z. r.). Api., *n*ala. Paama., *ke*ila. Heb., aleh. In My., marika, we have the √ m that appears in the Arb. and Heb. pronouns plural. It only remains to add that the various pronouns used in the Sh. for the third plural are all, like the Oc. just explained, compounds of the above simple demonstratives. Thus, Heb., hem; Arb., hum; is hu and m. Ch., anun is an, hu or u, and n; so anin fem. is an, hi or i, and n; and from these Assy. sun, sin, differ only by prefixing √s instead of √n; and thus, it may be remarked, we solve the mystery of the Sh. inflexion of number, both in nouns and verbs, for the numeral particles, whether prefixed or postfixed to nouns and verbs, are simply these or other of the above demonstratives abridged or unabridged. After nouns we find hum or hem represented by ym or im, and anun, anin, by un, in: -oth. Heb. fem. pl. is √t instead of √n or √m. In the inflexion of the verb the final n demonstrative of un, is frequently dropped so as to leave simply u.

§2. In Oc., as in Sh., demonstratives, simple or compound, are used as indefinites, thus, Maori, mea; Heb., mah; Arb., ma, anything. Ef., matuna; Assy., matina; Ch., ma dun, anything whatever, &c., &c.

§3. In Oc., as in Sh., the article is a demonstrative put before the noun, as in Heb., or after it, as in Ch. In Ef., the New Hebrides generally, and Mg., the common article is in, an, ni, ny; to be compared with an, Heb. and Ch.; and Syr., hno, hono, in, *e.g.*, Acts viii. 35, hno ketobo, the Scripture. Thus the Latin ille has become an article in the Romance languages, and thus generally every Sh. simple demonstrative (in §1) may be found used as an article in Oc. Thus, *e.g.*, the word uma, house (Heb., hhomah) in Ef. is *s*uma; My., *r*umah; An., *ne*om: child, Heb., yanak (suckling, Ps. viii. 2), in My. is anak, and *k*anak, sometimes *z*anak, as it is commonly in Mg. Heb., h.; Phen., a.; in Ef. is a. Arb., al, in Sam., is the equally common article le. The My., like the Ch. and Syr., commonly uses the article postpositive.

§4. In Oc., as in Sh., the interrogative is a demonstrative used interrogatively (see for Heb., mi. Arm., man. Voc., 202).

§5. The reflexive or emphatic pronoun self in Ef. is tuma; Heb., 'atzem; and followed by the pronominal suffix as the same word in Heb., or the analogous words in the cognate languages—*e.g.*, raman in Assy. The Heb. verb 'atzam means to bind; Ef., tuma*n*, is a bundle.

§6. The personal pronouns in Sh. are distinguished as separate of full form, or attached of shortened form. These latter are used to denote the persons of the verb, accusative of the pronoun, and its genitive. They have no case inflexion; the full form, usually nominative, is sometimes accusative or genitive, and generally the same suffix is accusative or genitive, according as it is attached to a verb or a noun; and the shortened form is sometimes nominative, though usually accusative or genitive. Demonstratives are found attached to these pronouns, whether separate or suffix (nun epenthetic). Generally all these statements are equally applicable to Oc.

First Singular.

I, *k*inau—*i.e.*, inau, inu; Heb., anī.; Syr., ina u, (u, hu, dem.).

Verbal person, a; Heb., a.

Verbal suffix, nau, nu; Heb., nī.

Nominal suffix, k, ku. Cf., Assy., ku, v. p. (separate form, anaku; Heb., anoki; An., ainyak). My., aku, ku.; Mg., aho, ahy, ko; Sam., a'u—*i.e.*, aku. This My. ku is used as v. p., v. s., and n. s.

First Plural.

In Oc., as in Heb., there are two pronouns of the first person plural.

1. Ef., *ki*nam—*i.e.*, inam, inim, or inüm (commonly called the exclusive). Heb., anu, originally anum (Green's Hebrew *Grammar*); is, ina, I, and m, the indefinite plural demonstrative as used after Sh. pronouns and nouns.

V. p., au—*i.e*, a, the singular above, and u; Heb., u, plural. My. and Ef. (dialect), kami, kam, we—*i.e.*, ku (above), I, and m, plural; hence, Ef.,

N. and v. s., kam, ngam.

2. Ef., akit; My., kita; Ef., ningita—*i.e.*, nikit; Heb., anachnu; Arm., anachna. This pronoun is commonly called the inclusive (*i.e.*, it means I you they) and it is probable that this is what the Heb. anachnu originally meant, being composed of ana, I; ch, -ch-, you; and nu, they (anun). So Oc. akit, a, I; -k-, you; and ta (tu), they, as in Amharic, in which arsu is he, arsa*tu* they (*i.e.*, he, they).

Second Singular.

*N*ango, *a*ng (ng, *i.e.*, k). Arm., Heb., Arb., ka, thee, thou; v.p., ku, v. pl. (like Eng., you for thou): v.s., -ko, -k. Arm., Heb., Arb., -ka, -k: n.s., ma (mu); v. pl., like your for thy. My., angkau, ang, kau (*i.e.*, ka u). Api, tau, ta u; Heb., attah.

Second Plural.

Ef., kum. (kumu); Arb., v. and n. s., kum (ko, sing. and m, pl.): v. p., ku; k, sing., u, pl., as in Assy. and Heb.: n. and v. s., Ef., mu, kumu shortened; Arb., kum; Heb., kem. My., kamu, -mu, as in Ef.

Third Singular.

V. p., e. (i, y); Heb., i (y): v. s., -s.; Assy. -s; a, e, na, nia; Heb., ah, eh, nah; Ch., e: n. s., na (as in v. s.); Mg., ny., My., nya, (nun epenthetic).

Third Plural.

V. p., ëu; Heb. i——u (he they): v. and n. s., ra or ta, analagously formed to Heb. m, and already explained above:—ta same as Amharic - tu. It is the same *t* that is used in Sh. to form the plural of nouns.

For the separate pronouns sing. and plural of the third person (see above, §1). In Oc., as in Sh., the dual is a modification of the plural. It only remains to notice the personal pronouns with epenthetic demonstratives, of which nun epenthetic is one that may be regarded as typical. Gesenius says "this nun is of a demonstrative nature, and belongs to the appended accusat. of the personal pronoun, to which it seems to direct attention as the object of the verb. This nun is frequent in Chaldee. In Samaritan it is appended also to the preterite, and in similar cases even a t (th) inserted. In the Syriac there is a yodh with a consonant power used in the same way." This last is the *i* of Sam., Ef., and My. The Ef. (and Fiji) epenthetic demonstratives are numerous, but are simply the demonstratives in §1. Thus we have Ef., third sing., acc., bia, mia, ria, tia, sia, ngia (kia), nia; second sing., acc., fik (or fiko), mik, rik, tik, sik, kik, nik, &c., &c. Then we have compounds thus—makinia (ma ki ni) sakinia (sa ki ni), &c., and note especially the compound kin or kan, which, as *kan* is one of the most important words of the My. grammar and dictionary, turning every verb after which it is put into a transitive or causative. It does the same in Ef., but is not so much used.

Remark 1. It seems that many, perhaps all, of these are in use in the My., but not observed or noticed. They being epenthetic, or always coming after the verb, have at last been written as if part of the verb root. This is very interesting, as throwing light, as will be seen, upon a somewhat obscure problem of Sh. philology, the tri-consonantal form of a large part of the Sh. vocabulary. Thus, take the common Ef. words *minu*, to drink; *rongo*, to hear; *turu*, to descend; *tangi*, to wail. These in the My. are given as *minum, dangar, turun, tangis*, in which the final m, r, n, s, are the demonstratives epenthetically used, as above shown, but exhibited as a part of the root. There are examples in Ef. of the same thing. If I mistake not, it will be found that the third consonant of many of the Shem. stems has a similar origin—*e.g.*, the f in Heb., *g*a*d*a*f*, properly like the "Arb., to cut off;" Ef, kotef, whose final f is the Sh., fa of §1: the real stem is biliteral, or monosyllabic; Ef., kot, kut. Heb., gad, gud, &c. (*vide* Vocabulary, **71-3, 76-7**; *vide* Ges. *Heb. Gr.*, §30, 2.) This, if correct, would partly explain the tri-consonantal, or dissyllabic mystery. When the third consonant is prefixed, as Syr. *n*akas (Ges., l.c.), it probably is an auxiliary verb. But this by the way.

2. The so-called numeral and case inflexions have already been noticed. The inflexion of gender has also to be noticed now, as connected with the pronouns. In Ef. we have traces of it, thus—

Ma, a mas. demonst., used only before the names of males; it is the same m which forms in Heb. the mas. plural of nouns and pronouns.

Li, lai, similarly used before the names of females is the demonst. la, with i suffixed to make it fem. The very same *i* is similarly suffixed to pronouns in all the Sh. languages.

Tete (te), a pronoun used only in addressing females, is the same t as is used to form the Heb. fem. plural of nouns. It is a fem. demonst. in Arb. It appears as v. p., third person singular, fem., generally in all the Shemitic languages. Heb. t (th) is a fem. termination in the demonst. zath, and in some fem. nouns sing.

§7. THE NOUN. In Efatese the number of nouns is denoted by plural demonstratives; so, for the most part, in the Sh.; but in the Sh. these plural pronouns are suffixed, whereas in Oc. they are usually found separate, though sometimes by "printer's grammar" suffixed. Ef., mara, manga, manang, maro Mg., id.; Maori, ma; Tannese, mi. In all these m is the principal demonstrative; Heb. m, also plural. The Tannese use of m for plural is especially remarkable; it has been printed suffixed to nouns just as in Heb. In the My. the plural is often represented by doubling, or re-duplicating the noun; not only is re-duplication much used in the Sh. generally, but it is found used also in this particular way—*e.g.*, Assy., mami, waters; and Syr., doka doka, places, leson leson, tongues (Mark xiii. 8; Acts ii. 4).

2. In Ef. and Oc., as in Heb. and Sh., a noun is in the construct state when followed by a noun in the genitive or by a pronominal suffix, and exhibits also, to some extent, vowel changes connected with the throwing forward of the accent ("to which," in Heb., as Gesenius says, "is commonly given the name declension"). Thus, to take the Ef. word túo, foot, with suffixes, the accent is thus Shemitically thrown forward.

Tuóngu, my foot; tuongámi, our foot (ngami being a "grave suffix"); and, to give an example of vowel as well as accentual change, Ef., máta, eye—

Mitángu, my; mitáma, your; mitána, his eye; mitangámi, our eye. Before nouns, thus, mál, place, but, middle—

Mălē but, place of the middle; and so natamol, man; mĭta natamol, eye of man. Naturally there is not nearly the same fulness of declension by vowel and accentual change in Oc. as in Sh. In My. the rule is thus given by Marsden (in his Malay grammar), a name ever to be mentioned with respect by a student of Oc.—"The most general rule, but admitting exceptions as will hereafter appear, is, that upon annexing a particle, the long vowel in the first syllable of the primitive, if a dissyllable, or, if a trisyllable, in the penultimate (the situations where they usually occur), becomes short, and the short vowel (expressed or understood), in the second or last syllable, becomes long . . . bīnĭ (I omit his Arabic characters), wife, with nia (nya), becomes bĭnī-nia, his wife." As in Sh., in some cases the noun in the const. state differs only by its position from the noun in the absolute state, so, perhaps, more frequently in Oc. But we have traces in Oc. of Sh. grammatical forms now no longer in living use, but regarded as parts of the root. Thus, to take the Heb. pah or fah, fem., side; const., peth or feth (pet or fet), we have it in Ef. fā or va, side, and const., fit or vit (always in const. in Ef., as fitina, his side; fiti natamol, side of man). Now, this form was not only const., but const. fem., and exhibits in Ef. all the original changes of case and gender, and, it may be added, of number, for this is the common, the universal Oc. word denoting four, Ef., bāt, pāt—*i.e.*, literally and originally, as will be explained under the numerals, sides or quarters, of which there are four, hence four. It is the plural of *pah*, a side or quarter. I could give other examples, and hundreds of such relics are waiting to reward the diligent student of Sh.-Oc. There is a peculiar redundant Syr. idiom found in Oc. Thus (Acts iv. 35) "apostles' feet," literally, feet of them the apostles. So (John xviii. 10), "his ear the right." Ef., talingena ni matua, his ear the right, is exactly analogous. This idiom is common in Fiji and Madagascar. Corresponding to Syr., Ch., d, Assy., s, signs of genitive, we have Ef. and Mg., ny, ni.; Java, ne, &c., &c., all of which Sh. and Oc. are to be found in §1. I need not say that in both Sh. and Oc. the relative pronouns were originally demonstratives.

3. In Oc. we have nouns of the type of Heb., ab, Ef., ava, ab; formed from verbs by a change of vowel, as in Sh., thus --Ef., bēs, a prey from bass, to snatch, like Heb. biz from bazz, Ef., tīko, a pole (thrusting), from taka, to thrust, &c., &c.; and formed from verbs, as in Sh., by attaching particles, thus—Ef., moru, Heb., ma'rah, a hole, is formed from the verb by prefixing the demonstrative m (§1); so Ef., mwit, Heb., ma'teh, a covering. Usually Ef. and Mg. prefer ni, ny, and My., ka, to m. A kind of verbal noun is formed universally in Ef., Tannese, My., and Mg., by suffixing n to the verb: the n in Heb., korba*n*, an offering, is the same n used in the same way.

§8. THE VERB. The late Bishop Patteson thought that the Oc. tense usages threw light upon the perplexed subject of the Sh. usage, and wrote a book on the subject, which I have not seen. To express the tenses in Ef. auxiliary verbs are used. This usage had already become common in Ch. and Syriac, the verb substantive, future or preterite, with the participle of any verb, denoting the future or past tense. In Ef. the verb *to be* is ba or bi, fa, fi, future wo, fo, or o; An., pu; Mg., hi or ho; Heb., havah; Ch., id.; and the Syr. often dropped the initial h. The Ef. wo is used before a verb to denote the future exactly as the Syr. ʻwu—

e.g., Acts vi. 4; Dan. ii. 43. This Ef. verb substantive and the next mentioned are perhaps the only ones that have preserved their original Sh. futures; in another Ef. dialect mi is used as v.s. instead of bi, future mo (*vide* above, Voc., 262), used for wo, fo, o, with all verbs; corrupted to ma in Tagala and Mallicollo. This ma, mi, am, &c., is the most prevalently used v. s. in Oc. as a kind of redundant auxiliary of the present tense—*e.g.*, it is thus prefixed to almost every verb in Mg., My., and Tannese, and to a good many in Ef.

The commonest way of expressing the future in Ef. is by prefixing a conjunction to the above wo, fo, or o; and this is exactly analogous to what was done in Ch.—*e.g.*, in the passage above cited (Dan. ii. 43), the Syr. expresses the future by ‘wu, without a prefixed conjunction, but the Ch. prefixes the conj. l = that. The Ef. conj. = that, in order that, to, is ki, so Raratongan; Heb., ki. The Arm. equivalent of ki is d, di. As l is used before the future of the verb subs. in Ch. to denote the future, so k, ki in Ef., and so t in Tannese. Like the Syriac, the Mg. does not thus use a conjunction.

This conj. alone in Ef. put before any verb gives it the force of a subjunctive, optative, imperative, precative, or infinitive, according to the context or design of the speaker: so the l Heb. and Ch. just mentioned was used in Sh. As in Heb., when one verb follows another, according to a frequent usage, the second is in the infinitive, with or without this conj. prefixed to it, so exactly in Ef. The Syr. m forming the infinitive is the Fiji *me*, doing the same; and also, like the Ef. ki, forming the imp. and subjunctive. We should, therefore, expect to find that ma (Sh.) had anciently been used, not only as a demonst. and interrogative pronoun, but also as a conjunction, like the English *that;* accordingly we find Assy. “ma, conj. that” (Norris' *Assy. Dict.*, s. v.).

I have already spoken (above) of the formation of verbal substantives.

The simple verb in Ef. is either in the present or the past tense, according to the context and intention of the speaker, and often no auxiliary of the past is used. Sometimes, however, the v. s. ka (cf. its use in Maori), Heb. chayah, is used like the cognate word in Syr. A pluperfect is formed in Ef. by suffixing to this ka (which may be regarded as a preterite), another verb subst. i, Heb. hih (hayah), thus, kai (ka i): so analogously a Syr. pluperfect is formed by putting the cognate verb subst. after a preterite.

The passive. Gesenius says of the Heb. (Paul part.) that it "is probably a remnant of a lost passive form of qatal," and remarks that "in the Aramæan the passives of Piel and Hiphil are in like manner lost, except in the participles." Now, this shows a tendency to lose passives considerably developed even in ancient Sh. In the Oc. we naturally find this tendency carried further. Instead of the ancient passives we see in Ch. and Syr. substitutes consisting of a syllable ath, eth or ith (cf Arb. t, Conj. V.) prefixed to the active, which syllable is probably originally the verb subst. ath or ith. Accordingly we find the ethpeel, ethpaal, ethtaphal, and eshtaphal "conjugations" having a reflexive or reciprocal as well as a passive signification. What we find in Oc. is exactly analogous; but, first, it may be noted that of the original Sh. passives there are only traces in Oc., thus, Ef. bārua, to be clear of, free from; Heb., bārua (Paul part. of b*a*ra) which, in Arb., means to cut, plane (cf. Voc., 179). The later Arm. method of indicating the passive by prefixing a verb subst. we find well represented and in living use, thus, ta—perhaps the Ch. ita (itha), cf- Arb., tawa (*vide* Voc., 296)—ma, and bi, in Ef.; and di (Ef. ta), tar, Heb. dur, and ka (Ef. aux. verb) in My. So in My. ma and be are used before instransitives, as in Ef.; and bar, Eth. nabar, to dwell (*vide* Voc. above, 55.)

These, or some of them, as Ef., bi, fi; Sam., fi; Mg., fa, are also used in a reflexive or reciprocal sense; and sometimes these particles, like the Arm. ath, &c., are merely intensitive.

The intensive effect is also secured by re-duplication, as in the Sh; in My., as Crawford (My. Gr.) says, "by the simple repetition of the radical;" so also in Ef., where, however, as well as in Po. and My., the radical is sometimes abbreviated according to the following rule, taken from Sayce's *Assy. Grammar*:—"When a monosyllable is repeated the last consonant of the first syllable is generally assimilated to the first consonant of the second syllable," as kakabu for kabkabu. The same thing is found very prevalent in Oc., as a glance at any respectable vocabulary will show (*vide* for examples Voc., 49, 54, 150, 235, 256). This is simply the Pilpel conjugation, which, as Gesenius says, is analogous to Piel, and which is in living use every day all over Oceania.

Of Piel and Hiphil we have traces in Oc. (*vide* for examples Voc., 103, 112, 118, 159, 173, 234, 50, 245). They are no longer in living use. The Oc. causative is formed by prefixing ba or baka (explained Voc., 50) to the verb. Mg., ampa. Ero.. ampi (m euphonic), seems to be the original Sh. Hiphil or Aphel of ba, and prefixed to verbs, denotes *to make to come to be,* what the verb signifies. The My., and sometimes the Ef., forms a causative by suffixing to the verb *kan* or *i.* These are simply epenthetic demonstratives, as already explained above.

Here note a curious example that may throw light on a word occurring but once in the Bible, and whose meaning is disputed—the word charak (as to which see Ges. *Dict.*). Ef., karák, to catch, seize, lay hold upon, more especially by clasping or becoming intertwined with, to catch and cling to, and to seize in order to slay (Voc., 172).

§9. ADVERBS. There are certain adverbs in Oc., as in Sh., consisting of the particle k, as, prefixed to a demonstrative thus, kasa, ngasa ; so ; Heb., kazeh : ku, ngu (k*ua*) ; so ; Heb. koh (from kehu, Ges.) : ngaku (kaku); so, thus ; Heb., kakah : kĭte ; Ch., kĕti (or kĭte); as, as if, when, &c.

2. Certain demonstratives are used interrogatively, as follows :—Se ? we or wabe ? sabe ? wabe ? &c., where ? Mg., aiza ? Sam., o fea ? My., mana ? Ngasa (kasa), above, with na prefixed, in Ef. means when ? Sam., afea ? Bia or bisa, how many ? Mg., firy ? Sam., fia ? My., birapa ? In Heb. how many ? is kemah ? to which is analogous Tannese kefa only substituting √ f, for √ m (*vide* §1).

3. Certain demonstratives are used as adverbs of affirmation, as ia ; Mg., eny ; Sam., io ; My., iya ; so the Heb. hua, &c., means not only *this,* but sometimes *it is,* &c.

4. Adverbs of negation. The Shemitic negatives are usually formed from verbs signifying to be void, null, to be empty, &c.; Ef., ta, ti, tu ; My., same ; Heb., t*a*hh (whence tohu, Gen. 1.), to be waste, empty. Cognate to this is Heb. shah, and the Santo negative is sa ; Mg., tsy. Heb., *all* is described by Ges. as "a verb having the force of nothing, emptiness," whence the common Heb. negative la, which Ges. says was "anciently pronounced lē;" the Sam. negative is lē. Another negative occurs in My. and Tanna, bu or pu, and the Arb. verb bahi signifies "to be void and empty." Ef. e, or i (Voc., 25); Heb. e, is from un or in, according to Ges., which signifies nothing, negation : in Api, i, as in Eth. and Amh., is used before the verb. As in Arm. (Ch. and Syr.) a verb substantive is suffixed to the negative, forming a word

literally meaning *it is not*, lath, leth, so in Oceanic, thus—Ef. tika (*vide* Voc., 137, for ka, *is*); My., tiada, tada (ada, *is*, Arm. ata, or atha; Syr. lath is formed exactly like tada, with same verb substantive); My., bukan (kan, *is*; Arb., kan, to be, used as an auxiliary verb); Mg., tsia (ia, Heb. hih or hayah, to be); Ef., ewo, or awa (wa Voc., 116, *is*).

In Efate and many other Papuan languages a demonstrative is placed after the verb to emphasise the negative that is before it. This demonstrative in Ef. is mau (ma u), Futuna, ma. In Amharic, mo is constantly used in the very same way (*vide, e.g.*, Jno. i. 5, 8). This is all the more striking as it is the very same demonstrative that is thus strangely used in places so widely apart as the New Hebrides and Abyssinia.

5. The following are demonstratives used as expletives:—My., pun; Ch., pun or pon. Ef., la; My., lah (very much used); Arb., la; Heb., lu.

§10. PREPOSITIONS. Mg., amy, "the only preposition in the Mg. language," "from, with, to, &c.; "its precise meaning is determined by the verb that precedes it;" Heb., 'am or 'im. Ef., ki.; My., ka.; Heb., k(e).; Assy., k(i); Amh., ka.; Heb., k, prob. from ki (*vide* Ges. Dict., s. v. and Gr., §118, 3, Rem.); as, as if, according to, of, from, by, with, to (Amh., Jno. i. 15). My., pada; *to*, &c.; Heb., ba, 'ad. Ef., baki (ba ki).; My., bagi (or baki); to, unto.; Heb., ba ki (same as 'ad ki). My., ulih.; Java olih; for, from; Heb., 'al.; An., ehele, to, from, Heb., 'al.; Ef., ole, for, on account of, Heb., 'al.

§11. CONJUNCTIONS., Sam., Ef., ma, *and*; Assy., ma; Amh., mo. Ef., ngo (ko); Mg., koa; also; Heb., koh; so. My. joins the two foregoing, thus—maka, literally, and-so, a, word which begins nearly every sentence in My., and is often untranslatable. Ef., k, ka, nga, that, in order that, but. Heb., ki. Ef., te, that, in order that, because; Ch., di. Ef., kin, but; Amh., gin. An., par; Ero., wor; that, in order that; Heb., 'ăbūr.

§12. INTERJECTIONS. Ef., na! Heb., na! Ef., mo! Heb., mah! Arb., ma! Ef., wana! Heb., hineh! Ef., ita, come! Common Oceanic: Heb., eta, imperative of atah, to come, go. Ef., ito, farewell!* (go!); Heb. imp. of atah. Ef., ako! exclamation of mourning, pain; Heb., akah, ekoh!

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* Cf. Arb. "wada', farewell."

13. THE NUMERALS.

1. Tesa, Ef., Sam.; Assy., edisu.

Fiji, edua; Assy., edu; Amh., andy, &c., &c.

2. Ef., trua, rua; Mg., roa, &c.; Ch., trī.

3. Ef., tolu; New Guinea (one dialect), told; Mg., telo, &c.; Syr., tholth, tolt.

4. The Oc. four, like the Sh., is a word originally meaning side; then, because there are four sides to a square and four principle points of the compass, it came to denote four. This word in Ef. is bate, pāte, plural of pah (Heb.), as already explained*, and it is universal in Oceania; Sam., has the sing., fa: Mg., fatra; My., ampat, pl., as in Ef. Pah is thus explained Ges. Dict.:—" 1. A quarter of the heaven, prop. wind (?), so called from its blowing. Compare in Targg. arba' ruchin, four winds; for Heb., arba't kinpot haaretz . . . fet yam, the west quarter (Josh. xiv. 14); fet tzafon, the north quarter (Ex. xxvi. 18, 20.) Hence—2. Side, region," &c. The Sh. arba' four is analogously from reba', "a side (one of four sides). The word so used is found in Abyss. (Arkiko), as ubah, four; Savu (Oc.), uppah.

5. The Oc. numeral five is a Sh. word (explained Voc. 29); meaning hand, which it also means in Oc.; Ef., lima; Mg., dimy; Po., rima, &c., &c. (the l, d, r being articles).

10. Bulu, pulu, folo, hul, &c., &c., is literally a gross; Heb., yabal, to grow, flow, whence bul, produce, wealth.

6—9 are formed† in Oc. by attaching a demonstrative or the numeral five to the first four numerals, so that 6 is literally 1 + 5 or 5 + 1. The same thing is found among the Abyss. Sh. languages.

1000. Mg., arivo; My., ribu; Heb. and Ch., ribo, a myriad.

I shall now conclude by remarking—first, that this discovery clears up the hitherto impenetrable mystery surrounding the origin of Oceanians. The Sh. language could only have been carried into Oceania by Shemites from the Sh. mainland. The numeral system of Oceania, and the relics of ancient civilisation found in the islands, prove that these Shemites belonged to an ancient powerful commercial Shemitic state or empire that lasted for ages, and navigated the Indian or Southern—that is, the Oceanian—seas. That empire we find at the head of the Persian Gulf, and it matters little whether we call it Chaldean, Babylonian, or Euphratean. It was the commercial meeting place of East

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* §7, 2. † Usually, not always.

and West in the ancient world. It was from there that the Phœnicians, and Hebrews (in the person of Abraham), emigrated to the West. The Chaldean ships sailed the Oceanian seas, just as did the Phœnician the Mediterranean; and as the Phœnicians planted colonies on the Mediterranean shores, so, but with more lasting effects, did the Euphrateans in the multitude of the isles. Not only did they establish secondary commercial states in Southern Arabia and Abyssinia, but they sowed men in Madagascar and Malaysia. The negro element among the Shemitic-speaking Oceanians can be accounted for best in this way. They were in the homes and ships of the ancient Shemites as slaves, and learned their language just as the American negro slaves learned English. There are no negroes in Asia. Ancient history is not altogether silent, but seems to stand with uplifted hand and parted lips, and just stops short of uttering the whole secret. Herodotus gives a celebrated account of a voyage round Africa undertaken by Phœnicians for Pharaoh-Necho, king of Egypt; and it is not to be supposed that the circumnavigators of Africa were ignorant of Madagascar. Isaiah mentions China by name. I have only further to mention the magic word Ophir, to which Solomon's fleet went on three years' voyages, and which Josephus declares to be Malacca. These, the first ocean voyages recorded by history, were performed in Oceania and by Shemites, whose ships, according to so sober an authority as Chambers' *Encyclopœdia,* may have gone as far even as the Spice Islands, near New Guinea. Finally, the fact that Madagascar and Easter Island, or Efate, are peopled by the same race cannot be accounted for so well on any other hypothesis; and, if their language is Shemitic, as I think I have proved, can be accounted for on no other hypothesis whatever.

In solving the problem of the origin of the Oceanians there are four groups of facts, or possible facts, to be considered and compared; and the consensus of these, so far as they are obtainable, gives the highest certainty possible. These are the philological, ethnological, geographical, and historical. It may be said that, strictly speaking, there are only two theories possible, that Oceania has been peopled from South-Eastern Asia, or, as I maintain, from South-Western Asia, or the Persian Gulf. You may assert the former of these, but philology is totally against it. History, so far as it speaks, is totally against it, for it shows that the Malays emigrated to Malacca from the islands, and not *vice versa.* Ethnology gives no utterance for, and unambiguous utterance against it, inasmuch as it cannot account for the negro element of blood, but not of language, among the Oceanians, and it cannot account for such facts, for instance, as that the Tannese and some others in the New Hebrides dress their hair in the very remarkable style of the ancient Assyrians, which obtained among no other Asiatic people. But I refrain from a comparison of customs. Geography, which at first sight appears to be for it, turns out, on closer examination, to be more against it, inasmuch as it utterly fails to account for the peopling of Madagascar, which the other theory most satisfactorily does. Therefore the theory of the peopling of Oceania from South-Eastern Asia fails from the utter want of evidence to support it. And I have already shown that all the evidence obtainable, philological, ethnological, geographical, and historical, harmonises into a body of proof irresistibly establishing that South-Western Asia, or the Shemitic mainland of Oceania, at the time when the Shemites were supreme in civilisation, navigation, and commerce, was the home from which hived off the people whose descendants we now find inhabiting these isles of the sea.

Secondly, this discovery has an important bearing upon the evolution theory: in so far as that theory endeavours to draw support from the existence of savages, and the supposition that they are descended—or shall I say ascended?—from "hairy quadrupeds," it tends utterly to overthrow it; for it shows, as to one of the greatest bodies of savages, that they are descended from the most renowned and civilised people of antiquity.

Thirdly, I consider this discovery more important on the whole than that of the Assyrian or Euphratean inscriptions, deciphered of late with such marvellous ingenuity. In these inscriptions we have only a fragment of the dead language of a lost people, but very valuable as throwing a happy light upon historical parts of Holy Scripture. But here we have, so to speak, that people found, their language full-orbed and in all its living vigour. It will probably be found that every recorded word of ancient Sh. has its cognate in Oc.; and, in investigating and illustrating the meaning of the words and the grammatical usages of the Hebrew and

Chaldee of the Bible, it will become necessary henceforth to refer not merely to the Arabic and Syriac, Phœnician and Ethiopic, but also to the Oceanic. Moreover, as men and as Christians, we owe a duty to these men and women of the isles of the sea, and it is to be hoped that the discovery of their high birth, of their ancient and noble ancestry, and remarkable and sad history, will engage us to the performance of that duty with more interest and sympathy, even as by the increase of knowledge it gives us for performing it additional means of the highest value, and greater power.

Fourthly and finally, I invite other workers into the field. There has been discovered a mine of inexhaustible wealth. Let all who will come and dig. A wealthy gentleman of New South Wales some time ago fitted out a scientific expedition to New Guinea, and for this his name is worthy to be held in high honour as long as Australia shall exist. The "Cheviot"—that was the ship of that expedition—now lies a dismasted hull in Havannah harbour, Efate,* within sight of the writer's residence. Let some such gentleman, or scientific body, send an expedition to Oceania and the Shemitic mainland, from which its population originally came, to gather knowledge, philological and ethnological, in accordance with the discovery announced in this paper, and the results, as certain as harvest to the husbandman, will be altogether adequate and worthy, in a great and sensible addition to the permanent and public stock of wisdom and knowledge.

ABBREVIATIONS:

Oc., Oceanic
Ef., Efate
My., Malay
Po., Polynesian
Mg., Malagasy
Tah., Tahitian
Sam., Samoan
An., Aneityumese
Ero., Eromangan
Mall., Mallicollan

Sh., Shemitic
Ch., Chaldee
Heb., Hebrew
Syr., Syriac
Arb., Arabic
Amh., Amharic
Arm., Aramaic
Eth., Ethiopic
Abyss., Abyssinian
Assy., Assyrian

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* Efate, Fate, or Vate, was discovered by Captain Cook, who called it Sandwich Island: it is about the middle of the New Hebrides Group.

ART. XXI.—*On the Occurrence of Alcohol and Idoform in a supposed Non-Alcoholic Wine.*

BY MR. E. S. MARKS.

[Read 16th November, 1882.]

ART. XXII.—*Patent for "Improvements in Contrivances for Varying the Gauge of the Wheels of Rolling Stock for Rail and other Permanent Ways."*

BY D. ANDERSON.

[Read 16th November, 1882.]

THE nature and working of my invention may be described in these terms, viz.:—

The axle is made with a solid collar in the centre. On each side of this collar is a sleeve, to the outer end of which the wheel is fastened, and these sleeves are drawn out *from* or *in to* the solid collar by right and left-handed screws fastened to a double platform, on which the wheels rest in recesses shaped to their bottoms. On the inner end of each sleeve is a flange, which is held by a hinged clamp on each side of the solid collar. In these hinged clamps are recesses for the reception of the flanges when the clamps are closed. The hinged clamps are opened and allowed to fall back by the partial unscrewing of two nuts, working on two hinged bolts, thus enabling the sleeves with their flanges to slide along the solid axle, either away *from* or *to* the solid collar, according to whether the wheels are to be adjusted to run on a broad or a narrow gauge.

A truck with its load by this method, and with the aid of machinery to work the right and left-handed screws, can, without unloading, be made to run on either a broad or a narrow gauge in a few minutes. When the clamps are closed the nuts are screwed home, and a split key or pin is inserted through the bolt, thus rendering it impossible that they can get loose or shift in the slightest degree. If preferred, Ibbotson's safety nuts can be used without the split pin.

By my patent the inconveniences and delays in transmitting goods over country laid down with lines of different gauges can be reduced to a minimum. Should the Governments of Victoria and New South Wales adopt my plan, goods can be carried from Melbourne to Sydney as quickly as if the two lines were of the same gauge, allowing for a detention of, say, one hour at the break of gauge if one truck at a time is altered by my platform, or half an hour only, if each truck be provided with a platform.

If machinery be used to work the right and left-handed screws, I estimate that a truck can be altered from the broad to the narrow gauge, or *vice versa,* in five minutes. If a platform be provided for each truck, any number can be altered, after the hinged clamps are opened and thrown back, in the same time as one, by the aid of an engine in the pit working an endless cogged chain which would turn all the right and left-handed screws simultaneously.

Between Victoria and New South Wales I propose using an axle of 5 inches diameter, and as my sleeves are 1¼ inches in general thickness, I add to the strength instead of diminishing it. The first axles made according to my patent will be more expensive than those now used, because the sleeves and hinged clamps are difficult to make; but as they are practically indestructible, it will only be the first lot that will be expensive. As the sleeves are prevented by the feathers from revolving on the axles, there will be no friction, and when the journals of the solid axles are worn out the same sleeves and hinged clamps can be used for the new solid axles required. The forging of the solid collar on the axle will be troublesome, but I think it better to do this than risk any failure. At the same time, I consider that were the centre of the axle recessed a little all round, a collar in two parts, fastened together by strong riveted bolts, would answer the purpose equally well, and would, of course, be less expensive. This, however, is for the consideration of the Governments who adopt the patent. In bringing dead meat from the interior of New South Wales to Melbourne my invention gets over the present difficulty of break of gauge, for it can be placed in refrigerating cars and sent to Melbourne without re-handling, thus avoiding all risk of thawing by being exposed to the warm air, as must follow if the contents of the cars are transferred from New South Wales' to Victorian trucks. Again, in bringing coal from New South Wales to Victoria, all the trouble, expense, and loss of time in unloading would be avoided. Provided that an axle according to my patent is made wide enough to run on the broader gauge, all that is necessary to enable trucks to run on a narrower line is to shorten the sleeves and make the hinged clamps wide enough to carry recesses to keep the flanges in position. As there is a difference of 6½ inches between the gauges of the Victorian and New South Wales lines, I make my solid axle 5 inches in diameter, being half an inch thicker than the present Victorian axles, in order to allow for the overhang. Between New South Wales and Queensland, the difference of gauge being 14½ inches, I propose making the solid axle 5½ inches thick. For South Australia and Tasmania, where the gauges are 5 feet 3 inches and 3 feet 6 inches, the difference being 21 inches, I propose making the solid axle 6 inches. The sleeves and hinged clamps, however, will be of the same thickness in every case. It is reasonable to suppose, however, that if the axles are made of the very best steel procurable, these dimensions may with safety be lessened, and the cost, as a consequence, diminished. Experience only will prove this, and the various Governments must decide upon these points after trial. My invention can be applied to passenger cars as well as goods trucks; but as persons can walk from one train to another in a few minutes, there is no absolute necessity for it. Each passenger train may, however, be provided with luggage trucks placed upon my axles, and these can be altered to the broad or narrow gauge as required. The alteration of brake fastenings and blocks can be effected in a variety of ways, and I show a simple and inexpensive one on my model.

Letters patent have been granted to me for Victoria, New South Wales, New Zealand, and the United States, while they have been applied for in the other colonies, Great Britain, Canada, India, and most of the European States. Plans were sent to England on 5th September last for the manufacture of two sets of axles and wheels, which ought to arrive in Victoria in the latter end of March next, when I hope to get permission from the Governments of Victoria and New South Wales to run a truck, provided with my axles, from Melbourne to Sydney and back again. No alteration of truck will be required, as my axles can be placed under any of the Victorian ones now in use.

SPECIFICATION

OF

DAVID ANDERSON, of Fairview, Stawell, in the Colony of Victoria, Gentleman, for an invention entitled

"IMPROVEMENTS IN CONTRIVANCES FOR VARYING THE GAUGE OF THE WHEELS OF ROLLING STOCK FOR RAIL AND OTHER PERMANENT WAYS."

MY invention consists mainly of certain improvements in railway and other rolling stock, by which the gauge of the wheels may be adjusted; and, secondly, of machinery whereby such alteration or adjustment of gauge is effected.

The first part of my invention consists of a peculiar construction of the axles of rolling stock for rail and other permanent ways in which either wheel is keyed to a sleeve, the inner end of which terminates in a flange. This sleeve slides over and upon the axle and the feathers thereon. The axle I make with a solid collar in the centre, and on either side of such collar I place a clamp or hinged collar having two or more recesses or hollows to fit over the flange of the sleeve and a strong hinged bolt to tighten said clamp thereon. I bolt both clamps or hinged collars together through the solid collar of the axle.

The second part of my invention consists of a certain combination and arrangement of machinery in which a sole plate carries the bearings fcr two sets of rollers. Each set consists of two rollers upon which travels a platform, the upper side of which is recessed to the shape of the tire of a wheel, or carries a rail. The underside carries a nut (right or left handed as the case may be) in which one end of a right and left handed screw works. This screw has a thrust bearing in the centre of the sole plate, and is provided with a collar having sockets for a crowbar or other means of turning it.

In order, however, that my invention may be more perfectly understood, I will now describe the same with reference to the accompanying drawings, in which Fig. 1 shows a side elevation, partly in section, of a pair of wheels, provided with my improved axles, resting in the recesses upon the platforms of my improved machinery as they would be just previous to narrowing their gauge. Fig. 2 is an end elevation of the same. Fig. 3 a plan of the machinery alone, and Figs. 4 and 5 detail views of the hinged clamps.

AA are the wheels which may be of any description so long as their bosses A1 are large enough. B is the axle with solid collar B1 in the centre. B2 are steel feathers properly secured to said axle. C are the sleeves terminating in flanges C1. DD are the clamps or hinged collars having two recesses D1 and D2 in each. D3 are the hinged bolts having plate washer D4. D5 are the bolts through the clamps and the solid collar of the axle and having connecting plates D6 at either end. E is the sole plate of my improved machinery firmly bolted to a solid foundation, and E1 and E2 are the two sets of rollers thereon. F are the platforms carrying recesses F1 and nuts F2. G is a right and left handed screw with turning collar G1 and thrust bearing G2.

The mode of operation is as follows:—When it is desired to use the rolling stock of a rail or other permanent way upon another way of different gauge, my improved machinery is placed where the break of gauge occurs. To transfer the rolling stock, the rails or recesses F1 on the platforms F of such machinery are set by means of the screw G to the gauge of the line on which the stock is. A vehicle provided with my improved axles is then pushed upon such platforms, the clamp bolts D3 of such axles unscrewed so as to admit of the clamps being opened on their hinges D5, so freeing the flanges C1 of the sleeves C, to which the wheels A are keyed. The rails or recesses on the platforms are next adjusted by means of the right and left-handed screw G to the gauge of the line upon which it is desired to run the vehicle. The flanges C1 of the sleeves C on the axles should now fit in another recess D2 in the clamps, which are closed and tightened up as shown in Fig 4, and the vehicle then moved on to the second line.

In the drawings illustrating this invention the vehicle is shown at its widest gauge and with only one vacant recess in each of the clamps on the centre of the axle, thus admitting of its alteration to one other gauge only, but of course the number of these recesses might be increased and the length of the sleeve altered so as to admit of its adjustment to as many gauges as may be required.

Having thus described the nature of my invention and the manner of performing same, I would have it understood that

WHAT I CLAIM AS MY INVENTION IS:—

First, constructing axles of railway rolling stock with an extensible sleeve or sleeves to admit of the alteration of the gauge of their wheels.

Second, constructing such axles with a solid collar in the centre and with a hinged clamp on either side having recesses for receiving and holding the flanges on the inner ends of the axle sleeves substantially as herein described and explained.

Third, The combination of the sole plate E, the rollers E2, platforms F having recesses F1 (or their equivalent in the shape of rails) with a right and left handed screw G, turning collar G2 and thrust bearing G3, in the manner and for the purpose herein described and explained.

D. ANDERSON.

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Book 3.

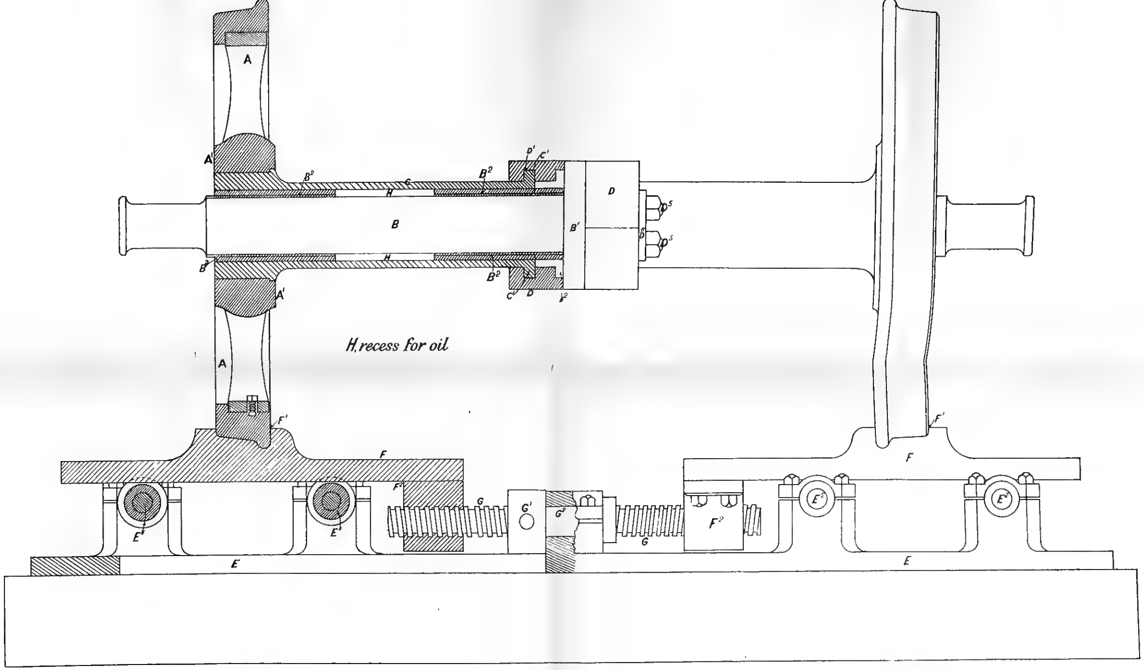


FIG: I.

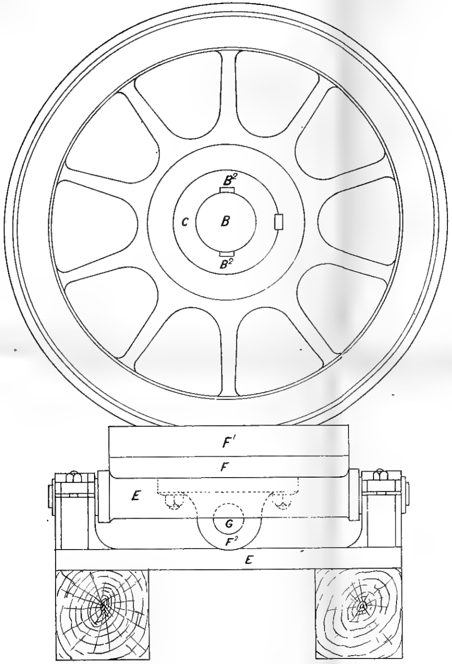


FIG: 2.

— D. ANDERSON'S PATENT —

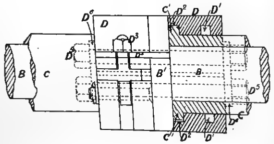


FIG: 4.

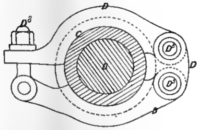


FIG: 5.

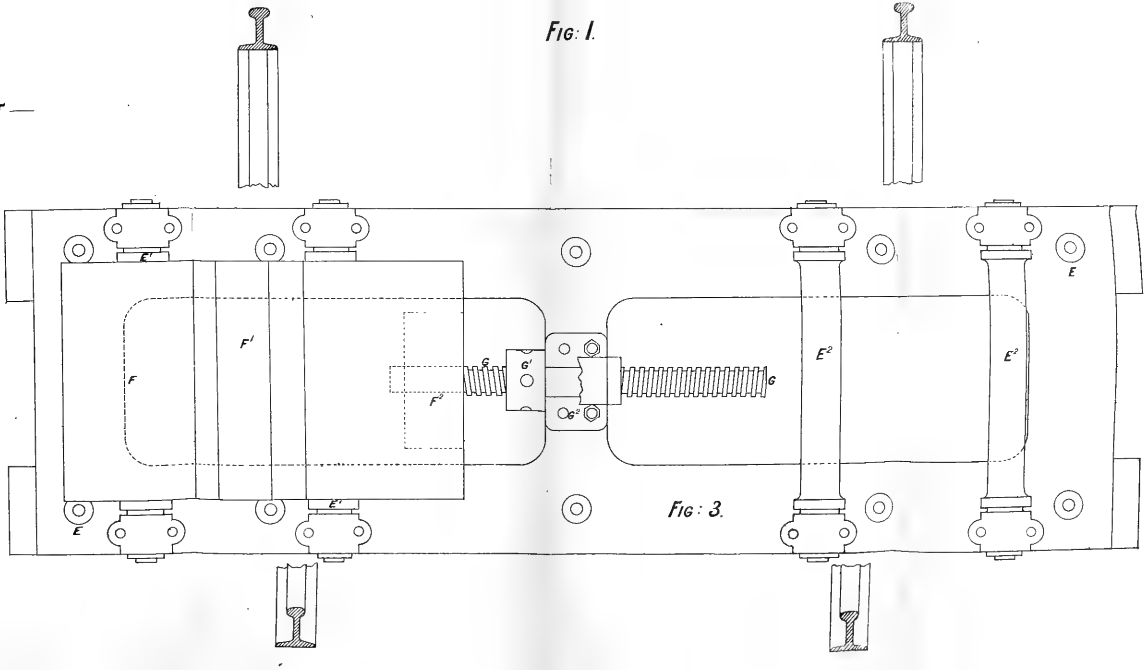


FIG: 3.

Art. XXIII.—*On the Lateral Stability of the Victoria-street Bridge.*

By Professor Kernot.

[Read 16th November, 1882.]

Numerical Particulars Relative to the Victoria-Street Bridge.

Height of highest pier ...	86 feet from rock foundation. 74 feet from bed of river.
Breadth of base, extreme ...	19 feet.
Breadth to centres of cylinders	16 feet.
Weight of highest pier and corresponding portion of superstructure	105 tons.
Moment of stability, $105 \times \frac{18}{2} =$	945 ft. tons.
Overturning wind pressure ...	69 lbs.
Moment of stability if provided with additional cylinders on the down-stream side only	On up-stream side, 2625 ft. tons. On down-stream side, 1574 ft. tons.
Overturning wind pressure ...	North, 192 lbs. South, 115 lbs.

The Victoria-street bridge occupies a peculiarly difficult site, one bank of the river being unusually high and the other comparatively low. To overcome this extreme difference of level it was necessary to adopt an unusually high bridge, and to place it upon a considerable slope. The funds available being very limited, it was not possible to adopt what may be called the heroic style of engineering, of which we unfortunately have so many examples in this country. The usual competition having been held a design was chosen, which happened to be the production of two young and comparatively inexperienced men; and the subsequent troubles have given rise to various remarks as to the undesirability of entrusting important designs to inexperienced persons. In reply to these remarks, it is to be pointed out that the choice of the design from a considerable number of competitors was made by experienced practical engineers, and the execution of the work supervised by a gentleman of high standing in the profession, and thus the responsibility was entirely removed from the shoulders of the original designers.

The engineer in charge of the execution of the work departed from the original design as far as the construction of the abutments was concerned, and a partial failure took place in this part of the structure. With the question of the desirability of this departure I do not propose at present to deal, but would merely say that the failure does not appear to me to be by any means as serious as it has been represented, or as similar movements in other structures with regard to which the public mind is at rest.

Before the failure took place the bridge was subjected to an unusually severe test by being traversed by the heavily-loaded drays carrying earth and rock from the cutting on the high side to the bank on the low side of the stream. Under this ordeal no sign of weakness appeared in the iron columns or girders.

On the occurrence of the partial failure of the abutments considerable alarm arose, and a Government engineer of high standing was called in to advise as to the remedy. This gentleman not only proposed a most complicated and costly reconstruction of the abutments, but went further, and condemned the rest of the bridge as unsafe under wind pressure, and insisted upon the width of the base of the taller piers being increased threefold. The arguments used in favour of this startling proposal were as follows:—

1. It was ascertained that on one occasion a wind pressure of 35 lbs. had been registered at the Observatory.

2. This pressure was multiplied by 3, giving 105 lbs. to the square foot as the extreme pressure the structure ought to be able to endure.

3. The moment of stability of the highest pier and corresponding portion of the superstructure was computed, and the ultimate overturning wind pressure determined as only 56 lbs. per square foot.

4. It was proposed to increase the width of the piers threefold in order to give the requisite resistance to wind pressure.

In conclusion, the case of the Tay Bridge was cited as an example confirming the preceding recommendation.

Let us consider the above investigation in detail.

1. The assumption that the bridge was liable to be exposed to a wind pressure of 35 lbs. per square foot is erroneous. No doubt such a pressure was once recorded at the Williamstown Observatory, which is excessively exposed. The bridge, however, is quite differently situated, and is protected on the north by a high range of hills. Whatever may have happened at Williamstown, the Victoria-street bridge is not likely to be exposed to a wind pressure of above 25 lbs., either from the north or the south.

2. The multiplying of the wind pressure by 3 involves a confusion between stability and strength. In a question of strength we need to allow a large factor of safety to cover the gradually weakening effect of a series of strains, each of which may be considerably less than what would be needed to cause immediate fracture. In the case of stability no such factor is needed, or as yet been proposed. If it takes a pressure of 35 lbs. to overturn a given object, a pressure of 34 lbs. may be allowed to act for ever, or may be exerted and removed a million times with perfect safety.

3. The calculation that makes the overturning wind-pressure of the structure only 56 lbs. per square foot is not a fair one. It arises from taking the distance between the centres of the cylinders (16 feet) as the effective base of the structure. As the cylinders are 3 feet in diameter the extreme width of base is 19 feet, and the effective width in view of overturning at least 18 instead of 16. Taking this into account, and calculating the weight and the area exposed to the wind with extreme care, I come to the conclusion the resistance to wind pressure of the highest pier is 69 lbs. per square foot, or 2·7 times the greatest possible wind pressure. Nor is this all. The adhesion of the concrete filling of the cylinders to the bed rock, the friction of the soil in which they are imbedded, and the assistance derived from the ends of the bridge through the medium of a wide and well-braced platform, constitute additional sources of stability, the effect of which cannot be exactly calculated, but which may at the most moderate estimate be taken as increasing the resistance to wind pressure to at least 100 lbs. per square foot. Thus

the bridge is seen to have most abundant stability against wind pressure, far beyond the practical requirements of the case.

As comparative examples confirming this view, it may be noted that ordinary chimneys have a resistance to wind pressure of from 20 to 50 lbs. per square foot, and that hundreds whose resistance is less than 30 have been standing for many years in positions far more exposed than the Victoria-street bridge. Further, that ordinary railway carriages have a resistance of in no case more than 55, and in many cases of less than 30 lbs., and yet have for many years traversed high embankments and viaducts in positions far more exposed than the structure in question, and that without accident.

In view of what has been above stated, it might appear unnecessary to refer to the proposed alteration. It is, however, a very singular fact that the recommendation greatly exceeds the requirements of the calculation upon which it is supposed to be based. Granting for the time being the 35 lbs. wind pressure as observed, and the desirability of providing a resistance of threefold the greatest force that can be brought to bear, all requirements may be complied with in a far simpler and cheaper way than that proposed. Instead of placing additional cylinders on both sides of the pier, as shown in Fig. 1, suppose we place them on the downstream, or south side, only, as in Fig. 2. We shall find that the overturning wind pressures become 192 lbs. per square foot on the north side and 115 lbs. on the south; and as the greatest observed pressures are 35 and 23 lbs. respectively, it will be seen that in this way much greater stability might be obtained than the calculation requires.

A strong protest having been entered against the preceding proposals, a second engineer was called in, and he endorsed the recommendation to place additional cylinders on both up and down stream sides, but refrained from submitting any calculation, contenting himself with briefly expressing an opinion that it was desirable in view of floods.

This aspect of the question we must next proceed to examine, for it is manifestly conceivable that, though amply safe against wind, the structure might be dangerous when exposed to high floods. Particulars as to flood velocities and pressures are difficult to obtain, and consequently the only way to proceed is to institute comparisons with existing successful structures whose moment of stability does not exceed that of the bridge in question. On the Goulburn Valley railway, at Toolamba, is a very large timber bridge crossing the Goulburn. The highest pier of this structure is 69 feet high, and 27 feet wide at the base. It consists of redgum piles, driven through 7 feet of soft material, and then resting on the bed rock. At first sight the Toolamba pier seems much more stable than that at Victoria-street. But calculation tells a different tale. The former structure is composed of timber, a material which loses its weight entirely when immersed in water, while the latter is composed of iron and concrete, and will not lose more than one-third of its weight under similar conditions. Allowing for this circumstance, we find by a calculation, the details of which need not be given, that the moment of stability of the Toolamba bridge when the river is at high flood is barely half that of Victoria-street under similar conditions. As the Goulburn is a larger, deeper, and swifter river than the Yarra, and as the Toolamba bridge has already endured uninjured one very heavy flood, in which the floating timber formed a complete dam across the river, it follows that there are no grounds of apprehension at Victoria-street; and even if there were, additional cylinders on the down-stream side only would increase the resistance threefold, and render the bridge more than double as strong as the somewhat similar structures at Johnston-street, Collingwood, and Swan-street, Richmond. Thus the proposed alteration is seen to be as unnecessary from the flood as from the wind point of view.

The Victoria-street bridge question derives its importance from the fact that it is a point of contact and of conflict between two opposing schools of thought on engineering subjects. Those who belong to the old, or empirical, school, who hold that mathematical investigation is "mere theory," and that practice is the only guide, unanimously condemn it because it departs from the proportions to which they have been accustomed. Those who belong to the new and scientific school, who hold that the principles of statics are really and universally true, and constitute the essential basis of all sound engineering practice, approve of it because they find that its proportions throughout agree with the requirements of exact mathematical calculation; and the question before us to-night is, which of these opposing views is correct. If the recommendations of the two engineers who condemn the bridge are well founded, it will then follow that the principles of statics as laid down by all the authorities, and as taught in all our universities, are unreliable, and calculated to lead to serious errors when applied to engineering questions. If, on the other hand, the mathematicians are in the right, if the laws of statics are universally and practically true, then it follows that the engineers who have condemned the Victoria-street bridge are in the unfortunate position of being under a most serious misapprehension as to the correct mode of proceeding in the solution of the problems of engineering practice. Which of these two alternatives we are to adopt is the question I submit to the Royal Society to-night.

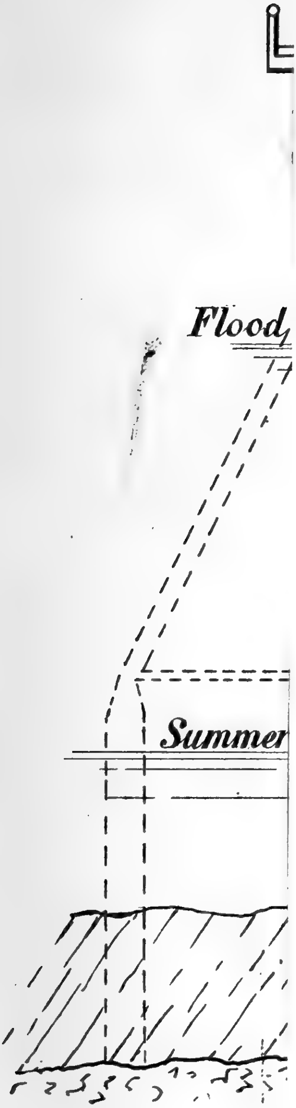

Flood
Summer

Fig: 1.

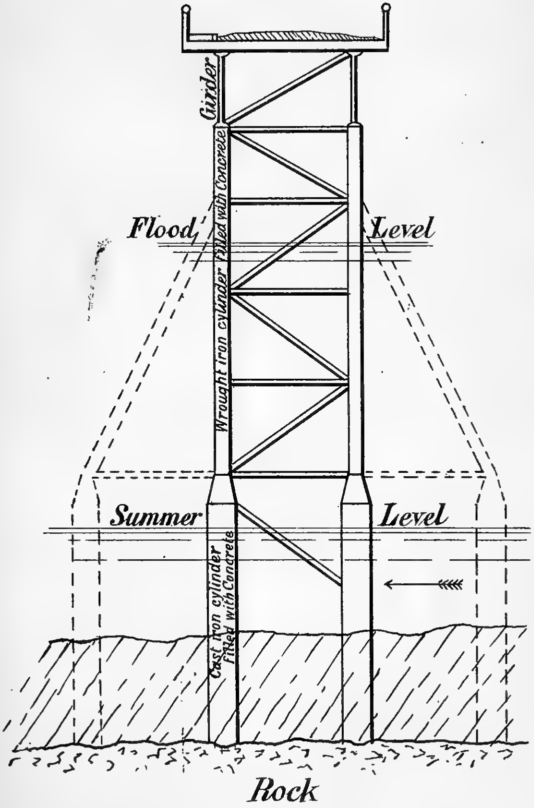
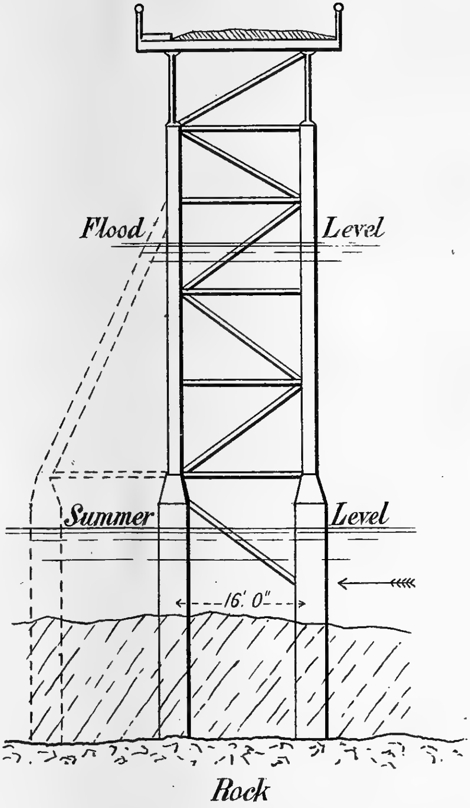

Girder
Wrought iron cylinder Filled with Concrete
Flood Level
Summer Level
Cast iron cylinder Filled with Concrete
Rock

Fig: 2.


Flood Level
Summer Level
16' 0"
Rock

Art. XXIV.—*Descriptions of New, or Little Known, Polyzoa.*

Part IV.

By P. H. MacGillivray, M.A., M.R.C.S., F.L.S.

(WITH TWO PLATES.)

[Read 14th December, 1882.]

Of the species of Retepora described in this paper, three are new; three others have already been briefly described by me in the *Society's Transactions* for 1869. Two of these, *R. granulata* and *R. porcellana* (as *R. robusta)*, have since been more fully described by Mr. Hincks, in a valuable paper in the *Annals and Magazine of Natural History* for May, 1878. We have one or two other undescribed species, as well as *R. monilifera* (McG.), *R. phœnicea* (Busk), *R. tessellata* (Hincks), and what I believe to be *R. cellulosa.* Of the last, I have not had an opportunity of examining European specimens, but I expect to receive authentic ones soon.

Retepora serrata, n. sp. Fig. 4.

Polyzoary expanded. Fenestræ about the same width as the interspaces, or slightly wider. Cells much elongated separated by raised lines; mouth nearly circular, or oval, projecting forwards, with a small sinus below, and a fringe of about twelve short, pointed processes arranged round the margin. Ovicell rounded, smooth. A sessile avicularium, with a long, narrow, pointed mandible at the bottom of each fenestra, opening directly upwards. Back obscurely tubercular, strongly vibicate.

Of this species I have one perfect specimen, dredged off Port Phillip Heads in about fifteen fathoms. The entire specimen forms a small expansion three-quarters of an inch in diameter, curved on itself on one side, where it is attached to the calcareous tube of an annelid. The colour is leaden grey. The cells are elongated, narrow, slightly expanded upwards, separated by narrow raised lines. In the youngest the mouth is smooth, the lower lip straight, slightly hollowed, or with a slight sinus. The peristome is rapidly developed to form a serrated circle of small, sharp teeth, projecting forwards; at the lower part of this circle is a small sinus. The ovicell is rounded, projecting, smooth, and destitute of a fissure. At the bottom of each fenestra is a sessile avicularium, the rostrum with a tooth on each side behind the strong curved apex, the mandible long, narrow, curved, and pointed. There are a few other large avicularia, situated on mound-like elevations on the cells, and with spatulate, or linguiform mandibles. The back is obscurely tubercular, glistening, divided into numerous angular spaces by narrow, sharply-raised ridges; a few scattered, rounded avicularia about the edges of the fenestræ.

Retepora aurantiaca, n. sp. Fig. 5.

Polyzoary expanded, foliaceous, convoluted. Fenestræ elliptical, or oval, about the same width as the interspaces. Cells quadrate, separated by narrow raised margins; mouth rounded above, straight below, with a deep narrow sinus, on one side of which is a rounded avicularium; a long, jointed spine articulated on each side of the mouth; usually a round, vertical, or oblique avicularium on the front of the cell. Ovicell large, pyriform, with a vertical narrow fissure, wider above, and with thickened margins. Back strongly vibicate, granular, and with numerous, small, rounded avicularia, similar to the anterior ones, especially abundant near the fenestræ.

Dredged off Port Phillip Heads.

The largest complete specimen I have found forms a foliaceous, convoluted polyzoary, three inches wide by about two in the other diameters. The base of attachment is about an inch long. Some fragments indicate that it attains a still larger size. The avicularium on the front of the cell is by no means constant. The ovicells are abundant, and have a very distinctive appearance. It is of a beautiful orange colour.

Retepora avicularis, n. sp. Fig. 6.

Polyzoary expanded, curled. Fenestræ elongated, wider than the interspaces. Cells elongated, separated by distinct margins; mouth arched above; lower lip with a small suboral avicularium at the centre (frequently absent, and leaving a loop-shaped notch), on each side of which is a triangular projection pointing upwards; a long spine articulated on each side of the mouth. Numerous large avicularia, the rostrum elevated, and with strong curved beak, the mandible triangular and pointed. Ovicell rounded, widely open below, crossed by an obscure ridge. Back smooth, vibicate, with scattered avicularia, with triangular mandibles.

Off Port Phillip Heads.

Of this elegant species I have only one complete specimen. It is three-quarters of an inch in length, by half-an-inch at the broadest part, and forms a slightly convoluted, leaf-like polyzoary. I have also three or four other fragments, which all present the same character. The small, central, suboral avicularium, with the triangular process on each side, is very characteristic. In place of the avicularium there is frequently a loop-shaped opening, no doubt formed by the destruction or loss of the chitinous part. The ovicell also is very distinct from that of any other species, and the huge avicularia, situated on the front of many of the cells, form very striking objects.

Retepora porcellana, M'G. Fig. 9.

(*R. robusta*, Hincks, *Ann. and Mag. N. Hist.*, May, 1878.)

Polyzoary massive, expanded, convoluted, or calyculate. Fenestræ elongated, narrower than the interspaces. Cells separated by distinct raised lines, terminating superiorly opposite the lower part of the mouth; mouth arched above, straight or slightly hollowed below; lower lip entire, with (usually) an avicularium immediately below it; a spine articulated on each side; an elliptical avicularium on the front of the cell toward the lower part, directed straight or obliquely downwards. Ovicell rounded, smooth, entire, not much projecting; when young with a broad, short, vertical opening, which, as growth advances, becomes filled in, and in some cases forms a prominent ridge. Posterior surface obscurely granular or slightly areolated, traversed by numerous raised lines, and usually with one or more small oval avicularia situated on each part defined by these vibices.

Port Phillip Heads and elsewhere.

Varies a good deal in appearance, according to age, old specimens being very massive, the fenestræ shorter and interspaces thicker than in younger ones. The form of the lower lip varies; it is usually straight and entire, with a rounded avicularium immediately below; sometimes there is a slight fissure in place of the avicularium, and occasionally there is a fissure towards one side, and on the wider part of the lip an avicularium. In young marginal cells there is no appearance of any sinus. In one specimen, which I was inclined at first to refer to a distinct species, the fenestræ are very long, and are formed by the irregular anastomoses of branches from a main stem. The cells are longer, the separating raised margins not so prominent, the avicularia not so regularly placed, and many of the oral spines, of which in the marginal cells there are frequently four or five, present the same telescope-like appearance as is seen in *R. monilifera.* The back is smooth, the vibices not so prominent, the enclosed spaces not so angular, and each with a small round avicularium near its centre. In another older and somewhat worn specimen, in which the mode of branching is precisely similar, many of the cells present the characters of the typical form.

Retepora granulata, M'G. Fig. 7.

Polyzoary massive, convoluted. Fenestræ rounded, small, much narrower than the interspaces. Cells elongated, separated by narrow raised lines; mouth arched above, straight below; lower lip with a narrow vertical sinus, on one side of which is a rounded avicularium; surface of cells granular or tuberculate; numerous small oval avicularia scattered over the cells, and a few larger situated on rounded elevations. Ovicells large, rounded, granular. Back of polyzoary granular, vibicate, with small, scattered, rounded avicularia.

Port Phillip Heads.

Of this, the most massive species with which I am acquainted, I have one perfect specimen four inches high, and of the same width at its widest part. It is attached by a stout calcareous basis. The polyzoary is very thick, foliaceous, twisted, and united so as to form several calyculate chambers. It is of a brownish colour (dried). The other specimens I have are mostly fragments. In addition to the usual granulations over the surface, in many cases there is a row forming small processes on the upper margin of the mouth. The young ovicell is fissured, the fissures becoming filled in as calcification advances. In some specimens there are numerous rounded avicularia scattered over the cells and ovicells, occasionally raised on small elevations. There are also other large avicularia with triangular mandibles, on large mound-like elevations.

Retepora fissa, M'G. Fig. 8.

Polyzoary expanded. Fenestræ narrower than the interspaces. Cells separated by narrow raised lines; mouth rounded above, lower lip hollowed, entire, or with a loop-shaped mark about the centre; a considerable avicularium with a triangular mandible near the middle of the cell, directed downwards and outwards. Ovicells large, rounded, prominent, with a vertical fissure wider above; posterior surface vibicate, slightly granular, with a few small avicularia.

Allied to *R. cellulosa.* The lower lip is usually entire, although sometimes (as in the figure) with a small loop-shaped mark or notch. The avicularium about the middle of the cell varies in its direction, being usually pointed obliquely outwards and downwards, sometimes nearly transversely outwards, and occasionally slightly upwards. It is sometimes very large, the rostrum much elevated on a calcareous basis, and the mandible long and triangular.

Hornera robusta, n. sp. Fig. 1.

Polyzoary composed of one or more thick, flattened stems, from which lateral branches extend on either side, these lateral branches frequently anastomosing with each other and with those from adjacent stems. Cells arranged in numerous longitudinal rows, separated by raised ridges; mouth in central cells slightly exserted; in the lateral and those near the edge the peristome produced and irregularly dentate. Back of polyzoary longitudinally sulcate; the narrow intermediate ridges thickly punctate. Ovicell large, posterior, elongated in the direction of the branch, pitted.

Port Phillip Heads.

My largest specimen measures an inch and three-quarters in height, and is of the same width at its broadest part. It originates in a single stem, which immediately divides into two, these again sub-dividing into several main branches.

From the main branches others spread on each side, nearly at right angles, in a penniform manner, and these again give origin to still smaller branches; these anastomose irregularly together, and the large branches from the neighbouring main stems frequently unite in the same way. Some specimens consist only of a single stem with lateral branches, frequently not so regular, while in others these stems are still more numerous. The resulting polyzoary in those with several stems is more or less expanded and curled. The anastomoses of the branches and branchlets are very irregular, being absent in some specimens, while in others they are very numerous. There is nothing like the regular fenestrate arrangement, which is seen in *Retihornera foliacea.*

Pustulopera regularis, n. sp. Fig. 3.

Polyzoary dichotomously branched. Cells arranged in nearly regular sub-spiral series, projecting above, indistinct below; mouth rounded, directed forwards; surface subgranular.

Port Phillip Heads.

I have only examined two specimens, the larger the one figured. The cells follow more or less spiral lines in both directions, so as to result in a nearly quincuncial arrangement. The upper part is prominent, the lower indistinct. The mouth is nearly circular, and the peristome sometimes produced into a very short tube.

It is closely allied to some of D'Orbigny's fossil species, and may prove to be identical with his *Entalophora subregularis.*

Fasciculipora gracilis, n. sp. Fig. 2.

Cells very long; arranged in flattened bundles, the upper parts usually distinct and free; surface thickly punctate.

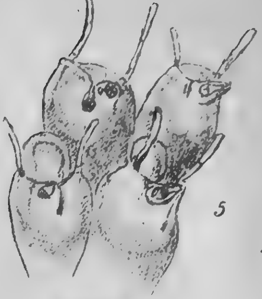
Port Phillip Heads.

The specimen, of which a portion is figured, grows on a small specimen of *Retepora aurantiaca.* There are two groups springing from the same calcareous basis. The cells are arranged in flat fasciculi, closely bound together at their bases, but at the summit separating into smaller bundles, or being each distinct and considerably projecting. The whole surface, including part of the free portions, is thickly

Plate I.

Plate II.


4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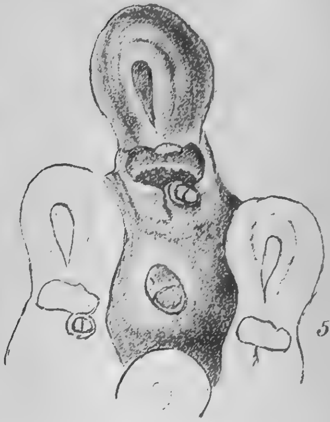
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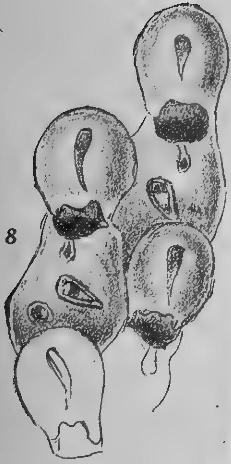
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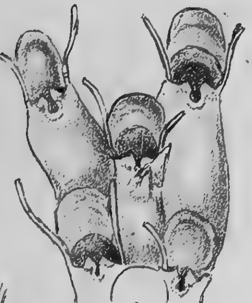
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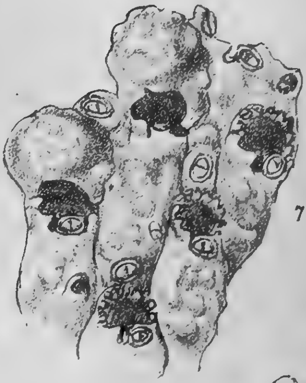
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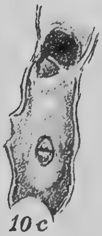
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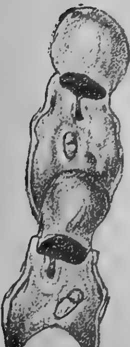
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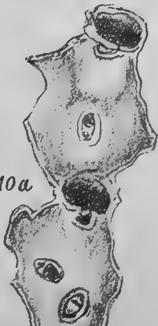
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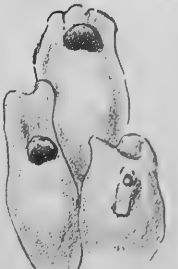
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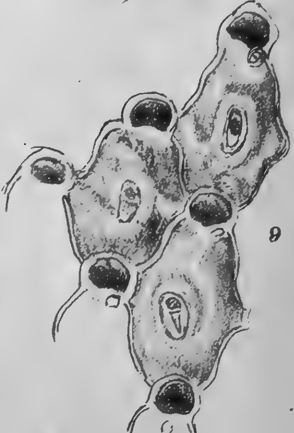
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P. H. McG. del. & lith.

1/100 inch

C. Troedel & Co. imp.

punctate. The mouth is circular and entire, and the part of the cell (peristome) immediately below it is smooth or with obscure transverse wrinkles. In many of the fasciculi the cells all end at the same level, are closely packed together, and have prismatic orifices. This is generally owing to the free portions of the cells being broken off.

EXPLANATION OF FIGURES.

PLATE I.

Fig. 1. *Hornera robusta.*
Fig. 2. *Fasciculipora gracilis.*
Fig. 3. *Pustulopora regularis,* natural size. Fig. 3*a.* Portion of same magnified.

PLATE II.

Fig. 4. *Retepora serrata.*
Fig. 5. *R. aurantiaca.* Young cells, showing oral spines. Fig. 5*a.* Older cell and ovicells.
Fig. 6. *R. avicularis.* Fig. 6*a.* Avicularium in profile.
Fig. 7. *R. granulata.*
Fig. 8. *R. fissa.*
Fig. 9. *R. porcellana.* Group of cells from old, worn specimen.
Fig. 10. Young cells from the growing edge. Figs. 10*a, b,* and *c.* Other cells, from the same specimen as 10.

Obituary.

THOMAS E. RAWLINSON, C.E.

Mr. Rawlinson was one of the founders of the Philosophical Institute, in 1854. He was subsequently active in promoting the union of that society with the Victorian Institute, the combined society receiving the name of the "Royal Society of Victoria." For many years Mr. Rawlinson was a member of the Council, and devoted himself with much zeal to extend the usefulness of the Society.

In 1856 Mr. Rawlinson read a paper entitled "The Importance of Sanitary Works for Towns, having Especial Reference to Collingwood, with Suggested Remedial Works for that District."

In 1857 he read a short note on a sawfish recently captured in Hobson's Bay.

In 1862 he read "Suggestions for the Formation of a Colonial Navy, and for Securing Speedy and Certain Communication with Europe and Defence of our Coast in Time of War."

In 1863 he read reports on the entrance to the Gippsland Lakes.

In 1864 he read "Notes on the Tidal Phenomena of Hobson's Bay, as Affecting the Discharge of Flood Waters from the River Yarra."

In 1865 he read a paper on the "Probable Erosion of the Mountain Ranges of Gippsland."

In 1874 he read "Notes on the Discovery of Keys near Geelong;" also a paper on the "Importance of a More Close and Systematic Observation of the Oceanic and Atmospheric Phenomena of our Coasts;" also a paper on the "Past and Present of the Port of Melbourne, and Proposed Works for its Improvement."

In 1876 he again returned to the subject of the improvement of the port of Melbourne.

In 1877 he read a paper on the "Coast-line Formation of the Western District, and Proofs of the Uniform Condition of Meteorological Phenomena over Long Periods of Time."

Mr. Rawlinson was in 1858 a member of the Exploration Committee which prepared and carried out the arrangements for the memorable expedition of Burke and Wills, and at other times he took a prominent part in the schemes of the Society.

In 1880, when he returned to England, he ceased to be an active member, though still connected with the Society; but he left the colony greatly broken in health, and after a long and tedious illness he died of heart disease, in Lancashire, on the 3rd of February, 1882.

Mr. Rawlinson was one of the few surviving original members; for nearly thirty years he maintained the same steady interest in its work. His papers were all of them intended to be of only temporary interest, and having done their work they are apt to be forgotten, but their author is worthy of remembrance for his zeal in helping to found and his industry in assisting to maintain a learned society in so small a community as that of Victoria in 1854.

MR. JOHN FLANAGAN

Became a member of the Society in May, 1861. He was for some years an active member of the Society, though he never contributed to the *Transactions.* He was born in 1835, at Manchester, and educated for the profession of architect in Dublin. He had no sooner served his articles than he emigrated to Melbourne, where in 1858 he entered into business as an architect. Some of the prominent buildings of the colony were built from his designs.

In 1871 he won the prize of £200 offered for the best design for the Eastern Market in Melbourne, but the building was not then erected. Five years later, when fresh designs were called for, he declined to compete, on the ground that he had already done so, and been successful. The erection of the building passed into other hands, and Mr. Flanagan suffered severely in health from the disappointment. In September, 1882, he died of consumption, at the comparatively early age of forty-six.

SIR CHARLES WYVILLE THOMSON

Was born in 1830. At the early age of twenty-one he became a lecturer on botany in the King's College, Aberdeen. Two years later he accepted the chair of natural history in the Queen's College, Cork. He had scarcely begun his work there, however, when the selection of Professor M'Coy to fill a chair in the University of Melbourne left a vacancy in the Queen's College, Belfast, which Professor Thomson was appointed to fill. The original work carried on by him while filling these positions was so great and valuable that he rapidly rose to occupy a leading position among the naturalists of Europe, and in 1868 he was chosen by the British Government to accompany a scientific expedition which explored the bed of the Atlantic. His well-known work, *The Depths of the Sea*, was a description of the expedition and its results.

Professor Thomson next occupied the chair of natural history in Edinburgh, and there carried on his original researches with still greater zeal. In 1872 he was selected to accompany the "Challenger" expedition in the capacity of chief of the scientific staff. Three and a half years were spent in an expedition on a grander and more successful scale than the world had previously seen. In every quarter of the globe the depths of the seas were carefully examined, and an enormous collection of specimens was gathered.

It was during the stay of the "Challenger" in Melbourne that Professor Thomson became an honorary member of this Society.

On the return of the expedition to England, Professor Thomson commenced the enormous task of editing the report. He had completed the two introductory volumes, and made a beginning of the detailed account, when, in 1879, an attack of paralysis forced him to desist, and leave the work in other hands. His health declined for some time, and at last, in March, 1882, a third attack of paralysis ended, at the age of fifty-three, one of the most distinguished careers of our time.

Professor Thomson was in 1876 knighted, as a testimony to the the value of his scientific services.

1882.

PROCEEDINGS.

ROYAL SOCIETY OF VICTORIA.

ANNUAL MEETING.

March 15*th*, 1883.

The President in the chair. Present, 22 members and associates.

The Annual Report and Balance-sheet for 1882 were read, as follow:—

"*Report of the Council of the Royal Society of Victoria, for the Year* 1882.

"Your Council has again to report the conclusion of a satisfactory year, during which the number of members increased, and the activity shown in the preparation of papers, in the attendance at the meetings, and in the discussion evoked by the various subjects of interest brought under the notice of the Society, was generally gratifying.

"We continued to send our Transactions to all the leading scientific societies of the world, and in return have received 59 volumes and 432 parts of scientific publications.

"The Council has agreed to set aside a certain sum annually for the binding of the valuable scientific works now stored away upon our shelves, and during the year have had sixty-three volumes bound.

"The Crown grant of the land on which the Society's hall is situated is now in course of preparation, and will ere long be in the possession of the Society. It will be issued in the names of Sir William Stawell, Mr. R. L. J. Ellery, Mr. E. J. White, and Mr. W. C. Kernot, as trustees for the Society.

"During the past session there have been elected 21 members and 8 associates. The Society now consists of 163 members, 6 corresponding members, 8 honorary members, and 41 associates; or, in all, 218 gentlemen belonging to the Society.

"During the year the Society held ten meetings in addition to the usual conversazione.

"On the 20th April Mr. J. Stirling read a paper on 'The Phanerogamia of the Mitta Mitta Source Basin and their Habitats.' Mr. W. W. Culcheth, M.I.C.E., read a paper on 'The Quantity of Water Consumed in Irrigation.' A paper by Mr. W. Mitten was contributed by Baron von Mueller, and ordered to be printed.

"On the 11th May Mr. Joseph read a paper on 'Electric Lighting.' Mr. Kernot, M.A., read a paper compiled by Mr. F. A. Campbell, C.E., on 'Experiments upon the Hard Woods of Australia.' Mr. White, F.R.A.S., reported that the committee appointed to examine the papers left by the late Governor Latrobe had perused them, and that the Government had consented to print them.

"On the 8th June Mr. Kernot, M.A., read a paper on 'Floods on the River Barwon.' Dr. Jamieson read a paper on 'The Influence of Light on the Development of Bacteria.' Mr. Rudall, F.R.C.S., read a paper, 'Remarks on Railway and Marine Signals, and on the Necessity of Accurate Testing of the Sight of Signal and Look-out Men by Land and Sea.' A short discussion took place on Mr. Culcheth's paper on 'The Quantity of Water Consumed in Irrigation.'

"On the 13th July Dr. MacGillivray read extracts from his paper, 'Descriptions of New or Little Known Polyzoa, Part II.' Mr. Ellery, F.R.S., read a paper by Mr. Barker, 'On Cyclones of the Southern Hemisphere.' Mr. Kernot, M.A., read a paper by Captain Griffiths, entitled, 'Propulsion of Steam Vessels without Machinery.'

"On the 10th August Mr. R. L. J. Ellery, F.R.S., read a paper by the Rev. J. E. Tenison-Woods, F.G.S., on 'A Physical Description of the Island of Tasmania.' Mr. C. W. Maclean read a paper on 'An Improved Grab Crane.'

"On the 14th September Mr. E. J. White, F.R.A.S., read a paper 'On the Performance of Some Timekeepers.' Mr. Kernot, M.A., read a paper on 'Experiments on Model Girders,' and Mr. Ellery, F.R.S., read some notes on 'The Coming Transit of Venus.'

"On the 12th October Dr. MacGillivray read his paper, 'Descriptions of New or Little Known Polyzoa, Part III.' Professor Nanson, M.A., read his paper on 'Methods of Election,' and Mr. P. Behrendt gave a 'Description and Estimate of an Electric Railway Suitable for Melbourne.'

"On the 16th November Mr. D. Anderson read a paper on the 'Improvements in Contrivances for Varying the Gauge of the Wheels of Rolling-stock for Rail and other Permanent Ways.'

Mr. W. C. Kernot, M.A., read his paper on the 'Lateral Stability of the Victoria-street Bridge.' A paper by the Rev. D. Macdonald was read, on 'The Oceanic Languages Shemitic : a Discovery.'

"On the 14th December Dr. MacGillivray's paper, 'Descriptions of New or Little Known Polyzoa, Part IV.,' was ordered to be printed.

"Volume XVIII. of the Transactions of the Society was issued on the 1st June, and forwarded to the members and to the Societies entitled to receive it. Volume XIX. is expected to be ready for members of the Society at the April meeting.

"The Council has to announce with regret the loss by death of the following members :—

"Mr. Thomas Rawlinson, C.E., who has been a member since the foundation of the Society. Sir Charles Wyville Thomson, who was elected an honorary member in 1874. Mr. John Flanagan, Architect, who was elected a member in 1861."

On the motion of Mr. Rosales, seconded by Mr. Blackett, the Report and Balance-sheet were adopted.

The office-bearers of the preceding year were re-elected for 1883. The following gentlemen were elected members of the Council:—Professor Andrew, M.A, Joseph Bosisto, M.L.A., Dr. James Jamieson, James T. Rudall, F.R.C.S., James Duerdin, LL.B., William H. Steele, C.E., C. R. Blackett, R. S. Bradley, T. B. Muntz, S. W. M'Gowan, R. E. Joseph, J. Cosmo Newbery, B.Sc.

BALANCE-SHEET.

The Hon. Treasurer in Account with the Royal Society of Victoria.

Dr.

	£	s.	d.	£	s.	d.
To Balance in Bank				£62	9	0
" Government Grant—1881–82				200	0	0
" Sale of "Transactions"				0	5	0
" Rents				4	10	0
" Eighteen Entrance Fees				37	16	0
" Subscriptions—						
66 Members	£138	12	0			
5 do. (Half-years) ...	5	5	0			
21 Country Members	22	1	0			
2 do. (Half-years)...	1	1	0			
26 Associates	27	6	0			
3 do. (Half-years) ...	1	11	6			
Arrears	26	5	0			
Commission	0	2	6			
				222	4	0
				£527	4	0

Cr.

	£	s.	d.
By Printing and Stationery	£166	7	0
" Binding	14	10	6
" Alterations to Hall	78	15	0
" Books	5	16	0
" Freight and Charges of Books and "Transactions"	14	6	2
" Conversazione and Teas	18	14	6
" Rates	4	13	4
" Gas and Fuel	4	15	4
" Repairs	13	7	9
" Clerical Assistant	26	0	0
" Hall-keeper	6	0	0
" Collectors	20	11	6
" Insurance	3	10	0
" Postage	22	8	9
" Petty Cash	3	10	0
	£403	5	10
" Balance in Bank	123	18	2
	£527	4	0

Compared with the Vouchers, Bank Pass-book, and Cash Book, and found correct.

2nd March, 1883.

(Signed) JAMES E. GILBERT } AUDITORS.
ROBERT E. JOSEPH }

STATEMENT OF LIABILITIES AND ASSETS.

Dr. LIABILITIES.	£	s.	d.	ASSETS. Cr.	£	s.	d.
To Three Debentures outstanding	£15	0	0	By Estimated Value of Outstanding Subscriptions	£20	0	0
,, Interest unclaimed	12	12	0	,, do. do. Rents due	5	0	0
,, Estimated Amount of other Outstanding Liabilities	10	0	0	,, Hall, Library, Furniture	3000	0	0
				,, Balance in Bank	123	18	2
	£37	12	0				
,, Balance	3111	6	2				
	£3148	18	2		£3148	18	2

20th April, 1882.

The President in the Chair—Present, 19 members and associates.

The following members signed their names in the members' book: —Mr. J. Stirling, Mr. Lane, and Mr. Chesney.

Mr. Spencer R. Deverill was nominated for membership. Mr. O. R. Rule and Professor Halford were elected members. Mr. W. Luplan, Mr. E. F. Pittman, Mr. J. Oddie, Mr. M'Lelland were elected country members.

Mr. H. V. Champion and Mr. H. M'Lean were elected associates.

Mr. Stirling then read a paper on the "Phanerogamia of the Mitta Mitta Source Basin," and exhibited a collection of plants made by him.

In answer to questions, Mr. Stirling said that the pepper-tree grows at the height of 5000 feet on the Australian Alps, and bears a dark bluish-black berry. There is a shrub with a large bushy top and woolly leaves called the "flannel plant," whose properties are as yet quite unknown. When cut down, and left for two or three days, horses and cattle will eat it as fodder. The clematis often climbs to the top of eucalypti 200 feet in height.

The President then laid on the table a paper on the "Mosses of Australia," by Mr. Mitten, of Sussex, England, which that gentleman had forwarded to Baron von Mueller for presentation to the Society.

Mr. Culcheth then read his paper entitled "Notes on Irrigation."

Mr. Kernot said the countries in which irrigation is most used in cultivation are Northern Italy and India. There the channels are placed 30 feet apart, and the ground between is cut up into small beds, surrounded by little trenches, which fill up when the channels overflow. In both these countries labour is so cheap that irrigation pays, but circumstances are very different here.

Mr. Ellery and Mr. Culcheth agreed that with a population so widely scattered as ours irrigation would be very costly, and would not give adequate returns.

Mr. Kernot said that he had recently noticed that the fall from Shepparton to Numurkah was only one foot in a thousand ; the evaporation in excessively warm weather amounts to only one-eighth of an inch per day; the soil is of a retentive, basaltic character, and offers every facility for irrigation.

Mr. Culcheth considered that the cheapest kind of irrigation was that of the water channels of India, where beds of about 500 to the acre are arranged on a gentle slope. As soon as the seed is sown, men admit the water to the different beds in succession by opening sluices in the channels.

Mr. Lane remarked that in America for small areas they irrigate by means of pipes let down below the surface, and containing numerous apertures, by which the water flows out after being pumped up from a river or lake.

After some conversational remarks as to the probability of success in any scheme of irrigation for Victoria the meeting closed.

11*th May*, 1882.

The President in the Chair—Present, 45 members and associates.

Mr. O. R. Rule and Mr. H. V. Champion, two new members, were introduced to the meeting.

Mr. Spencer Deverill was elected a member of the Society.

Mr. D. B. W. Sladen, B.A., and Mr. T. Shaw were proposed as members. Mr. John Booth was proposed as an associate.

Mr. E. J. White reported that the committee appointed by the Royal Society to confer with a committee of the trustees of the Public Library, in reference to the publication of the letters and historical documents left by the late Governor Latrobe had appointed a sub-committee, consisting of Professor Irving, Mr. Sutherland, and himself, to examine and report on these papers. This sub-committee had reported that the papers were all worthy of publication, and the Government had, with great liberality, promised to have them printed.

Mr. R. E. Joseph then read a paper on "Electric Lighting."

Mr. Kernot said that, while it was possible that in Melbourne, where coal was of comparatively easy access, gas might be cheaper than electricity, in many of the country townships there could be no doubt that the advantage lay with the latter. In a country like Switzerland the abundant waterfalls might make the cost of light almost nominal; but even in Australia such townships as have abundance of fuel in the shape of timber would find electricity much the cheaper. In so warm a climate as this the electric light presents a great advantage in not raising the temperature of the room lighted up by it.

Mr. Ellery and Mr. Foord said that the secondary battery invented by Mr. Sutton, of Ballarat, may perhaps be of much assistance to the success of electric lighting.

Mr. Blackett asked which of the incandescent lamps was considered to be the best?

Mr. Joseph said that he had tested only one, the "Swan;" but it was said that the "Moxim" was superior. It had a thicker carbon; but though it might give better light it certainly did not last so long. After 800 hours it breaks down completely.

Mr. Kernot said that the chief objection to the arc light was that either a great quantity of light or none at all must be used. The light given by the incandescent lamp is more expensive, but more useful.

Mr. Kernot then read a paper by Mr. Campbell on the "Strength of Colonial Timber."

At the conclusion of the meeting the President mentioned that a memorial was being erected to the memory of the late Professor Wilson, one of the earliest and most active members of the Society; he asked the Society to contribute so far as they could to this desirable object. Professor Wilson died while engaged on the greatest scientific work yet done in Australia.

8th June, 1882.

The President in the Chair—Present, 19 members and associates.

Mr. D. B. W. Sladen, B.A., and Mr. Thomas Shaw, were elected members, and Mr. John Booth, C.E., was elected as an associate.

The following associates were introduced to the meeting :—Mr. John M'Lean, Mr. W. Finney, and Mr. J. C. Jones.

A further discussion of Mr. Culcheth's paper on irrigation then took place, after which Mr. Kernot read a paper entitled "Some Remarks on the Barwon Flood of 1880."

The papers elicited some conversational discussion.

Dr. Jamieson read his paper, "The Influence of Light on the Development of Bacteria."

Dr. Rudall read his paper on "The Necessity of Accurately Testing the Sight of Signalmen by Land and Sea."

13th July, 1882.

The President in the Chair—Present, 17 members and associates.

The following new members and associates were introduced to the meeting :—Mr. D. B. W. Sladen, B.A., Mr. S. R. Deverill, Mr. Steane.

A ballot for the election of Mr. H. Cornell, as a member, and of Mr. H. Sutton and Mr. C. E. Oliver as country members, resulted in the election of these gentlemen.

The Hon. Librarian reported that during the month 7 volumes and 83 parts of scientific publications had been added to the library, and that 63 volumes had been bound.

Dr. MacGillivray then read some "Notes on New Australian Polyzoa, of the Species *Membranipora, Microporella, Lepralia, Schizoporella*," mentioning that they closely resembled the species found in the Gulf of Florida. He then exhibited some plates of specimens.

Mr. Ellery mentioned that these plates had been drawn on stone by Dr. MacGillivray himself, and that the Society was very much indebted to that gentleman for the great care with which he had prepared them.

Mr. Ellery then read a paper by Captain Barker, of the ship "Sobraon," on "The Cyclones of the Southern Hemisphere.' After the paper was concluded, Mr. Ellery said—We generally get two days' warning of the approach of these storms—that is, if they move in a true course. But they do not always move in the curve which theory assigns to them, owing, I suppose, to the intervention of causes hitherto unknown to us. By electric telegraph from Western Australia we are warned under ordinary circumstances two clear days before they reach us. So far as I am aware, this paper is one of the first attempts to give a definite account of the cyclones of southern latitudes.

Mr. Kernot.—Is it yet definitely established how these cyclones originate ?

Mr. Ellery.—The temperature of the air is undoubtedly the primary cause, but the friction of the earth has much to do with their force and direction. We may take it as an ascertained fact that cyclones, wherever they may be, are always attended with anticyclones.

Captain Barker.—The duration of these storms varies from a few hours to a couple of weeks. Their diameter often exceeds 600 miles.

Mr. Kernot then read a paper by Captain Griffiths, on a "Proposal for the Propulsion of Steamers Without the Intervention of Machinery." He observed that the method proposed had no advantage over the present system, either in cheapness or in the actual speed attained.

Several members related the attempts already made by engineers and scientific men to attain this object.

August 10*th*, 1882.

The President in the chair—Present, 15 members and associates.

Mr. John Wall was elected a member. Mr. J. P. Wilson, M.A., was elected an associate.

Mr. H. Cornell, a new member, was introduced to the meeting, and signed the members' book.

Mr. Ellery then read a paper, "A Physical Description of the Island of Tasmania," by the Rev. J. E. Tenison-Woods.

In connection with this paper, Mr. Ellery gave a description of a remarkable mimosa scrub found in Tasmania. This grows on elevated places, where it is blown down by the wind. The branches take fresh root in the soil, and new plants spring up, which are in turn blown down, and again take root. In this manner immense tracts of land are rapidly covered with a dense brushwood.

Mr. Kernot described a somewhat similar phenomenon he had witnessed on the top of the Buffalo Ranges, 4000 feet high. The scrub there is so thick that the only mode of progress is to walk on top of it 5 feet above the ground.

Mr. M'Lean then read his paper on "A New Dredge Crane," and exhibited a fine model of the contrivance.

Mr. M'Lean, in answer to questions, said that it had raised about 600 tons in eight hours, but that was with many stoppages, on account of an insufficient supply of barges. Without stoppages, he thought 1000 tons in eight hours might be a fair average. The dredging we have to do in the South Channel is something over 30 feet deep. The new crane will dredge to 30 feet. It need not be confined to silt and light soils. It can be used to excavate solid earth for reservoirs. Mr. M'Lean then pointed out the main difference between this crane of his invention and previous grab cranes. In answer to further questions, he said that with the old cranes, when the scoop seized a rock or root that could not be moved, a diver had to be sent down to release it. He showed on the model how the simple pulling of a rope would release the new scoop. With the ordinary dredge the buckets are raised much higher than necessary, thus wasting time and power. The new one merely lifts the weight to the height actually required, swings it round and deposits it. It lifts three tons per minute.

14*th September*, 1882.

The President in the Chair—Present, 19 members and associates.

Mr. J. R. Corr, M.A., and Mr. P. Behrendt were elected members. Mr. D. Anderson was elected as an associate.

Mr. J. P. Wilson and Mr. Chas. Rowan, two new members, were introduced to the meeting.

Mr. E. J. White read his paper on the "Performance of Some Timekepeers," and in answer to questions said that the chief causes of variation were change of temperature and change of position. Most watches would go at different rates when lying horizontally and when standing upright.

Mr. Ellery then said that a transit of Venus was fast approaching. There had been one eight years ago, but the next would not occur for 121½ years. From England and the Continent there are many observing parties coming out to Australia and New Zealand. Here the sun will rise at a quarter to five on the 6th December, and at that time the planet will be in the middle of the sun's disc, so the egress will be distinctly visible to us.

Mr. Kernot then exhibited two models of iron girders—one representing a girder on a railway footbridge in Melbourne; the other that girder as it ought, on scientific principles, to be. The latter contained half the material, but sustained a load of 770 lbs., while the former broke with 208 lbs.

Mr. Barnes objected to the manner in which Mr. Kernot held up to ridicule the work of practical men, who had in the early days of the colony done the best with the material at their disposal.

Mr. Kernot said he had studiously avoided ridicule. All he wished to show was that the designers of these girders had wasted their materials without gaining strength.

Mr. Ellery thought it Mr. Kernot's duty, as professor of engineering at the University, to call attention to the faults of defective structures wherever he found them.

12*th October*, 1882.

The President in the Chair—Present, 35 members and associates.

Mr. R. Stephens, B.A., was duly elected a member; Mr. Wakelin a country member.

The Hon. Librarian reported that during the month 14 volumes and 47 parts of scientific publications had been received.

Dr. MacGillivray then read the third portion of his paper on "New, or Little Known, Polyzoa," and exhibited engravings of them.

Mr. Behrendt read a paper entitled "Description and Estimate of an Electric Railroad for Melbourne."

Mr. Kernot remarked that electric railways had many advantages for city traffic. Not only were the annoyances of smoke and noise avoided, but by their elevation these railroads interfered less with traffic than any other street railway. There was no ponderous locomotive to carry, hence a saving in the permanent way and in the power used.

Several other members concurred in the idea that such railways would be of great advantage in Melbourne.

Professor Nanson read his paper on "Methods of Election," the discussion on which was postponed to a future meeting.

16*th November*, 1882.

The President in the Chair—Present, 26 members and associates.

Mr. Joseph Summers was elected a member, Mr. J. A. Stuart a country member, and Mr. J. H. Horner an associate.

A communication was received from Mr. E. L. Marks, lecturer at the School of Mines, Sandhurst, stating that he had analysed a specimen of a so-called non-alcoholic wine, with the result that alcohol was shown unmistakably to be present, as well as iodoform.

Mr. D. Anderson then read his paper on "Improvements in Contrivances for Varying the Gauge of Wheels of Rolling Stock for Rail and other Permanent Ways." He likewise exhibited a model of his invention.

Mr. Kernot pointed out that the gauge in use in New South Wales being 4 ft. 8½ in., while that of Victoria is 5 ft. 3 in., some such contrivance became of the utmost utility in encouraging intercolonial traffic. Mr. Anderson's invention was not costly, and might be used on a large scale.

Mr. White said that New South Wales was entirely responsible for the differences in gauge.

Mr. Kernot then read his paper, "The Lateral Stability of the Victoria-street Bridge."

Mr. Ellery said that a considerable lateral stability was very necessary, as so little was known of the force of sudden wind gusts in ravines.

Mr. Kernot said that the result of some experiments he had recently made was that even in gusts the ordinary pressure of the wind was only some 3 lbs. or 4 lbs. to the square inch ; 5½ lbs. was an uncomfortably strong breeze. There are many of our Melbourne chimneys and steeples which will fall if the wind pressure exceeds 12 lbs. to the square foot.

The Rev. D. Macdonald read extracts from his paper, "The Oceanic Languages Shemitic: a Discovery."

14*th December*, 1882.

The President in the Chair—Present, 14 members and associates.

Mr. G. S. Griffiths and Mr. Thomas Walters were elected members, and Messrs. J. H. Fraser and H. W. Mills associates.

The Hon. Librarian announced the receipt of 8 vols. and 105 parts.

Mr. M'Ivor then read a paper on "Whakaari, a New Zealand Sulphur Island."

Mr. M'Ivor exhibited specimens of sulphur he had collected when in New Zealand.

In answer to questions, Mr. M'Ivor stated that the springs generally shoot straight up—some to the height of 50 feet—and that there are ten fumeroles on one side of the centre lake. The total area is estimated at about 640 acres. The meaning of the

Maori word "whakaari" is "the mouth or place of vapour." All action appears to have ceased on one side of the lake, and as far back as the Maories can recollect it has been in the same state. It is a remarkable thing that the escape of gas in these springs is much more violent in the middle of the day than at any other time. It gradually lessens in the afternoon, till it reaches a minimum in the night.

Mr. Ellery remarked that in all perennial and intermittent springs this has been observed.

In reply to a question from Mr. Ellery, Mr. M'Ivor stated that the quantity of mineral matter in solution was as much as 2 lbs. to the gallon. After some few further remarks the discussion closed.

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Muntz, T. B., Esq., C.E., 41 Collins-street West
Murray, K. L., Esq., Railway Department, Melbourne

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Neild, J. E., Esq., M.D., Collins-street East
Newbery, J. Cosmo, Esq., B.Sc., C.M.G., Technological Museum
Noone, J., Esq., Lands Department

Parkes, Edmund S., Esq., Bank of Australasia
Parnell, Major E., 148 Latrobe-street West
Paul, Rev. A., Chapel-street, East St. Kilda
Phelps, J. J., Esq., Melbourne Club

Ridge, Samuel H., Esq., B.A., Messrs. Collins, M'Petrie and Ogilvie, Sandridge
Rosales, Henry, Esq., care of J. Hood, Esq., Exchange, Melbourne
Rudall, J. T., Esq., F.R.C.S., 121 Collins-street East
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