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TABLE OF CONTENTS.

CONTENTS OF NO. I.

CONTENTS OF NO. II

CONTENTS OF NO. III.

CONTENTS OF NO. IV.

ERRATA.

p. 29, line 20, for "Fox Hills" read Ft. Pierre.

p. 43, line 15, for "*argentifacies*" read *nobilis.*

p. 109, line 18, for "beyond" read before.

p. 125, line 21, for "*Panicum sanguinale*" read *Setaria germanica.*

The plates illustrating Prof. Blackmar's article "Penology in Kansas" numbered "1. 2, 3, 4" and "5," should be numbered 14, 15, 16, 17 and 18.

INDEX.

A

B

C

G

H

I

K

L

M

N

O

P

Q

R

S

KANSAS PTERODACTYLS.

BY S. W. WILLISTON.

PART I, WITH PLATE I.

The first American species of the singular group of extinct Mesozoic reptiles variously know as Ornithosaurs, Pterosaurs or Pterodactyls was described by Marsh from a fragmentary specimen obtained in 1870, by the Yale College Expedition in Wallace County, Kansas. About a dozen other specimens were obtained by a similar expedition the following year in charge of Professor Marsh, or by Professor Cope, and were described by these authors shortly afterward. By far the largest number of known specimens, however, other than those in the Kansas University Museum, were obtained during the years 1874, '75, '76 and '77 by parties of which Professor Mudge, Dr. H. A. Brous, E. W. Guild, George Cooper and myself were the members, and it was from these specimens that most of the published characters were derived. Many of these specimens are necessarily fragmentary ones, still the material now in the Yale College Museum is ample to elucidate everything of interest concerning these animals.

During the past few years, the Museum of Kansas University has been enriched by a series of excellent specimens of these animals, obtained from the same regions, specimens that permit the solution of most of the doubtful characters and throw not a little light on the affinities of the Kansas forms.

The species hitherto named are as follows:

PTERANODON.

Pteranodon Marsh, Amer. Journ. Sci. xi, p. 508, June 1876; and xii, p. 479, Dec 1876; xxiii, p. 253, April, 1882; xxvii, p. 423, May, 1884; Williston, Amer. Naturalist, xxv, p. 1174, Dec. 1891.

Pteranodon occidentalis.

Pterodactylus Oweni Marsh, Amer. Journ. Sci. i, p. 472, June 1871, Sep. p. 16 (nom. preoc).

Pterodactylus occidentalis Marsh, Amer. Journ. Sci. iii, p. 242 , April 1872, Sep. p. 1; Cope, Cretac. Vert. p. 68, pl. vii, ff. 5, 6.

Ornithocheirus harpyia Cope, Proc. Amer. Phil. Soc. 1872, p. 471 (Cope).

This species was originally based upon the distal end of two wing-metacarpals, and teeth. In the following year, a fuller description was given of additional remains referred to the same species and renamed *P. occidentalis*.

Pteranodon ingens.

Pterodactylus ingens Marsh, Amer. Journ Sci. iii, p. 246, April 1872, Sep. p. 6.
Pteranodon ingens Marsh, Amer. Journ. Sci. xi, p. 508, June 1876.

This species is based upon various bones of the wing-finger of several individuals, and three teeth.

Pteranodon umbrosus.

Ornithocheirus umbrosus Cope, Proc. Amer. Phil. Soc. 1872, p. 471.
Pterodactylus umbrosus Cope, Cret. Vert. p. 65, pl. vii, ff. 1-4.

Marsh (Amer. Journ. Sci. xii, p. 480, Dec. 1876) says this name is a synonym of *P. ingens*, published two days earlier. As this synonymy is not certain, and as Cope's species has been figured, I am not ready to accept his views.

Pteranodon velox.

Pterodactylus velox Marsh, Amer. Journ. Sci. iii, p. 247, April 1872, Sep. p. 8.

Based upon the distal end of the right metacarpal of the wing-finger, and the proximal extremity of the adjoining first phalanx, two uncharacteristic parts of the skeleton, Marsh to the contrary notwithstanding. It is doubtful whether the direct comparison of the types will suffice to determine the species with certainty. "Both of the bones are somewhat distorted by pressure."

Pteranodon longiceps.

Pteranodon longiceps Marsh, Amer Journ. Sci. xi, p. 508, June 1875; xxvii, p. 424, pl. xv, May 1884.

Based upon a somewhat defective skull, without other bones. There is no evidence whatever that the species is distinct from the preceding.

Pteranodon comptus.

Pteranodon comptus Marsh, Amer. Journ. Sci. xi, p. 509, June 1876.

Based upon wing-bones of three individuals. The description is meagre.

Pteranodon nanus.

Pteranodon nanus Marsh, Amer. Journ. Sci. xxi, p. 343, April 1881.

Based upon various remains of one individual; the humerus, alone, is recognizably described.

NYCTODACTYLUS.

Nyctosaurus Marsh, Amer. Journ. Sci. xii, p 480, Dec 1876. (nomen preoc.*).
Nyctodactylus Marsh, Amer. Journ. Sci. xxi, p. 343, April 1881; ibid. xxvii, p. 423, May 1884.

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* This preoccupation rests, so far as I am aware, upon Marsh's statement. I can find no evidence of the name having been previously used.

Nyctodactylus gracilis.

Pteranodon gracilis, Marsh, Amer. Journ. Sci. xi, p. 508, June 1876.
Nyctosaurus gracilis Marsh, Amer. Journ. Sci. xii, p. 480, Dec. 1876.
Nyctodactylus gracilis Marsh, Amer. Jour. Sci. xxi, p. 343, April 1881.

PTERANODON.

Skull.

Fragmentary portions of the skull of Pteranodon are not at all rare in the Kansas chalk; but it is exceedingly seldom that a complete, or even approximately complete specimen is found. Their great length and slenderness, together with the extensive pneumaticity of the bones, render their preservation, as a whole, a thing of great rarity. Probably the most nearly perfect one yet known is now in the Museum of Kansas University. It was discovered the past summer by Mr. E. C. Case, a member of the University Geological Expedition. The specimen was carefully cleaned on its upper surface, as it lay in the chalk, and then imbedded in plaster before removal. The surface now exposed was the under one, which surface is, almost invariably, better preserved and less distorted than the upper one in these animals. A figure of this specimen is given in Plate I. The only portion restored is that indicated by the line in the lower jaw; it is possible that this part of the symphysis may not be exactly as it is drawn. Other, incomplete, specimens in the Museum confirm the outlines, except in the occipital crest, which is not present. As stated by me in the American Naturalist (*l. c.*), the type specimen of *Pteranodon*, also collected by myself, was incomplete, and the figures of it, as given by Marsh, are faulty.

The elements of the skull are all so firmly united that they can not be distinguished. There are no indications whatever of a horny sheath enclosing the jaw, and it is improbable that the covering of these parts was essentially different from that in the slender jawed *Pterodactylidæ*. In texture, the maxillaries are fine-grained, and wholly without the vascular foramina found in the corresponding bones of birds. The bones are composed of two thin and firm plates, separated by cavities which are bounded by irregular walls of bony tissue. In the compression from which all the Pterodactyl bones have suffered more or less, the greater resistance of these walls has caused irregularities upon both the outer and the inner surfaces. At the borders of the bones, where the thickness has been greater, the roughening is not observed.

Seen from above, the skull is narrow, as stated by Marsh; but, contrary to his statement, there is not a sharp ridge extending along the upper border. This border is obtuse and rounded, and in the frontal region, flattened. The sagittal crest is large, but not nearly so large as it is figured by Marsh, the restored outline of whose figure is undoubtedly wrong. The texture of the bone forming the crest is materially different from that of the remaining bones of the skull. The bone is more roughened, and less firm. There is a well-developed ring of sclerotic ossifications. In the specimen figured, the separate plates measure from six to eight millimeters in diameter. They were not imbricated, as in the Pythonomorpha, but have a similar dense texture. There is a superior temporal arch, bridging over a small opening leading downward to the inferior temporal fossa. The following measurements will give the principal dimensions of this specimen.

Length from tip of premaxillary to occipital condyle	680 millim.
Extreme length of skull	780
Extent of crest beyond orbit	145
Greatest diameter of orbit	65
Antero-posterior diameter of nasal opening	135
Length of quadrate	120
Width of lower jaw at articulation	22

Pubis.

In a previous paper on the anatomy of *Pteranodon*,* I stated that I had never seen the so-called "prepubic bones." Since that time, however, an excellent specimen of them has been discovered among our material. The specimen of which they are a part consists of the larger portion of the skeleton, and is perhaps conspecific with the one to which the described pelvis belongs. The figure given herewith will convey a good idea of their shape. The bones of the two sides are firmly co-ossified, and have been pressed nearly flat; the figure repre-

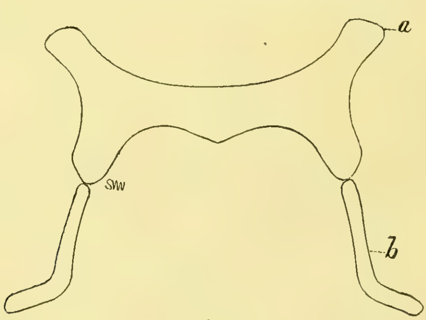

FIG. 1.

* Amer. Naturalist, Dec. 1891, p. 1124. In this article the description of the foot-phalanges should read: "All are slender, except the second one in the third toe, and the second and third in the fourth toe, where they are scarcely longer than wide."

sents them as they are spread out in one plane. The bone is very thin throughout, with a slight thickening at the ischial (*a*) attachment only. Lying contiguous with the anterior projection, is a slender ventral rib (*b*). It is possible that the curvature of this bone may be inward, rather than outward.

This peculiar structure of the pubis (I belive it represents the pubis, and not the prepubis) seems to be quite similar to that which obtains in the genus *Rhamphorhynchus*, and, perhaps also, in *Pterodactylus suevicus* (*Cycnorhamphus* Seeley), and very different from that found in other species of *Pterodactylus*.

The principal measurements of the above described specimen are as follows:

Antero-posterior expansion	40 millim.
Length of symphysis	14
Expanse of the united bones, as flattened	90
Width of ischial process	11

NYCTODACTYLUS.

The type species of this genus was described as follows by its author (loc. cit. supra):

"One of the smallest American species yet found is represented in the Yale Museum by several bones of the wing, a number of vertebrae and the nearly complete pelvis. The wing-bones preserved are elongated and very slender. The pelvis is unusually small, and there are five vertebrae in the sacrum. The last of the series indicates that the tail was short. The following are the principal measurements of this specimen:

Length of ulna	187 millim.
Length of metacarpal of wing-finger	300
Antero-posterior diameter of outer condyle at distal end	15
Transverse diameter of shaft, above condyles	13
Length of first phalanx of wing-finger	347
Extent of five vertebrae of sacrum	57

This species, which may be called *Pteranodon gracilis*, was about two-thirds the size of *P. velox* Marsh. It probably measured about ten feet between the tips of the expanded wings."

In the December number of the same volume of the American Journal of Science, he described the genus as follows:

"A second genus of American Pterodactyls is represented in the Yale museum by several well preserved specimens. This genus is nearly related to *Pteranodon*, but may be readily distinguished from it by the scapular arch, in which the coracoid is not co-ossified with the scapula. The latter bone, moreover, has no articulation at its distal end, which is comparatively thin and expanded. The type of this species is *Pteranodon gracilis* Marsh, which may now be called *Nyctosaurus gracilis.* It was a Pterodactyl of medium size, measuring about eight to ten feet between the tips of the expanded wings."

The specific description of this species rests solely upon the measurements; the other characters given are not only vague, but are also common to all the known species. The generic description, as it is seen, is based upon the structure of the coraco-scapula. It will also be observed that the characters are not drawn from the type specimen, as that did not include this part of the skeleton, according to the author's statement. Of these two characters, the non-ossification of the coracoid and scapula is a somewhat doubtful one, as the same character may or may not occur in allied species, as, for example, in the species of *Rhamphorhyncus* (*R. Muensteri* Goldf.) described by the author himself. So incomplete and unsatisfactory are the characters thus given that Zittel, in his Handbuch, dismisses the genus with the brief remark, "noch unbeschrieben."

Nevertheless, from the peculiar form of the scapula, and from my recollection of the specimens upon which the genus was based, I believe I have determined with certainty an excellent specimen in the Snow Museum of Kansas University as a member of it, and here give a sufficiently complete description to place the genus on a more secure foundation.

This specimen was collected by Professor E. E. Slosson, of Wyoming University, while a member of my party in western Kansas the past season. It was partly exposed upon a gently sloping surface of firm yellow chalk on the Smoky Hill river, in the vicinity of Monument Rocks. Originally, the nearly complete skeleton must have been preserved, but a number of the bones had been either wholly or partially washed away, in some cases leaving their imprint in the chalk. The bones uncovered, and now lying upon the chalk slab nearly in their natural relations, are a humerus, both radii and ulnae, a pteroid, the two carpals of one wrist, both wing metacarpals, a first and a last wing phalanx, both coraco-scapulae, the posterior part of the lower jaws, ilium, femur, sternum, numerous ribs and vertebrae. The two coraco-scapulae lie with their scapular ends nearly touching, and their coracoid ends separated by a space equivalent to the width of the sternal articulation. The two elements appear to have been imperfectly united and were probably not co-ossified. The inferior border of the coracoid, near the humeral articulation, has a greater expansion than is found in *Pteranodon*; its shaft is more rounded and less rugose, lacking especially the strong muscular markings upon the external surface. The articular surface does not appear to differ materially from that in *Pteranodon*. The scapula is of nearly the same length as the coracoid, but is much less stout. It is a thin, spatulate bone, slightly expanded at the distal extremity, where the margin is rounded, and without the characteristic oblique articular facet. It has no supra-glenoid expansion or process on the posterior proximal border, but has its margin nearly straight or gently concave from the articulation to its extremity. The space included between the bones of the two sides as they lie is a nearly regular, oval one, measuring ninety-five millimeters in its greater, forty-five in its lesser diameter.

The sternum lies at a little distance from the coraco-scapulae. It is an extremely thin bone, with a stout anterior, styliform projection, at the base of which, on either side, looking upward and outward, is the articular, trochlea-like surface for the sternal end of the coracoid. The width between these articular surfaces measures fifteen millimeters; the length of the process in front of the articulations is twenty-five millimeters. Immediately posterior to the articular surfaces, the bone expands nearly at right angles to the longitudinal axis to a width of about sixty millimeters. The thin lateral margins are nearly parallel with the longitudinal axis, and show three shallow emarginations between the four costal articular projections. The hind angles are nearly rectangular. The bone, as preserved, is only shallowly concave, and shows no true keel, though a more pronounced median convexity towards the front doubtless subserved the function of a carina in part.

The left humerus lies in position, and is especially characterized by its enormous deltoid crest (radial crest of Marsh), though otherwise slender. This crest is further removed from the head of the bone than is the case in species of *Pteranodon*. It is directed somewhat downward, and has its distal, gently convex, border about twenty-five millimeters in extent, while the width of the process midway between the extremity and the base measures but sixteen millimeters. The bicipital crest is also prominent. The bone is relatively shorter than in *Pteranodon*.

The humerus, as will be seen from the above description, and from the measurements given below, is remarkably like the same bone in *Pteranodon nanus*, as described by Marsh (*l. c. supra*), and but a little larger. In *P. nanus*, however, the coracoid and scapula are said to be firmly co-ossified, and the scapula has of course a different structure.

The skull has been, unfortunately, almost wholly washed away, a fragment of the cranial wall and the posterior part of the lower jaws alone remaining. It is impossible, hence, to say much concerning this part of the anatomy. The lower jaws show a different structure from that in *Pteranodon*. As they lie in their natural position, the width at the condyles is about twenty-four millimeters. The angular is less produced posterior to the articulation than in *Pteranodon*, indicating a less elongated and less powerful mandibular portion, an indication further borne out by the slenderness of the rami. The impression in the chalk shows the symphysis to begin ninety millimeters from the articulation. The width at this place could not have exceeded sixteen millimeters; and the entire length of the lower jaws could hardly have been more than one hundred and twenty-five millimeters. In the parts preserved, measuring seventy-five millimeters, there are no indications of teeth; yet it is not impossible that there may have been teeth in the anterior portion of the dentary, as in some species of *Pterodactylus*,. I hardly think it probable, however.

There are seven cervical vertebrae preserved, apparently the full complement, as in *Pteranodon* and other members of the order. They differ in no especial respect from the corresponding vertebrae of *Pteranodon*, and, apparently, of *Pterodactylus*. The imperfectly anchylosed, possibly free, atlas shows three pieces, the odontoid process and the two slender lateral pieces. The lateral pieces are entirely free, with a thickened base and a slender, curved upper portion. The odontoid is gently concave in front, and seems to be imperfectly ossified with the axis; it occupies the lower part of the articulation, corresponding to the hypapophysis of the Pythonomorpha. The axis is the shortest of the remaining vertebrae, and has a well developed spine. The centrum is strongly convex behind, as are the remaining centra of the series. The following five vertebrae decrease gradually in length. The anterior ones have only a thin ridge or plate for the neural spine; the seventh, however, has a neurapophysis of some length. They are all, as is usually the case, somewhat distorted from pressure. The under side is flattened, apparently gently concave longitudinally, and with a lateral ridge terminating in an obtuse hypapophysis at each inferior hind angle.

In his discussion of the Pterosauria, Zittel says concerning the vertebrae: "zwischen oberen Bogen und Centrum ist keine Sutur zu bemerken." Handbuch, iii, p. 776. In this he is in error, so far as the American forms are concerned. It is usually the case in the Kansas specimens of both genera that the neural arch of the post-cervical vertebrae is wholly or in part detached from the centrum, showing a sutural, and not anchy- losed union in life. The centra of twelve vertebrae are preserved, in the present specimen, from the region back of the neck; in only five of them are the neural arches in any way attached. Three of these are evidently anterior thoracic, judging from their structure and the position in which they lie. The shortest of them, to which was attached a very large rib, and which was lying in front of the scapulae, may represent the first thoracic vertebra (*a*). Its centrum is fully as wide as long, is flat on the under surface, and has a large, stout, horizontal parapophysis near the anterior end. Just above this process for the attachment of the head of the rib, and separated by a deep notch, is a much more elongated, horizontal diapophysis for the tuberculum. The cup of the centrum is shallowly concave; the transverse, shallowly U-shaped ball is only a little convex.

Two other vertebrae (*b*), found close by the one just described, and possibly one or the other contiguous with it, differ remarkably in having no, or a rudimentary, parapophysial process, and in having the diapophyses much shorter. It is not impossible that a slight expansion at the lateral margins of the ball may represent small parapophyses. In *Pteranodon* there are at least four vertebrae with dia- and parapophyses. In the other vertebrae from this region the diapophyses are yet shorter and the neural spine stouter and broader. The other centra preserved are all shaped somewhat like the half of a cylinder, and are a little longer than broad. They have no distinct cup or ball. In two of them there is a very long, recurved parapophysial process, as though formed by an anchylosed rib, on each side; they are probably lumbar vertebrae.

Most of the ribs are very slender; a few are moderately thickened; one only is very stout; its measurements are given below.

Length of lateral pieces of the atlas	7 millim.
Diameter of lateral pieces at the base	$3\frac{1}{2}$
Width of odontoid	$4\frac{1}{2}$
Height of odontoid	3
Length of axis	8
Height of axis	15
Length of third cervical vertebra	21
Length of fourth cervical vertebra	20
Length of fifth cervical vertebra	19
Length of sixth cervical vertebra	18
Length of seventh cervical vertebra	17
Height of seventh cervical (about)	15
Length of centrum, anterior thoracic vertebra (*a*)	6
Width of ball (*a*)	8

Expanse of parapophyses (*a*)	14 millim.
Expanse of diapophyses (*a*)	26
Width of neural canal (*a*)	3
Length of centrum, anterior thoracic vertebra (*b*)	8
Width of ball (*b*)	10
Expanse of diapophyses (*b*)	17
Height of neural spine (*b*)	20
Width of neural spine (*b*)	5
Length of rib (*c*)	45
Width of shaft (*c*)	5
Distance from center of capitulum to center of tubercle (*c*)	10
Length of coracoid	50
Antero-posterior diameter, sternal extremity	9
Length of scapula	45
Width of scapula at distal end	15
Length of humerus	80
Width through deltoid crest	24
Least diameter of shaft of humerus	13
Length of ulna	133
Width of ulna at distal extremity	22
Length of radius	130
Width of radius distally	15
Length of wing-finger metacarpal	220
Width of same metacarpal at proximal end	20
Diameter through condyles	15
Transverse diameter of shaft above condyles	10
Length of first phalanx, wing-finger	263
Width of same phalanx at proximal end	24
Width of same phalanx at distal end	15
Width of sternum	67
Length of rib borders	25
Length of femur	75
Diameter of head of femur	5
Diameter of femur through condyles	12
Length of pteroid bone	88

The principal dimensions of this species can be got at with considerable certainty. Although two of the wing-phalanges and the bones of the foot are wanting, yet the relative proportions of those present agree so closely with those of the corresponding bones in *Pteranodon*, that there can be but little possibility of error in assuming the same proportions for the missing ones. The position of the ilium and femur, as also the ribs, show that they hold their natural relations to the pectoral arch. The tail, alone, can not be got at.

Extreme expanse of wing-bones	2400 mm.	7 ft.	10 in.
Expanse of wings in life, approximated	2000	6	6
Length of head, estimated	150		6
Length of neck	128		5½
Length of trunk	165		6½
Length of leg and foot, outstretched	275		11

But one species has been described from the American Cretaceous smaller than the present one, *Pteranodon nanus* Marsh, in which the expanse of wings is given as not more than three or four feet. In this estimate the author is certainly in error. The size of the humerus, as given, is rather more than three-fourths that of the present species, and the expanse, hence, must be nearly five feet in life, or six feet as the bones lie outstretched.

As regards the specific determination of the present specimen, there must necessarily be some doubt until the species already named have been recognizably described. But three of the existing species can be taken into account, *N. gracilis*, *P. comptus* and *P. nanus*. That it can not be the last, has already been shown. In size, it agrees well with *P. comptus*, but the other characters throw no light upon the identity. The measurements given of the type specimen of *N. gracilis* show the size to be materially greater,—a character, however, of subordinate value—greater slenderness, and a relatively shorter first wing-phalanx. The relative lengths of wing-metacarpals, wing-phalanx and ulna in *N. gracilis* and the present specimen may be expressed as follows:

Length of wing-metacarpal	100	100
Length of first wing-phalanx	115.6	119.5
Length of ulna	62.3	60.4

It will be seen that not a single character has yet been given to disdinguish the genus from *Pterodactylus*, and it is not at all impossible that it may prove to be the same; its location among the *Pteranodontidae* rests solely on the assumed absence of teeth, and that is a character yet wholly unknown.

The material now in the museum permits a fuller discussion of the relations and characters of this group of reptiles than has been hitherto attempted. Originally, they were described as constituting a new order, a view still held by its author and no one else. Lydekker, in his Paleontology and Catalogue gives them a subordinal value; Zittel only a family value, though expressing doubt as to their subordinal rank.

It seems very probable that the genus *Nyctodactylus* has no teeth in the jaws; it agrees in *every other respect* with the genus *Pterodactylus*, so far as known. If the genus has teeth it must be united with *Pterodactylus*. Now, in not a few species of this genus, the teeth are confined to the anterior end of the jaws, and their entire absence, unaccompanied by other structural differences, will hardly constitute an order, or even family.

But, leaving aside *Nyctodactylus*, it is very much of a question whether the differences between *Pterodactylus* and *Pteranodon* are sufficient to locate them in different families, let alone different suborders.

The two genera have the following in common: Tail short. Skull with more or less elongated, pointed jaws, and very small upper and lower temporal fossae. Narial opening large, confluent with the preorbital foramen. Cervical vertebrae elongated, with rudimentary spinous processes. Fore and hind extremities, quite alike.

Pteranodon differs from *Pterodactylus*, so far as that genus is known, in the united coracoscapulae and pubes, both of which characters are found in *Rhamphorhynchus*.

The sole family characters remaining then, for *Pteranodon*, are, absence of teeth, a supra-occipital crest, and the articulation of the upper end of the scapula. Now it seems evident that to place the pteranodonts in a group equivalent to all the other pterosaurs is unwarranted, and any classification that will not show the more pronounced relationships with *Pterodactylus* is faulty. I would, therefore, propose the following:

Order Pterosauria.

Family Pterodactylidae, subfamilies Pteranodontinae, Pterodactylinae.

Family Rhamphorhynchidae.

Family Ornithocheiridae.

As regards the geographical distribution of the Pteranodonts, they have hitherto been recognized only from Kansas, but I am firmly of the opinion that they occur in Europe, and, if so, it is very probable that the name *Pteranodon* must be eventually given up. In fact, a toothless form of Pterodactyl was described by Seeley as long ago as 1871, under the name of *Ornithostoma*. I cannot refer to his description at present, and can, therefore, give no opinion as to their identity. It seems certain that the peculiar form of the scapulae and their vertebral articulation * occur among some of the European forms,

* The specimens in which I have seen the vertebral articulation show no co-ossification of the vertebrae: the facet for articulation being placed above the spines, and apparently formed by ossified ligaments.

which would strengthen the belief that *Pteranodon* is also an European genus.

In view of the above, the practice of the American text-books in Geology in introducing generic names of characteristic fossils as names of the geological horizons whence they come, is very reprehensible, in my opinion. Even the late edition of Leconte's Elements contains a long list of such names, the greater portion of which have been relegated to the limbo of synonymy by paleontologists. It is greatly to be desired that the name "Pteranodon Beds" shall not become established, so long as there is the least doubt of the validity of the name itself.

KANSAS MOSASAURS.

BY S. W. WILLISTON AND E. C. CASE.

PART I, CLIDASTES, WITH PLATES II-VI.

The group of extinct Cretaceous reptiles known as the Mosasaurs or Pythonomorpha was defined by Cope, "to whom Science is so largely indebted for its present knowledge of this interesting order of reptiles" (Marsh), in 1869.* Although some of the characters assigned by him to the order have since been shown to be inapplicable, and the group to have less value, yet his name, Pythonomorpha, has been generally retained. Lydekker and Zittel have assigned to the group a subordinal value, as has also Marsh, though under a different name. Owen rejected it entirely, and Baur, more recently,† has united it with the Varanidae to form a super-family, as follows:

Suborder Platynota.
  Super-family Varanoidea.
  Families Mosasauridae, Varanidae.
Super-family Helodermatoidea.
  Family Helodermatidae.

The group, whatever may be its rank or position, includes, so far, the following genera: *Mosasaurus* Conyb., *Liodon* Owen, *Platecarpus* Cope, *Clidastes* Cope, *Baptosaurus* Marsh, *Sironectes* Cope, *Plioplatecarpus* Dollo and *Hainosaurus* Dollo. *Pterycollasaurus* Dollo, founded upon *Mosasaurus maximilianus* Goldf., is omitted as doubtful. All of these genera, save *Plioplatecarpus* and *Hainosaurus*, have been recorded from North America, *Clidastes*, *Baptosaurus* and *Sironectes* being peculiar to this country. Of these latter three genera, however, *Clidastes* alone is well known; but this genus is suspected by Lydekker of being the same as the imperfectly known European *Geosaurus* Cuvier. Thus it seems that the genera, or at least the most of them, have a wide distribution; *Platecarpus*, in fact, is said to occur in New Zealand.

In America, members of the group have been discovered in the Cretaceous deposits of New Jersey, Alabama, North Carolina, the

* Proc. Bost. Soc. Nat. Hist., p. 253.
† Science, xvi, p. 262, Nov. 7, 1890.

upper Missouri region, Nebraska, Kansas and New Mexico. Probably nineteen-twentieths of all the known specimens, however, have been obtained in western Kansas. The material now in the University Museum, all from Kansas, comprises several hundred specimens of these animals, including, probably, the best ones known. It is upon this material that the following preliminary studies are chiefly based.

The genus *Clidastes*, as first described by Cope, was based upon two dorsal vertebrae of *C. iguanavus*, the type species, from New Jersey. Shortly afterward, however, he gave a full and careful generic description, as derived from an unusually good specimen of an allied species, *C. propython*, from Alabama. Only a little later, Marsh described a genus, which he called *Edestosaurus*, from Kansas, but without giving any real, distinctive differences from *Clidastes*, following the very reprehensible practice of naming supposed new forms in the hopes that future distinctive characters might be found. The genus *Edestosaurus* has been rejected by nearly all save the authors of the American text-books in Geology. It seems hardly necessary to point out the identity. The only distinctive character the author gave for his genus was the insertion of the pterygoid teeth, and even this character he modified later—"Palatine (sic) teeth more or less pleurodont." *

This character, even were it real, is of very slight value; indeed it cannot be used to distinguish the species even.

Clidastes is, without doubt, one of the most highly specialized genera in the group, and, what is very interesting, is one of the latest. It occurs in Kansas in the uppermost part of the Niobrara beds, in the horizon so markedly characterized by the toothed birds. Both *Platecarpus* and *Liodon* occur, though in diminished numbers, almost to the very lowest portion, but *Clidastes* has never been found except towards the top. From measurements made the past season, the thickness of the beds in which these saurians occur cannot be less than six hundred feet.

The following species have been found in Kansas: none of them are known to occur elsewhere.

MOSASAURIDAE.

Mosasauridae Conybeare, in Cuvier, Ossem. Foss., 2nd ed., p. 338, 1824.
Clidastidae Cope, Extinct Batr. Rept. and Aves of N. Amer., Trans. Amer. Phil. Soc. xiv, p. 59, 1870.
Edestosauridae Marsh, Amer. Journ Sci. xxi, p. 59, July 1878.

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* Amer. Journ. Sci. iii, June 1872.

CLIDASTES.

? *Geosaurus* Cuvier, Ossem. Foss. 2nd ed., 328, 1824, (*fide* Lydekker.)

Clidastes Cope, Proc. Acad. Nat. Sci. Phil. 1868, p. 233; Ext. Batr. etc, p. 21, 1870.

Edestosaurus Marsh, Amer. Journ. Sci. i, p. 417, June, 1871.

C. cineriarum.

Clidastes cineriarum Cope, Proc. Amer. Phil. Soc., 1870, p. 583; Cret. Vert. etc. pp. 137, 266, pl. xxi, ff. 14-17; Bullet. U. S. Geol. Surv. Hayden, iii, p. 583.

C. dispar.

Edestosaurus dispar Marsh, op. cit. i, p. 447, June 1871; iii, pl. xi., June, 1872.

C. velox.

Edestosaurus velox Marsh, Amer. Journ Sci. i. p. 450, June, 1871.

Edestosaurus pumilus Marsh, ibid. p. 452.

? *Clidastes affinis* Leidy, Proc. Acad. Nat Sci., 1870, p. 4; Rep. U. S. Geol. Surv., Hayden, vol. i, p. 283, 1873.

? *Edestosaurus dispar* Marsh, op. cit. xix, pl. i, f. 1, Jan., 1880.

C. Wymani.

Clidastes Wymani Marsh, Amer. Journ. Sci. i, p. 451, June, 1871: iii, p. 292, April, 1872.

Edestosaurus Vymani Marsh, op. cit. iii, p. 464, June, 1872.

C. tortor.

Edestosaurus tortor Cope, Proc. Amer. Phil. Soc. Dec., 1871; Marsh, op. cit. iii, p. 464, June, 1872.

Clidastes tortor Cope, Cret. Vert. Rep. U. S. Geol. Surv., Hayden, vol. ii, pp. 48, 131, 265, pls. iv, f i; xiv, f. i; xvi, ff. 2, 3; xvii, f. 1; xix, ff. 1-10; xxxvi, f. 3; xxxvii, f. 2; Bullet. U. S. Geol. Surv. Hayden, vol. iii. p. 583.

C. stenops.

Edestosaurus stenops Cope, Proc. Amer. Phil. Soc. p. 330, 1871; Marsh, Amer. Journ. Sci. iii, p. 464, June, 1872.

Clidastes stenops Cope, Cret. Vert. etc. pp. 133, 266, pls. xiv, ff. 4, 5; xvii, f. 7, 8; xviii, ff. 1-5; xxxvi, f. 4; xxxvii, f. 3; xxxviii, f. 3.

C. rex.

Edostosaurus rex Marsh, op. cit. iii, p. 462, pl. xxii, f. 1, June, 1872.

C. planifrons.

Clidastes planifrons Cope, Bullet. U. S. Geol. Surv. No. 2, p. 31, 1874; Cret. Vert. etc. pp. 135, 265, pls. xxii, xxiii.

C. Westii.

C. Westii Williston, n. sp. infra.

CLIDASTES VELOX.

A remarkably complete specimen, referred with considerable certainty to this species, was obtained by ourselves in western Kansas, (Butte Creek) in the summer of 1891. A brief preliminary description of the specimen was given by the senior author in Science, December

8, 1891. A more complete description is here given, which, it is believed, will be of service. The specimen is an unusually perfect one, being very nearly complete, and, as now mounted, shows the bones nearly all in the position in which they were found. The vertebral column is continuous, except in one place, where the tail had been bent up over the back; and complete, save at the very tip of the tail. The skull is complete, or very nearly complete, and has been restored nearly to the condition in life. Figures have been made of this portion of the skeleton, and will be given in a future communication. At present, it may be mentioned that the lacrymals are small, roughly irregular bones, and pointed at either extremity. There are no indications of transverse bones, as there are none in any other skull in the collection.

Cervical vertebrae.

Atlas. The intercentrum is a small bone with three sides of nearly equal extent. The two upper, articular surfaces are gently concave, and meet in a rounded margin; the inferior surface is convex, both antero-posteriorly and transversely, with a roughened prominence in the middle. The lateral pieces have indistinctly separated facets for articulation with the odontoid, the intercentrum and the occipital condyle. The rather short, flattened lamina extends upward, backward and inward, approaching, but not reaching its fellow of the opposite side; it is somewhat dilated distally. Directed outwards and forwards, there is a stout styliform process.

Axis. The neural spine of the axis is elongated antero-posteriorly. It is thin on the anterior portion, but stouter and longer at the posterior part. The large, stout odontoid process is united suturally, as is also the well-developed atlantar hypapophysis, which forms the anterior, inferior portion of the bone. The diapophyses are the smallest of the costiferous series, with only a small articular facet for the rib. The ball is strongly and evenly convex, with its greater diameter transversely. The hypapophysis is the largest of the series; it is suturally united with the stout, exogenous process of the centrum, and projects downward and backward; its distal extremity is roughened for ligamentous attachments.

The third cervical vertebra shows a well-developed zygosphenal articulation, and stout articular processes. The transverse process is small, only a little larger than that of the axis, though, unlike that, it is strengthened by a ridge continued from the anterior zygapophyses. The hypapophysis is smaller than that of the axis, but, like that, is directed downward and backward. The spine may be distinguished from that of any other vertebra by its stout, trihedral shape; it is directed rather more obliquely backward than in the following vertebrae.

The fourth cervical vertebra differs from the third in having stouter transverse processes; in the hypapophysis being directed more nearly downward, and in its smaller size; and in the spine being flattened antero-posteriorly toward the base.

The fifth cervical vertebra differs from the fourth in the broader spine, in the stouter transverse processes, and the smaller hypapophysis.

In the sixth cervical vertebra, the hypapophysis is reduced to a small ossification, scarcely longer than broad, directed downward. The spine has reached nearly the full width of those of the following vertebrae, though somewhat stouter above. The transverse processes are yet stouter.

In the seventh, or last, cervical vertebra the hypapophysis is wanting, or very rudimentary. The under part of the centrum shows a rounded ridge or carina, with a slight projection corresponding to the hypapophysis.

MEASUREMENTS OF THE CERVICAL VERTEBRAE.

1.	Antero-posterior diameter of intercentrum of atlas	14 millim.
	Transverse diameter of intercentrum	25
	Antero-posterior diameter of lateral piece	20
	Vertical extent of articular surface	17
	Extent of lateral piece	35
	Width of lamina above	16
2.	Length of axis	43
	Transverse diameter of ball	18
	Vertical diameter of ball	17
	Expanse of transverse processes	28
	Elevation of spine above floor of neural canal	34
	Antero-posterior extent of spine	50
3.	Length of third cervical vertebra	37
	Height of spine above floor of neural canal	36
	Depth of hypapophysis below floor of neural canal	34
4.	Length of fourth cervical vertebra	37
	Height of spine above floor of neural canal	39
	Depth of hypapophysis below floor of neural canal	35
5.	Length of fifth cervical vertebra	37
	Height of spine above floor of neural canal	42
	Depth of hypapophysis below floor of neural canal	33
	Transverse diameter of ball	17
	Vertical diameter of ball	18
6.	Length of sixth cervical vertebra	37

	Height of spine above floor of neural canal	42 millim.
	Depth of hypapophysis below floor of neural canal	30
	Width of spinous process	26
7.	Length of seventh cervical vertebra	37
	Height of spine above floor of neural canal	46
	Transverse diameter of ball	19
	Vertical diameter of ball	20
	Width of spinous process	27

Dorsal vertebrae.

There are thirty-five vertebrae between the cervicals and the first non-rib-bearing vertebra, to which the pelvis was, evidently, attached. The distinction between the cervicals and thoracics cannot be made from any characters they possess, as the seventh vertebra does not bear a distinct hypapophysis. Neither can it be said with certainty from this specimen which is the first thoracic vertebra, as the cervical ribs had, unfortunately, been displaced in the collection and preparation of the specimen. In another specimen, referred to *C. pumilus*, and which, as will be seen later, cannot be specifically distinguished from the present species, short cervical ribs were found attached to six vertebrae posterior to the atlas. That the eighth vertebra is a thoracic one is shown by the relation of the ribs in this specimen. Posteriorly there is no distinction, also, between the true thoracic vertebrae and those of the lumbar region. All the vertebrae anterior to the pelvis bear ribs, and will all be considered as dorsal vertebrae, the true thoracic vertebrae being restricted to those of which the ribs are elongated, and, probably, connected with the sternum.

In the anterior vertebrae of the series, the centra are subcarinate below, the obtuse, rounded ridge becoming less and less apparent until no indications of the keel can be seen, before the middle of the series. The transverse processes are stoutest, with a more elongated, sigmoid articular surface, with little or no constriction, and projecting only slightly beyond the stout articulating processes, in the anterior vertebrae. In the tenth or eleventh, the articular surface has become markedly smaller, more vertical, and less sigmoid in outline. Thence to the last, the articular surface for the ribs remains nearly the same. The process itself, however, becomes gradually more prominent and constricted, as the zygapophyses becomes smaller. The spinous processes increase slightly in length and breadth, and are only slightly oblique throughout. In length, the centra increase gradually. The vertical diameter of the ball increases gradually, while the transverse diameter remains more nearly the same.

MEASUREMENTS OF THE DORSAL VERTEBRAE.

1.	Length of centrum to rim of ball	38 millim.
	Transverse diameter of ball	20
	Vertical diameter of ball	19
	Height of spine above floor of neural canal	48
	Extent of articular surface of transverse process	30
	Width of spine	28
4.	Length of centrum to rim of ball	41
	Transverse diameter of ball	20
	Vertical diameter of ball	20
	Height of spine above floor of neural canal	48
11.	Length of centrum to rim of ball	41
	Vertical diameter of ball	22
	Extent of articular surface of transverse process	16
	Width of spine	32
15.	Length of centrum to rim of ball	41
	Transverse diameter of ball	21
	Vertical diameter of ball	24
20.	Length of centrum to rim of ball	42
	Vertical diameter of ball	25
	Height of spine above floor of neural canal	58
24.	Length to rim of ball	41
	Transverse diameter of ball	22
	Vertical diameter of ball	23
	Height of spine	49
28.	Length to rim of ball	40
	Vertical diameter of ball	24
	Transverse diameter of ball	23
	Height of spine	54
32.	Length to rim of ball	38
	Vertical diameter of ball	25
	Transverse diameter of ball	24
35.	Length to rim of ball	37

Caudal vertebrae.

Immediately following the thirty-fifth rib-bearing vertebra there is an abrupt change, the tubercular process for the rib giving place to an elongated transverse process. From the position of the pelvis, it is evident that the ilia were attached to the first pair of these. Precisely this relation of pelvis to the vertebrae is found in such lizards as the Monitor and Iguana, and it is probable that such is the relation in all the Pythonomorpha. It will thus be seen that there are no distinctively lumbar vertebrae, if by such are meant free, non-costiferous, pre-sacral vertebrae. The vertebrae of these animals that have been so designated by writers are in reality basal caudal. A distinctive term for them—those with transverse, non-costiferous processes and without chevrons—is needed, and we propose, provisionally, the term *pygial.* There are seven in the present series, all characterized by elongated transverse processes, and not differing much from each other. The vertebrae lie in the matrix with the ventral aspect uppermost, concealing the spine and upper parts. The under surface is somewhat flattened, and, as in the preceding vertebrae, is gently concave antero-posteriorly. The transverse processes are elongate, stout towards the base, apparently all of nearly equal length, and directed gently backwards and downwards. In the anterior vertebrae the processes spring from near the front part: as the centra become shorter they arise from near the middle. In the last one of the series there are minute indications of chevrons.

MEASUREMENTS OF THE PYGIAL CAUDAL VERTEBRAE.

1.	Length to rim of ball	36 millim.
	Width of ball	25
	Expanse of transverse processes	130
	Width of transverse process near base	17
2.	Length to rim of ball	33
3.	Length to rim of ball	31
4.	Length to rim of ball	29
5.	Length to rim of ball	28
6.	Length to rim of ball	27
	Expanse of transverse processes	130
	Width of ball	24
7.	Length to rim of ball	27

The centra of those caudal vertebrae which have chevrons do not differ much in shape. They become less constricted, and, back of the middle of the series, are smoothly cylindrical in shape. The transverse processes decrease gradually in length, disappearing entirely in the twenty-fifth or twenty-sixth. The spinous processes are more or less incompletely preserved in the anterior vertebrae. They increase only gradually in length for the first twenty of the series, and are markedly oblique, with the posterior border stout, and the anterior border alate. With the twenty-sixth they begin to increase more rapidly in length, and have become more nearly vertical in position, and are thinner at each margin. In the thirty-fifth or thirty-sixth they attain their greatest length, and are here directed slightly forwards. Thence to the end of the tail, the length decreases gradually, and, in position, they are directed more and more obliquely backward. The chevrons are strongly oblique throughout the series and are firmly co-ossified with the centrum.

The tail, it is thus seen, has a broad, vertical, fin-like extremity, which, doubtless, aided much in the propulsion of the animal through the water.

There are sixty-seven vertebrae with chevrons present in the specimen, all continuous, except in one place. The last one is less than one-fourth of an inch in diameter, and shows that there had been yet another, possibly several more. Toward the base of the series the tail has been bent forwards over the back, and it is possible that, where the break occurs, there has been a vertebra lost. The measurments, however, do not seem to indicate any loss. The entire series of vertebrae was not less than sixty-eight, and probably not more than seventy, making for the entire vertebral series one hundred and seventeen to twenty.

MEASUREMENTS OF THE CHEVRON-BEARING CAUDAL VERTEBRAE.

1.	Length to rim of ball	26 millim.
5.	Length to rim of ball	24
	Vertical diameter of ball	21
	Transverse diameter of ball	24
10.	Length to rim of ball	24
15.	Length to rim of ball	24
	Height of spine above floor of neural canal	40
	Length of chevron	45
20.	Length to rim of ball	23
	Vertical diameter of ball	21
	Transverse diameter of ball	22
25.	Length to rim of ball	20
	Height of spine	44
	Width of spine at base	19
	Width of spine at distal end	10
	Length of chevron	85
	Altitude of tail	112
30.	Length to rim of ball	18
	Vertical diameter of ball	17
	Height of spine	57
	Width of spine at base	19
	Width of spine at distal end	9
	Length of chevron	99
	Altitude of tail	120
35.	Length to rim of ball	16
	Vertical diameter of ball	16

	Height of spine	61 millim.
	Length of chevron	97
	Altitude of tail	122
40.	Length to rim of ball	15
	Vertical diameter of ball	15
	Height of spine	54
	Length of chevron	70
	Altitude of tail	110
45.	Length to rim of ball	14
	Vertical diameter of ball	14
	Height of spine	40
	Length of spine	50
	Length of chevron	58
	Altitude of tail	93
50.	Length to rim of ball	13
	Length of spine	43
	Length of chevron	55
	Altitude of tail	73
55.	Length to rim of ball	12
	Length of spine	38
	Length of chevron	42
	Altitude of tail	63
60.	Length to rim of ball	9
	Length of spine	46
	Length of chevron	25
	Altitude of tail	50
66.	Length to rim of ball	7
	Length of chevron	10
	Altitude of tail	20
67.	Length	6

Ribs.

As has already been stated, the cervical ribs were displaced in the present specimen, and measurements of them cannot be given. In a smaller specimen, specifically indistinguishable from the present one, the entire cervical series is preserved with the ribs attached. The first, that articulating with the axis, is very short. The following ones are stouter, but increase only moderately in length, that of the sixth measuring only thirty-five millimeters, while that of the seventh is but a little longer. In the specimen of *C. velox* described, there is a detached cervical rib sixty-five millimeters in length; it probably belongs with the seventh.

The thoracic ribs are simple, somewhat flattened rods, moderately expanded at the proximal end. The greatest convexity is shown about the middle of the series, where the versedsine of the curvature is forty millimeters, the chord being one hundred and sixty. Posteriorly, the short ribs are only gently curved.

Lying by the side of the vertebral column, and between the ribs, as they have been pressed down, are a number of flattened, soft, punctulate bones, which are evidently the costal cartilages. Posteriorly four rows of them are seen, lying closely side by side, some of them eight or ten inches in length. The sternum, composed of the same material, has been so crushed and crumpled that its shape cannot be made out. The whole structure here, whether of ribs, cartilages or sternum, reminds one very strongly of such lizards as the Iguana or Monitor. There is no indication, however, in any specimen, of an episternum.

MEASUREMENTS OF RIBS.

Length, first thoracic rib, (chord)	200 millim.
Length, eleventh thoracic rib, (chord)	145
Length, thirteenth dorsal rib	68
Length, eighteenth dorsal rib	64
Length, thirty-fourth dorsal rib	52

The lengths of the different regions, as they lie in their natural relations, are as follows:

Skull	0.420 meters.	
Neck	0.225	
Trunk	1.360	
Tail	1.460	
Total	3.465	11 ft. 7 in.

The measurements of an excellent specimen of *C. tortor* are as follows:

Skull	0.630 meters.
Neck	0.360
Trunk, (thirty-three vertebrae preserved)	2.370

A very complete specimen of a *Liodon* in the Museum, in which the *complete* vertebral column is present, numbering one hundred and seventeen vertebrae, gives the following measurements. The skull is complete, save the most anterior portion.

Skull (approximated within narrow limits)	0.700 meters.	
Neck	0.430	
Trunk	1.760	
Tail	3.420	
Total	6.310	20 ft. 8 in.

The vertebral series in this specimen is composed of seven cervicals, twenty-three dorsals, seven pygials, and eighty chevron-caudals.

The relative proportions of the different regions in the two genera, as shown by the two specimens of *Clidastes* and *Liodon*, may be represented as follows. The first column is for *Clidastes*.

Skull	12.1	11.1
Neck	6.5	6.8
Trunk	39.2	28.0
Tail	42.3	54.1

Limbs.

The figures in plates II and III will give a sufficiently good idea of the limbs in this specimen. They are figured as they were lying, showing the outer sides of the coracoid, scapula and pelvic bones, and the palmar or plantar surface of the remaining bones.

Coracoid.

It will be observed in plates II and IV that there are two very different types of coracoid, one with a deep emargination, the other without the slightest indication of such. The same non-emarginate form occurs in *C. tortor*, as specimens in our Museum show, in *C. propython* Cope (Ext. Batr. etc. pl. xii, f. 16,) and in *C. dispar*, as figured by Marsh*, and as stated by him in the same paper ("There is certainly no emargination in the coracoid of *Clidastes, Edestosaurus* and *Baptosaurus*, as specimens in the Yale Museum conclusively prove.") It is true that Marsh in a later paper† figured a specimen with emarginate coracoid under the name of *Edestosaurus dispar*, but it is certain that his identification of his own species was wrong, as will be seen by comparing his figures. From the senior author's memory of the specimen with the emarginate coracoid figured, and from the figure itself he feels confident that the second specimen is *C. velox*.

That the emargination was overlooked by the author seems strange, as in the same paper in which this figure is given occurs the description of *Holosaurus, founded upon that very character*. If the emargination is sufficiently important to base a genus in the one case, then it should be in the other, and the character could not be applied to *Edestosaurus*, based upon characters which it hardly seems possible that the author himself could seriously consider, for *E. dispar* was the type of *Edestosaurus*.

It will be observed, further, that the figured coracoids differ very materially in size, those with the emargination pertaining to a small species, while *C. dispar* is one of the largest. In our Museum there are three specimens with the emarginate coracoid, all of them small or very small, the described specimen of *C. velox* being the largest.

* Amer. Journ. Sci. iii, pl. xi, f. 1, June, 1872.

† Amer. Journ. Sci. xix, pl. i, fig. 1, Jan., 1880.

The point of chief interest in this relation is the value that can be given to this character. Is it individual, specific or generic? Marsh has called it generic, but we think an examination of the two very complete specimens of *C. tortor* and *C. velox* in our Museum will convince any unprejudiced student that he is in error.

A comparison of the figures herewith given of the paddles will show their great resemblance, and these two forms of paddles have been figured because the species are the most unlike of any that we know in the genus. As all the small specimens seem to possess this character, and as they cannot be called immature specimens, we believe the character is a specific one. As Marsh says, typically both *Clidastes* and *Edestosaurus* have a non-emarginate coracoid, so that neither name could apply to the emarginate form, were it generically distinct.

Our Museum also contains both forms of the coracoid pertaining to the genus *Platecarpus,* of which *Holosaurus* is a synonym.

While studying the specimen above described, a striking similarity was observed to several other specimens already determined with confidence as *C. pumilus* Marsh. A more careful comparison failed to bring out any real differences beyond size, and even this was shown to be very inconstant.

The following comparison of the descriptions given by Marsh will be of interest.

C. pumilus.	*C. velox.*
TEETH. Nearly round at base, somewhat curved and with smooth enamel.	Premaxillary and maxillary teeth smooth and subcompressed.
QUADRATE. The rugose knob near the distal end of the quadrate is similar to that in *C. Wymani* (just below the posterior superior process is a prominent rugose knob with a deep pit under it), but has no articular pit under it. The hook is comparatively short and has a free compressed extremity. The articular margin is not deflected toward the meatus.	The great ala less curved than in *E. dispar*, concave transversely on both surfaces. The alar process has its articular process very narrow in its extension over the great ala. No notch in posterior margin of external angle. On the ridge below the angle and nearly opposite the meatal pit is a strong rugosity which is rudimentary or wanting in *C. dispar*. The posterior margin of the hook is only a narrow tongue projecting towards the meatal pit, instead of a broad articular surface.
CERVICAL VERTEBRAE. Articular face nearly vertical, and having a broad transverse outline with faint superior emargination. The hypapophysis stout and transversely triangular.	Articular face transverse.

The description, otherwise, shows no discrepancies of importance. The chief difference given by the author is the size, and this character we think our specimens show to be of little specific value. "It is a question of some importance how far difference in size among the Mosasauroids may be a test of difference in species. Among the numerous remains of these animals which have been discovered I have never yet observed any which presented any evidence relative to age. * * * In this view of the case, some of the many described species of Mosasauroids may have been founded on different sizes of the same."*

The length of the cervical vertebrae in the specimen above described is thirty-seven or thirty-eight millimeters. The cervical vertebrae in two specimens referred to *C. pumilus* have lengths respectively of twenty-two and thirty millimeters. In the type specimen of *C. velox* they must have had a length of at least forty-two millimeters.

It thus appears that, between the smallest specimen, which, in life, could have hardly exceeded eight feet in length, our specimens, indistinguishable anatomically, represent forms of ten and twelve feet, while the type itself was about fifteen feet in length.

Of the material originally referred to *C. pumilus*, there are in the collection five or more specimens, which, altogether, furnish nearly every part of the skeleton. They present no tangible differences from the skeleton of *C. velox* described above. There can be, hence, little or no doubt but that the name *C. pumilus* is a synonym.

It is hardly possible to say with certainty that *C. affinis* Leidy is or is not the same as *C. velox*, but, so far as the description goes, we can find few differences. The type is of about the same size as the type of *C. velox*, and the figures agree well with the bones of the skeleton described. Although the description was not published till 1873, the author makes no mention of the species of Marsh's. Leidy describes the back teeth as having the enamel strongly striated, with the surface presenting evidences of subdivision into narrow planes. In this respect, only, it disagrees with the specimen.

Plioplatecarpus Dollo is described by its author as having a sacrum of two conjoined vertebrae,† by reason of which it is placed in a separate family from the rest of the *Pythonomorpha*. It may be presumptious to express a doubt of the genuineness of the sacrum, and yet, save from the fact that the author found two specimens quite alike, one might doubt it strongly. It is not very rare that two, or even three vertebrae are found united from injury in these animals, and such would readily account for the consolidation as figured and described by Dollo, except for the coincidence of the second speci-

* Leidy, Rep. U. S. Geol. Surv. Hayden, vol. i, p. 284.
† Bull. Su. Mus. Roy. S. Hist. Nat. d. Belg. i, p. 8, 1882.

men. A stronger reason for doubt is the statement that the consolidated vertebrae belong to the posterior "lumbar" region, and that the last vertebrae had small tubercles indicative of chevrons. In the reptiles which we have examined, the chevrons do not begin immediately behind the pelvis, but are separated by a longer or shorter region in which the vertebrae bear elongated diapophyses alone. If the conjoined vertebrae figured by Dollo are in reality sacral, it would appear that the animal is an exception to *Clidastes* and such lizards as we have examined. Furthermore, the pelvis must have been of a different structure from that in the Kansas genera of the Pythonomorpha, for, in these, it is evident that the ilium had an oblique position, and could have been attached to but a single diapophysis.

CLIDASTES WESTII, N. SP.

A specimen of much interest in the University collection differs so markedly from the other forms represented by specimens, as also from the descriptions of the known species, that we are constrained to regard it as new. It was collected by Mr. C. H. Sternberg from the uppermost of the Niobrara beds, in the vicinity of the old town of Sheridan. The character of the associated invertebrate fossils seems to indicate a different geological horizon, either the Fox Hills group, or transition beds to that group. The specimen consists of a complete lower jaw, quadrate, portions of the skull, the larger part of the vertebral column, and the incomplete hind and fore paddles. The vertebrae preserved are in two series, the one, numbering thirty-three, continuous with the skull; the other, sixty-three in number, all chevron caudals. The terminal caudals preserved indicate that there were several more in life, perhaps five or ten; the first of the series was evidently among the first of those which bore chevrons. Altogether the tail may have had seventy-five chevron caudals. The lengths of the two series are respectively seventy-one and seventy-two inches. Assuming that there was the same number of precaudal vertebrae as in *C. velox*, the entire vertebral column would have measured in life fifteen feet and four inches. The lower jaw shows the skull to have been very nearly twenty-four inches in length, making, for the animal when alive, a length of seventeen and one-half feet. This is one of the largest species, and it is interesting to observe that the real size here, as usually elsewhere among fossil vertebrates, is less than supposed. It is doubtful whether there is a *Clidastes* known that exceeded twenty feet in length.

While the skeleton was only about one half longer than the specimen of *C. velox* described in the foregoing pages, or of about the same length as a very complete specimen of *C. tortor* in the museum, the proportions of the animal were very much stouter. The figures given in plate VI of the twenty-fifth, or eighteenth dorsal, vertebra will show the relations between length and breadth: it is upon these remarkably stout proportions, and the shape of the articular faces, as indicated by the figures and by the measurements appended, that the species is chiefly based. The articular surfaces of the basal caudal vertebrae are remarkably triangular in shape, with the angles rounded, and the sides of nearly equal length. This triangular shape is persistent for the first twenty of the series as they are preserved. The paddles, as shown in plates IV and V, show much stouter proportions than in either *C. velox* or *C. tortor*.

The species comes nearest to *C. stenops* Cope, but it seems hardly the same. It is, also, evidently allied to *C. dispar* Marsh. From these and other described species, the following, extracted from the original descriptions, will serve to show the differences, in comparison with the specimen of *C. Westii*.

C. dispar.

The articular faces in the cervicals are a broad transverse oval, faintly emarginated above for the neural canal. In the dorsals and lumbars the cup continues transverse, and the emargination is deeper, but in the anterior caudals the outline becomes a vertical oval. There appears to have been thirteen mandibular teeth.

Length of axis with odontoid process	32 lines	100
Width between diapophyses	26.8	103
Length from edge of cup to end of ball in eleventh vertebra	25	100
Width of ball	14	56
Depth of ball	12	43

C. Wymani.

In the cervical vertebrae, the outline of the articular faces is transversely cordate. The centra of the anterior dorsals are elongate, and much constricted behind the diapophyses. In the anterior caudals, the articular faces are a broad vertical oval.

Length of axis with odontoid process	19 lines	100
Width between diapophyses	17	89.4
Width of ball	8	42.1
Depth of ball	7	36.7
Length of sixth cervical, without ball	13	100
Width of cup	9	69.1

C. rex.

The cervical vertebrae have very broad, transversely oval faces, with indications of emargination. The dorsals are elongated, with transverse faces, and a distinct superior excavation for neural canal. The articular ends of the anterior caudals are vertically oval.

Length of posterior cervical vertebrae	44	mm	100
Vertical diameter of ball	24		54.5
Transverse diameter	29.5		67
Length of a dorsal vertebra	52		

C. stenops.

The anterior caudals possess wide diapophyses. Their articular faces are a vertical oval, a little contracted above, sometimes a straight outline. They present a peculiarly elongate form.

Length of axis (alone)	60	mm	100
Vertical diameter of ball	27		45
Transverse diameter of ball	27		45
Length of the mandible	720		100
Depth at coronoid process	150		20.9

MEASUREMENTS OF CLIDASTES WESTII.

	Length of dentary	400 millim.
	Depth opposite the first tooth	20
	Depth opposite last tooth	62
	Entire extent of mandible	630
	Greatest depth at coronoid process	95
2.	Length of axis with odontoid process	80
	Length of axis without odontoid process	70
	Vertical diameter of ball	24
	Transverse diameter of ball	33
4.	Length of fourth cervical vertebra to rim of ball	49
	Expanse of diapophyses	82
5.	Length of fifth cervical to rim of ball	49
	Transverse diameter of ball	35
	Vertical diameter of ball	28
	Expanse of diapophyses	90
8.	Length of eighth vertebra to rim of ball	53
	Expanse of diapophyses	90
14.	Length to rim of ball	54
	Transverse diameter of ball	40
	Vertical diameter of ball	33
	Expanse of diapophyses	100
18.	Length to rim of ball	50
	Transverse diameter of ball	40
	Vertical diameter of ball	36
	Expanse of diapophyses	100

23.	Length to rim of ball	50
	Transverse diameter of ball	41
	Expanse of diapophyses	100
25.	Length to rim of ball	52
	Transverse diameter of ball	43
	Vertical diameter of ball	43
	Expanse of diapophyses	100
30.	Length to rim of ball	54
	Transverse diameter of ball	46

This species is named in memory of Judge E. P. West, lately deceased, to whom our Museum owes so much for his long, diligent and faithful labors in the collection and preparation of the geological material.

ERRATUM: P. 17, line 15, for "*Edestosaurus*," read *Clidastes*, and in next line, strike out "Proc. Acad." etc.

Notes and Descriptions of Syrphidae.

BY W. A. SNOW.

WITH PLATE VII.

Among the insects obtained by Prof. F. H. Snow in a recent trip to Colorado, is an excellent representative collection of the Diptera. The material for the following notes on Syrphidae is chiefly drawn from this collection. That such a collection affords so many points of interest in this, one of the best studied families of North American Diptera, is an evidence of the rich field that is presented by this important and little-studied order of insects.

CALLICERA.

Callicera Panzer, Fauna Germanica, 1806.

Callicera is a small genus hitherto supposed to be peculiar to Europe. The species are found in the high mountains, where the males are often taken while hovering in the air. The present collection includes numerous specimens of a species taken near the summit of Mt. Deception, in Manitou Park, Colorado, at an altitude of nine thousand feet.

The occurrence of members of this genus in the western part of the United States is a fact of especial interest and further substantiates the rule that American forms common to Europe are more apt to occur in the western regions. *Arctophila flagrans* Osten Sacken, is a case precisely similar to the present one, belonging as it does to a small European genus of mountain flies, and described from Colorado.

As the genus is a new one to our fauna, I here give an amended transcription of the generic characters from Schiner's Fauna Austriaca, to include the new species, which differs only in unimportant details.

Callicera.

Rather large, stout, green or black species with metallic lustre and abundant, long pile. Head hemispherical, somewhat broader than the thorax. Antennae porrect, longer than the head, somewhat remote at their base, inserted upon a protuberance of the front; first joint sometimes elongate; second joint shorter than, or as long as, the first joint; third joint one to three times the length of the first two joints taken together, with a short, terminal style. Face broad, under the antennae concave in profile; an obtuse tubercle below the middle; on the sides thickly covered with pile. Proboscis rather prominent, with broad labella. Eyes hairy, holoptic in the male. Abdomen elliptical, as long or longer than the thorax. Legs moderately strong. Third longitudinal vein straight, first posterior cell distally short petiolate; marginal cell open; cross-vein situated near the middle of the discal cell, oblique.

Callicera montensis, n. sp., Plate vii, f. 4.

MALE. Black, densely golden red pilose. Frontal triangle, face and cheeks deep black, shining, covered thickly with black pile, save a median facial stripe. Antennae black, basal third of third joint on the under side red; first joint short; second joint not more than half as long as the first; third joint three times as long as the first and second joints taken together; gradually broadened for a third of its length, and then attenuated; style white. Eyes thickly clothed with golden pile. Thorax and abdomen covered everywhere with long golden red pile. Legs black; tarsal joints below and at their articulations reddish. Wings nearly hyaline, brownish on the anterior basal portion; stigma yellow.

Length 11 millimeters. Three specimens, Colorado.

The genus may be distinguished from *Pelecocera*, in Williston's dichotomic table of the genera of North American Syrphidae, by the pilose eyes.

Microdon megalogaster, n. sp., Plate vii, f. 1.

MALE. Large, yellowish pilose species, in shape globose. Antennae reddish black, the first joint about as long as the following two together; second joint not one-third as long as the third. Face dark metallic green, shining, thickly covered with golden yellow pile. Front black, with similar pile, narrowed in the middle. Eyes bare. Thorax and scutellum deep metallic green, with long, thick, golden pile; scutellum gently emarginate, the small obtuse tubercles approximate. Abdomen short and broad, black, moderately shining; first two segments and the hypopygium somewhat green; pile at base yellow, elsewhere short, black. Legs black, with black pile; front tibiae and their metatarsi, on the inner side, with short golden pile; hind metatarsi incrassate and longer than the three following joints taken together. Wings uniformly subinfuscate; veins at the outer part of the first posterior and discal cells sinuous and rounded.

Length 12 millimeters. One specimen.

Chrysotoxum derivatum Walker.

Eight specimens from Colorado, which vary not a little from each other and from Williston's description. They seem to belong here, however, better than elsewhere. In one specimen, the second joint of the antennae is shorter than the first, and only one-fourth the length of the third. In five examples the second abdominal cross-band is not interrupted; in the others it is distinctly parted. In two, the third band does not reach the yellow of the broad hind margin; in two others it barely touches it; in five, the two bands broadly coalesce. The yellow of the fifth segment, in four specimens, incloses a black, inverted V; in two others an inverted Y.

Paragus bicolor Fabr.

Three specimens, Colorado. These may be located under Schiner's variety *taeniatus*.

Melanostoma stegnum Say.

Syrphus stegnus Say, Journ. Acad. Phil. vi, p. 163.
Melanostoma tigrina Osten Sacken, Western Diptera, p. 323.
Melanostoma stegnum Williston, Biol. Centr.-Amer. Diptera, iii, p. 10.

Eleven specimens, Colorado, which answer well to the descriptions. The metallic band of the fourth abdominal segment is sometimes interrupted, and there is usually a triangular opaque black spot near the anterior border of the fifth segment. "The female, hitherto unknown, has the front broad above, pollinose, except on the upper part, and with black pile; the thorax more shining metallic blue; the tibiae yellow, and on the third and fourth abdominal segments there is a narrow shining stripe, bisecting the black, as in the fourth segment of the male. The male has some long black hairs on the outer side of the front and middle tibiae, which are inconspicuous in the female. It is evident, from the lighter color of the tibiae, that Say's specimens were females." Williston, l. c.

Melanostoma mellinum Linne.

A single female specimen from Manitou Park.

Melanostoma, n. sp.?

MALE. Face and front dark metallic blue, shining, thinly covered with light-colored pollen; tubercle and epistoma black, shining, the former small. Antennae black, third joint yellowish red below, oblong. Pile of frontal and vertical triangles dusky. Thorax bronze-black, shining, sometimes bluish black, the pubescence white. Halteres yellowish. Abdomen long and narrow, with almost parallel sides; first segment metallic blue, shining; second segment opaque, or subopaque, black, with a light metallescent scallop on the sides, reaching to the distal third of the segment; third and fourth segments similar, marked anteriorly by a wide, interrupted, or subinterrupted blue fascia, deeply and widely emarginated, or concave behind; hind border of the third, and sometimes of the second segment, narrowly brown; fifth segment and the hypopygium metallic bluish green; sides of the abdomen with silvery white pile, longest and thickest at the base; the blue marking are whitish pruinose. Femora, except the tip, a broad ring on the tibiae, and the four posterior tarsi, black; elsewhere brownish or yellowish. Wings hyaline, stigma yellowish.

Length 7-8 millimeters.

Eupeodes volucris, Osten Sacken.

Numerous specimens, Colorado.

Syrphus arcuatus Fallen.

Four specimens, Colorado. These specimens vary not a little from each other, and somewhat from the descriptions. One female is very small, not over seven millimeters in length, and with the spots on the third and fourth abdominal segments hardly oblique. One male has the hind femora black as far as the tip, while in three females the black does not extend beyond the middle.

Syrphus disjectus Williston.

A single female specimen, from Colorado, agrees well with the description drawn from males. The pile of the thorax is more whitish than orange-yellow, and there are light colored lateral margins on the anterior part of the thorax.

Syrphus ruficauda, n. sp., Plate vii, f. 3.

Male. Eyes bare. Face greenish yellow on the sides, yellow in the middle; a rather broad black line marks the border of the mouth and is lost in the black of the cheeks. Frontal triangle yellow, with long black pile. Antennae dark brown, more or less reddish below. Pile of occiput light yellow. Dorsum of thorax deep metallic green, the scutellum olivaceous yellow; both with light yellow pile. First segment of the abdomen shining black; second segment opaque black, with the lateral margins and hind border shining, and with a broad, yellow, interrupted band, not reaching the lateral margins; third segment similar, but with the yellow band somewhat wider, interrupted or subinterrupted and slightly bilaterally oblique; fourth and fifth segments orange-red, the sides narrowly black; the fourth segment shows indistinctly a broad interrupted band of a somewhat lighter color, corresponding to the yellow bands of the preceding segments. Legs light brown; basal third of the front and middle femora and basal half of the hind femora black. Wings hyaline, stigma yellowish.

Female. Head wanting. Thorax purplish brown. The yellow band on the second abdominal segment narrower, the second band straight, narrower and interrupted. Legs light brown, except the proximal end of the femora, which is black.

Length 9 millimeters. Three males and one female, Colorado.

Syrphus pauxillus Williston.

Two specimens from Colorado undoubtedly come here. The species was described from a single male specimen. A female specimen offers the following differences or additions: Length nine millimeters, mesonotum more greenish black or bronze, the pile obscure whitish; fifth abdominal segment without yellow spots on the anterior angles; legs yellow, with the basal half of the front and middle femora, the hind femora except the tip, a broad band on the hind tibiae, and the hind tarsi, black.

Syrphus ribesii Linne.

Five specimens, Colorado.

Syrphus americanus Wiedemann.

Numerous specimens, Colorado.

Syrphus umbellatarum Schiner.

Five female specimens, Colorado. The only western locality heretofore given is Arizona (Williston).

Allograpta obliqua Say.

Five specimens, Colorado.

Mesogramma marginatum Say.

Numerous specimens from Colorado, showing very great variation.

Sphaerophoria cylindrica Say.

Twenty specimens, Colorado. I think the specimens belong here, though a positive identification is hardly possible at present.

Rhingia nasica Say.

One specimen, Colorado. This is the first time that this species has been recorded from beyond the Mississippi.

Copestylum marginatum Say.

Two specimens, Colorado, representing the extremes of variation in the species. The male corresponds to *C. lentum* Williston. Specimens of this species were bred from *Opuntia missouriensis*, in company with others of *Volucella fasciata* Macq.

Sericomyia militaris Walker.

Sixteen specimens from Minnesota and Colorado vary in the markings of the second abdominal segment, and in the color of the legs. Some have no spots at all on the second segment; in others the two yellow dots are conspicuous, approaching, in size and shape, the markings of the third segment. The tibiae vary from light yellow to reddish brown.

Brachyopa cynops, n. sp., plate vii, f. 2.

Head light yellowish brown, largely concealed beneath light glistening pollen; the shining ground color shows just above the antennae and in a stripe on the cheeks, extending from the eye to the mouth opening. Antennae wanting. Dorsum of thorax brown, covered with grayish pollen; anteriorly with two approximated, linear, blackish stripes; laterally with a broad, interrupted stripe. Scutellum light brown, with yellowish pollen. Abdomen but little longer than broad; yellowish gray pollinose; second segment with a circular brown spot in the anterior corners; the two following segments are marked with corresponding elliptical spots, and, in the middle of the anterior border with a triangular spot; on the fifth segment are two small round spots. Legs uniformly reddish brown, with light colored pollen and short whitish pile, Wing hyaline, distinctly clouded at anterior cross-vein, on the veins at the anterior outer corner of the discal cell and on the ultimate section of the fourth vein; posterior cross-vein about as long as the penultimate section of the fourth vein, the included angle obtuse.

Length 5 millimeters. One specimen, Colorado.

Eristalis latifrons Loew.

Numerous specimens, Colorado. The commonest Syrphid of the mountain meadows. Some specimens have very indistinct brownish spots on the second abdominal segment, and, when this is the case, the middle of the wing generally shows a brown spot, and brown clouds along the anterior veins between the spot and the base of the wing.

Eristalis brousi Williston.

One male specimen, Colorado.

Helophilus latifrons Loew.

Numerous specimens, Colorado.

Xylota flavitibia Bigot.

Eight specimens, Colorado. The glistening pile of the face and front varies from white to a golden yellow. On the dorsum of the thorax purplish stripes are distinctly visible. The fourth segment of the male abdomen is often red, as in the female abdomen.

Syritta pipiens Linne.

Eight specimens, Colorado.

Criorrhina umbratilis Williston.

A single, male specimen, collected by Mr. W. J. Coleman, at Lawrence, and agreeing exactly with the description. The only other known specimen of this species is the type, at Washington, from Connecticut.

Spilomyia quadrifasciata Say.

Seven specimens, Lawrence, Kansas, (F. H. Snow and E. S. Tucker). The species has not hitherto been recorded west of New York.

Notes on Melitera Dentata Grote.

BY VERNON L. KELLOGG.

WITH PLATE VIII.

At the meeting of the Entomological Club of the A. A. A. S., held in August, 1891, at Washington, Dr. Riley called attention to the habits of *Melitera prodenialis* Walker. The larvae burrow into and feed upon the fleshy leaves of the prickly pear, *Opuntia*. Dr. Riley's specimens came from Florida. Prof. J. B. Smith has recently bred the moth from the prickly pear in New Jersey. His notes were presented at the same meeting of the Club, and the brief references to the interesting notes of Doctors Riley and Smith, made in the Canadian Entomologist (v. xxiii, num. 11, pp. 242 and 256), suggest the presentation of the following notes on *Melitera dentata* Grote, the western species of this Phycitid genus.

Chancellor F. H. Snow, of this University, while investigating a grasshopper "outbreak" (*Dissosteira longipennis*) in eastern Colorado in July, 1891, noted the withered and dying condition of many leaves of the common prickly pear cactus (*Opuntia missouriensis*), and on examining the leaves found in them certain large, naked, bluish larvae. The larvae were imbedded in the fleshy leaves, eating away the soft inner tissue. The hollowed-out spaces were nearly filled with irregularly spherical, yellowish, translucent casts. The attacked leaves were withered and brown without. Prof. Snow took a few leaves and larvae on July 16, near Arriba, Colorado, and brought them to the laboratory.

The larvae were put into breeding-cage on July 18. On July 28 one larva had spun up and pupated in a corner of the cage behind a small porcelain dish. Another had made a cocoon in a broken, empty pupa-case of *Eacles inperialis*, but died before pupating. On August the adults appeared, and have been determined by Prof. J. B. Smith as *M. dentata*, Grote. As I am aware of no description of the earlier stages of this species, I record the following notes of description:

EGG. About 1-1.2 millimeters in diameter, surface with broad, meridian-like furrows from one pole for about one-third of the distance to the other pole. Color, creamy white.

LARVA. Food plant, *Opuntia missouriensis*, prickly pear cactus, burrowing into the fleshy leaves and eating the soft, succulent, inner tissues. Length, 40 millimeters. Five pairs of prolegs. Color, one specimen, ultramarine blue; skin, semi-transparent and shining anteriorly, dead blue on dorsum; second specimen, buffy with a bluish suffusion, blue between segments, prolegs bluish, and last abdominal segment blue, especially below; skin more opaque than in first specimen. No pronounced markings of skin; spiracles shining black and present on first thoracic and first to tenth abdominal segments. Head flattened, slightly narrower than first thoracic segment, umber. Prothoracic shield well marked, brownish black; anal shield, smoky brownish. Clothing, limited to tubercled hairs sparsely distributed as follows: a subdorsal line of small tubercles, two tubercles to a segment, each tubercle bearing three short, fine hairs; a supra-stigmatic line, one tubercle to each segment, each tubercle bearing three to four fine hairs; a similar infra-stigmatic line; a sub-ventral line of tubercles, bearing usually four fine hairs, the tubercles of the three thoracic segments in this line situated at base of legs outside, and similarly as to the prolegs on the third to sixth abdominal segments. The tubercles in all the lines are faintly smoky. The larva is rather heavy, and rotund in form, tapering toward both head and posterior segment. It moves with a lumbering gait, but rather rapidly.

CHRYSALIS. Length, 20 millimeters; in cocoon of silk, loosely covered with small dirt-masses. As made in the breeding cage the cocoons were above ground, but concealed under or in available objects.

ADULT. The adults obtained from the breeding cage, (there are no others in our collection), are easily distinguished from *prodenialis* Wlk., by the much stronger dentations of the outer line of the primaries. Prof. Smith kindly sent a specimen of *prodenialis* taken at Ocean Grove, New Jersey, for comparison. The row of marginal black spots on the primaries which Hulst (Tran. Am. Ent. Soc., v. xvii, p. 172) mentions as distinctive of *dentata* is as pronounced in Prof. Smith's specimen of *prodenialis* as in our *dentata*. The much lighter color of the primaries, head and thorax in *dentata* as mentioned by Hulst is characteristic. An interesting feature in the venation of the hind wings in our bred specimens of *dentata* is the considerable coalescence of the sub-costal and costal veins. Vein five is wanting, as mentioned by Hulst. In addition, there is further departure from a normal venation, in that vein seven after rising with six from its stem, (Hulst says: "Six short stemmed with seven"), coalesces for a short distance with eight and then runs free to the margin. Behind the forking of seven and six the stem (remnant of sub-costal) unites with the costal, and its basal portion is wholly merged with the forward vein. This partial disappearance of the sub-costal seems to be shared by *prodenialis* and is probably characteristic of the genus.

Prof. Smith, as recorded in the Canadian Naturalist, v. viii, p. 242, (1891), bred several specimens of *Volucella fasciata*, a Syrphid fly, from the same prickly pear leaves in which the *Melitera* larvae were living. It is interesting to note that pupariae and later, adults of *Volucella fasciata* and *Copestylum marginatum*, a closely allied Syrphid, were noted in the Opuntia leaves from which *M. dentata* was bred. (See note by Dr. Williston, Entomological News, v. ii, p. 165, 1891).

Diptera Brasiliana.

BY S. W. WILLISTON.

PART II.*

CONOPS.

1. First basal cell hyaline 2
   First basal cell clouded throughout 6
2. Third joint of the antennae as long as the first two together; small species . . . . *parvus*, n. sp.
   Third joint of the antennae but little if any longer than the second joint 3
3. First posterior cell hyaline 4
   First posterior cell more or less clouded 5
4. Cheeks yellow . . . . *angustifrons*, n. sp.
   Cheeks black . . . . *ornatus*, n. sp.
5. Face black in ground-color . . . . *argentifacies*, n. sp.
   Face yellow, large species . . . . *grandis*, n. sp.
6. Red species; front red . . . . *rufus*, n. sp.
   Black species; front black 7
7. Face and cheeks black in ground-color . . . . *magnus*, n. sp.
   Face and cheeks yellow . . . . *inornatus*, n. sp.

1. Conops magnus, n. sp.

FEMALE. Front black, shining, the vertical callosity somewhat reddish. Face and cheeks yellowish brown, the orbits silvery pollinose. Antennae brownish black; second and third joints subequal, first joint about two-thirds the length of the second; third joint of the style with a long bristly extremity. Thorax shining black; pleurae lightly whitish pollinose. Abdomen deep black, opaque; lightly whitish pollinose posteriorly; ventral process of the fifth segment large. Wings deep brown in front, extending through the two basal cells, and the basal part of the discal cell; outer part of the first posterior cell subhyaline, as also behind the streak corresponding to the spurious vein of the Syrphidae. Legs black; base of the femora, of the tibiae, and of the tarsi, somewhat yellowish.

Length 21-24 millimeters. Six specimens, Chapada, H. H. Smith.

*See Trans. Amer. Entom. Soc. xv, p. 243, for Part I.

2. **Conops grandis, n. sp.**

FEMALE. Front black, the lower margin of the vertical callosity reddish; just below the callosity opaque, elsewhere shining. Antennae black; the second and third joints of nearly equal length; the first joint about two-thirds the length of the second joint; style with a long bristly extremity. Face and cheeks light yellow, the orbital margins of the former silvery or light golden pollinose. Thorax black, the mesonotum shining, the pleurae lightly whitish pollinose. Abdomen deep black; posteriorly lightly pollinose. Wings brown in front; first posterior cell and the space behind the streak corresponding to the spurious vein of the Syrphidae in the first posterior cell, pure hyaline; outer part of the first posterior cell subhyaline; a brown streak in front of the fifth vein. Legs black; the tibiae and basal joints of the tarsi in large part reddish or yellowish; pulvilli light yellow; ventral process of the fifth segment extraordinarily large; seventh segment as long as the three preceding together.

MALE. Abdomen in ground-color black, either wholly so, or more or less, or rarely entirely, red; the ground color, save at the base, however, is almost wholly obscured by reddish brown pollen.

Length 19-23 millimeters. Six specimens, Chapada, H. H. Smith.

3. **Conops rufus, n. sp.**

MALE, FEMALE. Head red; face in the depression yellow, on the sides with a silvery sheen. Antennae black; first joint red, more than half of the length of the second joint; second joint sometimes reddish at the base; third joint about as long as the second joint, stout; third joint of the style suddenly attenuated into a moderately long bristly extremity. Thorax red; mesonotum with a median black stripe, and an oval, more or less distinct spot on either side; a golden pollinose spot on the inner side of each humerus. Abdomen red, lightly pollinose, the median segments more or less black; ventral process in the female large; the sixth segment in the same sex about as long as the two preceding together. Legs red, the tarsi a little darker, the pulvilli and the ungues, save their black tip, yellow. Wings brown in front, the brown extending to the fifth vein in the basal part of the discal cell; the space behind the spurious vein in the first posterior cell hyaline; the outer part of the same cell subhyaline.

Length 16-17 millimeters. Two specimens, Chapada, H. H. Smith.

4. **Conops angustifrons, n. sp.**

MALE. Front much longer than wide; black, shining at the vertex and below; an opaque band below the vertical callosity. Antennae black, the third joint somewhat reddish below towards the base; the first joint about half of the length of the third joint; third joint distinctly shorter than the second, rather broad at the base; style small, attenuate. Face, cheeks and the lower part of the occiput wholly light yellow. Thorax opaque black; a whitish pollinose spot on the inner side of each humerus; vertical pleural pollinose spot not distinctly limited above; a row of dorso-pleural, at least two prescutellar, and four scutellar, well-developed bristles. Abdomen subopaque black; second segment yellow at the base; sixth segment opaque golden yellow pollinose. Wings brownish before the third longitudinal vein, the first basal and the first posterior cells wholly hyaline; a streak before the fifth vein. Legs deep brown; the base of all the tibiae, the large pulvilli, and the claws (except their tips) yellow.

Length 12 millimeters. One specimen, Chapada, H. H. Smith. This species is peculiar in its narrow front, bristles of the thorax, and hyaline first posterior cell.

5. **Conops nobilis, n. sp.**

FEMALE. Head black; front, below the vertical callosity, except a crescentic space above the base of the antennae, opaque; face, on the sides and in the depression, with a conspicuous, light yellowish silvery reflection; in an oblique light from above the ground-color wholly concealed. Antennae black; the reddish first joint about two-thirds the length of the third joint; the third joint about two-thirds of the length of the slender second joint; third joint of the style with a short bristly extremity. Thorax black, lightly pollinose, opaque; on the front margin, and near the humeri, velvety; in the middle in front distinctly whitish when seen from behind. Abdomen black, subshining; second segment deep opaque black, save on the anterior part, where it is whitish pollinose; ventral process of the fifth segment small. Legs black; the tarsi and claws (save their extreme tips) light yellow; pulvilli very large, yellow; the tarsi dilated. Wings unequally brown in front, scarcely extending beyond the third vein, save in the first posterior cell; the costal cell and the outer part of the wing in front of the third vein of a lighter color.

Length 12 millimeters. One specimen, Chapada, H. H. Smith.

6. **Conops inornatus, n. sp.**

MALE. Front black, shining, the vertical callosity reddish. Face yellow, with golden pollen on the sides extending up on the lower part of the front. Cheeks wholly yellow. Thorax black, shining, lightly pollinose; margins of the thorax and of the scutellum with moderately large bristles. Abdomen slender, black, shining; the narrow hind margins of the third and fourth segments, the fifth on the sides and behind, and the sixth nearly wholly, light golden pollinose. Legs brown; base of tibiae yellow; basal joints of the tarsi yellowish.

Wings subhyaline, without distinct picture, though the color is more intense in front; yellow in the costal cell.

FEMALE. Wings distinctly brown before the third vein and in the basal cells and proximal portion of the discal cell. Abdomen diffusely whitish pollinose behind; the second segment largely reddish; ventral process of the fifth segment small.

Length 10 millimeters. Two specimens, Chapada, H. H. Smith.

7. **Conops ornatus, n. sp.**

MALE. Vertical callosity reddish; below it an opaque black band, connected in the middle with a V-shaped spot about the base of the antennae; the front elsewhere, and the face for the greater part, light yellow, the sides of the latter with a broad silvery sheen. Cheeks black. Antennae red; the first joint a little shorter than the third joint; second joint about twice the length of the first; style short, thick. Thorax black, opaque; near the humeri and behind, as also on the scutellum, thickly golden pollinose; pleurae diffusely pollinose; Abdomen opaque black; the hind margin of the first three segments, and the remainder of the abdomen, save spots on the sides of the fourth and fifth segments, thickly light golden pollinose. Legs reddish brown, the base of the tibiae and the basal joints of the tarsi yellowish. The brown of the wings extends to the third vein and through the middle of the first posterior cell; costal and subcostal cells lighter colored.

Length 11 millimeters. Two specimens, Chapada, H. H. Smith.

8. **Conops parvus, n. sp.**

FEMALE. Closely allied to *C. sylvosus* Williston, but differs in the lighter colored antennae and their more elongated third joint, which is as long as the first two joints together; in the wings being wholly grayish hyaline, save a quadrate brown spot in front a little beyond the middle; and in the lighter colored legs and abdomen. The proboscis is as long as the antennae; the legs are brown or brownish yellow.

Length 8 millimeters. Two specimens, Chapada, H. H. Smith.

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Unicursal Curves by Method of Inversion.

BY HENRY BYRON NEWSON.

This paper contains a summary of the work done during the last school year by my class in Modern Geometry. Since many of the results were suggested or entirely wrought out by class-room discussion, it becomes practically impossible to assign to each member of the class his separate portion. Many of the results were contributed by Messrs. M. E. Rice, A. L. Candy, H. C. Riggs, and Miss Annie L. MacKinnon.

The reader who is not familiar with the method of Geometric Inversion should read Townsend's Modern Geometry, chapters IX. and XXIV; or a recent monograph entitled, "Das Princep der Reziproken Radien," by C. Wolff, of Erlangen.

When a conic is inverted from a point on the curve, the inverse curve is a nodal, circular cubic.

This is shown analytically as follows: let the equation of the conic be written

$$ax^2+2hxy+by^2+2gx+2fy=0;$$

which shows that the origin is a point on the curve. Substituting for x and y $\frac{x}{x^2+y^2}$ and $\frac{y}{x^2+y^2}$, we have as the equation of the inverse curve

$$ax^2+2hxy+by^2+2(gx+fy)(x^2+y^2)=0.$$

The terms of the second degree show that the origin is a double point on the cubic; and is a crunode, acnode, or cusp, according as the conic is a hyperbola, ellipse, or parabola. The terms of the third degree break up into three linear factors, viz: $gx+fy$, $x+iy$, and $x-iy$, which are the equations of the three lines joining the origin to the three points where the line at infinity cuts the cubic; thus showing that the cubic passes through the imaginary circular points at infinity.

Since the above transformation is rational, it follows that there is a (1, 1) correspondence between the conic and the cubic. This fact is also evident from the nature of the method of inversion. The cubic has its maximum number of double points, viz: one; and hence is unicursal. This unicursal circular cubic may be projected into the most general form of unicursal cubic; the cuspidal variety, however, always remaining cuspidal.

By applying the method of inversion to many of the well known theorems of conics, new theorems are obtained for unicursal, circular cubics. If one of these new theorems states a projective property, it may at once by the method of projection be extended to all unicursal cubics. Examples will be given below.

The following method of generating a unicursal cubic is often useful. Given two projective pencils of rays having their vertices at A and B; the locus of the intersection of corresponding rays is a conic through A and B. Invert the whole system from A. The pencil through A remains as a whole unchanged, while the pencil through B inverts into a system of co-axial circles through A and B, and the generated conic becomes a circular cubic through A and B, having a node at A. Now project the whole figure and we have the following:—given a system of conics through four fixed points and a pencil of rays projective with it and having its vertex at one of the fixed points, the locus of the intersection of corresponding elements of the two systems is a unicursal cubic, having its node at the vertex of the pencil, and passing through the three other fixed points.

Unicursal cubics are divisible into two distinct varieties, nodal and cuspidal. The nodal variety is a curve of the fourth class and has three points of inflection, one of which is always real. The cuspidal variety is of the third class and has one point of inflection (Salmon, H. P. C., Art. 147). Each of these varieties forms a group projective within itself; that is to say, any nodal cubic may be projected into every other possible nodal cubic, and the same is true with regard to the cuspidal. But a nodal cubic can not be projected into a cuspidal and vice versa.

In applying this method of investigation to the various forms of unicursal cubics and quartics, only a limited number of theorems are given in each case. It will be at once evident that many more theorems might be added, but enough are given in each case to illustrate the method and show the range of its application. It is not necessary to work out all the details, as this paper is intended to be suggestive rather than exhaustive.

NODAL CUBICS.

If an ellipse be inverted from one of its vertices, the inverse curve is symmetrical with respect to the axis; it has one point of inflection at infinity and the asymptote is an inflectional tangent. This asymptote is the inverse of the circle of curvature at the vertex. The cubic has two other points of inflection situated symmetrically with respect to the axis. Hence the three points of inflection lie on a right line, a projective theorem which is consequently true of all nodal cubics. The axis is evidently the harmonic polar of the point of inflection at infinity. Since the axis bisects the angle between the tangents at the node, it follows that the line joining a point of inflection to the node, the two tangents at the node, and the harmonic polar of the point of inflection, form a harmonic pencil. There are three such lines, one to each node, and three harmonic polars; these form a pencil in involution, the tangents at the node being the foci.

Since the asymptote is perpendicular to the axis, we have by projection the following theorem:—through a point of inflection I, draw any line cutting the cubic in B and C. Through P the point of intersection of the harmonic polar and inflectional tangent of I, draw two lines to B and C. The four lines meeting in P form a harmonic pencil. The point of contact of the tangent from I to the cubic is on the harmonic polar of I. Any two inflectional tangents meet on the harmonic polar of the third point of inflection.

The locus of the foot of the perpendicular from the focus of a conic on a tangent is the auxiliary circle. Inverting from the vertex, there are two points, A and B, on the axis of the curve, such that if a circle be drawn through one of them and the node, cutting at right angles a tangent circle through the node, their point of intersection will be on the tangent to the curve where it is cut by the axis. Projecting:—through a point of inflection I of a nodal cubic draw a line cutting the cubic in P and Q; there are two determinate points on the harmonic polar of I, which have the following property:—draw a conic through P, Q, and the node touching the cubic; draw another conic through one of these points, P, Q, and the node cutting the former, so that their tangents at their point of intersection, together with the lines from it to P and Q form a harmonic pencil; the locus of such a point of intersection is the tangent from I to the cubic.

If three conics circumscribe the same quadrilateral, the common tangent to any two is cut harmonically by the third. Inverting from one of the vertices of the quadrilateral: if three nodal, circular cubics have a common double point and pass through three other fixed points, the common tangent circle through the common node to any two of the cubics is cut harmonically by the third; *i. e.*, so that the pencil from the node to the two points of intersection and the points of contact is harmonic. Projecting this:—given three nodal cubics having a common node and passing through five other fixed points; let a conic be passed through the common node and two of the fixed points, touching two of the cubics. The pencil from the common node to the points of contact and the point where the conic cuts the third cubic is harmonic.

The following theorem may be proved in similar manner:—given a system of cubics having a common node and passing through five other fixed points; let a conic be drawn through the common node and two of the fixed points; the lines drawn from the points where it cuts the cubics to the common node form a pencil in involution.

A variable chord drawn through a fixed point P to a conic subtends a pencil in involution at any point O on the conic. Inverting from O:—a system of circles through the double point of a nodal circular cubic and any other fixed point P, is cut by the cubic in pairs of points which determine at the node a pencil in involution. Projecting:—a system of conics through the node of a unicursal cubic, two fixed points on the curve, and any fourth fixed point, is cut by the cubic in pairs of points which determine at the node a pencil in involution.

We give another proof of the theorem that the three points of inflection of a nodal cubic lie on a right line. This is easily shown by inversion and is a beautiful example of the method.

There are three points on a conic whose osculating circles pass through a given point on the conic; these three points lie on a circle passing through the given point.* (Salmon's Conics, Art. 244, Ex. 5.) By inverting from the given point and then projecting, we readily see that there are three points of inflection on a nodal cubic which lie on a right line. If the above conic be an ellipse, the three osculating circles are all real; but if it be a hyperbola, one only is real. Hence an acnodal cubic has three real points of inflection, while a crunodal one has one real and two imaginary.

The reciprocals of many of the theorems of this section are of interest and will be given under Quartics.

CUSPIDAL CUBICS.†

Inverting the parabola from its vertex we obtain the Cissoid of Diocles. The focus of the parabola inverts into a point on the cuspidal tangent which I shall call the focus of the cissoid. The circle of curvature at the vertex of the parabola inverts into the asymptote of the cissoid. This asymptote is also plainly the inflectional tangent,

*See note A.

†A few of the results of this section are due to the late Mr. H. B. Hall.

and the point at infinity is the point of inflection. The directrix of the parabola inverts into a circle through the cusp of the cissoid having the cuspidal tangent for a diameter. Hall calls this the directrix circle. The double ordinate of the parabola which is tangent to the circle of curvature of the vertex inverts into the circle usually called the base circle of the cissoid.*

The cissoid may fairly be called the simplest form of the cuspidal cubic. Its projection and polar reciprocal are both cuspidal cubics. I shall now deduce from the parabola a few simple propositions for the cissoid, and then extend them to all cuspidal cubics.

(1) It is known that the locus of the intersection of tangents to the parabola which are at right angles to one another, is the directrix. Inverting:—the locus of the intersection of tangent circles to the cissoid through the cusp and at right angles to each other is the directrix circle.

(2) For the parabola, two right lines O P and O Q, are drawn through the vertex of the parabola at right angles to one another, meeting the curve in P and Q; the line P Q cuts the axis at a fixed point, whose abscissa is equal to its ordinate. Inverting:—two right lines, O P and O Q, are drawn at right angles to one another through the cusp of the cissoid, meeting the curve in P and Q; the circle O P Q passes through the intersection of the axis and asymptote.

(3) If the normals at the points P, O, R, of a parabola meet at a point, the circle through P O R will pass through the vertex Inverting:—through a fixed point and the cusp of a cissoid, three and only three circles can be passed, cutting the cissoid at right angles; these three points of intersection are collinear.

From the geometry of the cissoid we see that if any line be drawn parallel to the asymptote, cutting the curve in two points, B and C, the segment B C is bisected by the axis. Hence, projecting the curve we have the following theorem:—any line drawn through the point of inflection is cut harmonically by the point of inflection, the curve, and the cuspidal tangent. Thus the cuspidal tangent is the harmonic polar of the point of inflection. The polar reciprocal of this last theorem reads as follows:—if from any point on the cuspidal tangent the two other tangent lines be drawn to the curve, and a line to the point of inflection, these four lines form a harmonic pencil. These are fundamental propositions in the theory of cuspidal cubics.

(4) Projecting proposition (1) above, we have the generalized theorem:—through the point of inflection draw any line cutting the cubic in B and C; through B, C, and the cusp draw two conics tangent to

*See note B.

the cubic, and intersecting in a fourth point such that the two tangents to the conics at their point of intersection, together with the two lines from it to B and C, form a harmonic pencil; the locus of all such intersections is a conic through B, C, and the cusp having the point of inflection and the cuspidal tangent for pole and polar.

(5) Reciprocating (4) we have:—through any point on the cuspidal tangent draw the two other tangents, B and C, to the cubic. Touching B, C, and the inflectional tangent draw two conics, such that the points of contact of their common tangent, together with the points where their common tangent cuts the tangents B and C, form a harmonic range; the envelope of such common tangents is a conic having the cuspidal tangent and the point of inflection for polar and pole.

(6) Projecting (2) we obtain the following:—through the point of inflection draw any line cutting the curve in B and C; take any other two points on the cubic such that the pencil from the cusp, O, O (B P C Q) is harmonic; the conic passing through O B P C Q will pass through the intersection of the cuspidal and inflectional tangents.

(7) Reciprocating (6):—from any point on the cuspidal tangent draw two other tangents, B and C, to the cubic; take any two other tangents, P and Q, such that the range cut from the inflectional tangent by B, C, P, Q, is harmonic; the conic touching B, C, P, Q, and the inflectional tangent will also touch the line joining the point of inflection and the cusp.

(8) Projecting (3):—through the point of inflection draw any line cutting the cubic in B and C; through the cusp O and the points B and C on the cubic and any other fixed point P, three, and only three, conics can be passed, such that the tangent to the conic and cubic at their remaining point of intersection, together with the lines from it to B and C, form a harmonic pencil; these three points of intersection are collinear.

SYSTEMS OF CUBICS THROUGH NINE POINTS.

Let U and V be the equations of two given cubics, then $U + kV$ is the equation of a system of cubics through their nine points of intersection. Twelve cubics of this system are unicursal, and the twelve nodes are called the twelve critic centres of the system. (See Salmon's H. P. C., Art. 190.)

Let the equation of the system be written briefly

$$a+ka_1+(b+kb_1)\,x+(c+kc_1)\,y+u_2+u_3=0;$$

one, and only one, value of k makes the absolute term vanish; hence one, and only one, curve of the system passes through the origin, which may be any point in the plane. Make the equation of the system homogeneous by means of z, and differentiate twice with respect to z; we obtain thus the equations of the polar conics and polar lines of the origin with respect to the system.

The polar conics of the origin are given by

$$3(a+ka_1)+2\{(b+kb_1)x+(c+kc_1)y\}+u_2=0;$$

thus showing that the polar conics of any point, with respect to the system of cubics, form a system through four points. The polar lines of the origin are given by

$$3(a+ka_1)+(b+kb_1)x+(c+kc_1)y=0,$$

which represents a pencil of lines through a point.

Suppose now the origin to be at one of the critic centres; then for a particular value, k_1, all terms lower than the second degree must vanish, so that $\begin{Vmatrix} a & b & c \\ a_1 & b_1 & c_1 \end{Vmatrix}=0$. The factors of the terms of u_2, which involves k_1, represent the tangents at the double point to the nodal cubic, and also the polar conic of the origin with respect to this nodal cubic. Hence a critic centre is at one of the vertices of the self-polar triangle of its system of polar conics. The opposite side of this triangle is the common polar line of the critic centre with respect to its system of polar conics, and hence it is also the common polar line of the critic centre with respect to the system of cubics. The four basal points of the system of polar conics lie two and two upon the tangents at the double point of the nodal cubic.

When the origin is taken at one of the nine basal points of the system of cubics, a and a_1 both vanish. Hence it is readily seen that a basal point of a system of cubics is also a basal point of its system of polar conics and the vertex of its pencil of polar lines.

Suppose two of the basal points of the system of cubics to coincide, then every cubic of the system, in order to pass through two coincident points, must touch a common tangent at a fixed point. The common tangent is the common polar of its point of contact, both with respect to the system of cubics and to its system of polar conics. Hence the union of two basal points gives rise to a critic centre. The self-polar triangle of its system of polar conics here reduces to a limited portion of the common tangent. This line is not a tangent to the nodal cubic, but only passes through its double point.

Suppose three of the basal points of a system of cubics to coincide, such a point will then be a point of inflection on each cubic of the system. For, in the last case, if a line be drawn from the point of contact of the common tangent to a third basal point of the system, such a line will be a common chord of the system of cubics. Suppose, now, this third basal point be moved along the curves until it coincides with the other two; then the common chord becomes a common tangent, which cuts every cubic of the system in three coincident points, and hence is a common inflectional tangent.

Since the polar conic of a point of inflection on a cubic consists of the inflectional tangent and the harmonic polar of the point, and since the polar conics of a fixed point with respect to a system of cubics pass through four fixed points, it follows that in a system of cubics having a common point of inflection and a common inflectional tangent the harmonic polars of the common point of inflection meet in a point.

Since the common inflectional tangent is the common polar line of the common point of inflection, it follows that such a point is a critic centre of the system of cubics. One cubic of the system then has a node at the common point of inflection of the system, and forms an exception. The line which is the common inflectional tangent to the other cubics of the system cuts this also in three points, but is one of the tangents at the double point; the other tangent at the double point goes through the vertex of the pencil of harmonic polars.

It is evident that the nine basal points of a system of conics may unite into three groups of three each. The cubics will then all have three common points of inflection, and at these points three common inflectional tangents. These three points all lie on a line.

When four basal points of the system of cubics coincide, such a point is a double point on every cubic of the system. This is easily shown as follows, using the method of inversion. Let a system of conics through four points be inverted from one of the four points. The system of conics inverts into a system of cubics, having a common node and passing through three other finite fixed points and the two circular points at infinity. Since the common node counts as four points of intersection, it follows that any two cubics of the system, and hence all of them, intersect in nine points. This system can be projected into a system having a common double point and passing through any five other fixed points.

A number of theorems concerning the system of cubics can easily be inferred from known theorems concerning the system of conics. Since two conics of the system are parabolas, it follows that two cubics of the system are cuspidal. Since three conics of the system break up into pairs of right lines, it follows that three cubics of the system break up into a right line and a conic. Each right line and its corresponding conic intersect in the common double point. The line at infinity cuts the system of conics in pairs of points in involution, the points of contact of the two parabolas of the system being the foci; it follows on inversion that the pairs of tangents to the cubics at their common node form a pencil in involution, the two cuspidal tangents being the foci.

If the four basal points of the system of conics lie on a circle, this circle inverts into a right line, and one cubic then consists of this right line and the lines joining the centre of inversion to the circular points at infinity. This theorem may be stated for the system of cubics as follows: if the conic determined by the five basal points of the system of cubics (not counting the common double points), break up into right lines, the line passing through three of the five points, together with the lines joining the other two points to the common node, constitute a cubic of the system.

If three of the four basal points of the system of conics lie on a line, the conics consist of this line and a pencil of lines through the fourth basal point. Inverting from this fourth point and then projecting, we have a system of cubics consisting of a pencil of lines and a conic through the vertex and the four other fixed points. Hence, when the five fixed points of such a system of cubics lie on a conic through the common node, this conic is a part of every cubic of the system. If we invert the above system of conics from one of the three points on the right line, and then project, we obtain a system of cubics which consists of a system of conics through four fixed points, and a fixed right line through one of these four points. Hence, if two of the five basal points of such a system of cubics be on a line through the common node, this line is a part of every cubic of the system.

If a system of conics having one basal point at infinity be inverted from one of the remaining basal points, this point at infinity inverts to the center of inversion, and we obtain a system of cubics having five coincident basal points and hence passing through only four others. The system of cubics is now so arranged that one tangent at their common double point is common to all. Only one cubic of the system is cuspidal. As before three cubics break up into a right line and conic.

If two of three basal points of the system of conics be at infinity, the system of cubics obtained by projection and inversion has six coincident basal points and hence only three others. This system has both tangents at the common node common to all cubics of the system. If the two basal points at infinity in the system of conics be coincident, all the conics are parabolas, and hence all the cubics of the system are cuspidal and have a common cuspidal tangent.

If three of the basal points of the system of conics be at infinity, the conics consist of the line at infinity and a pencil of lines through the finite basal point. Inverting from the latter, we obtain a system of cubics with seven coincident basal points. This system is made up of a pencil of lines meeting in the seven coincident basal points together with the two lines joining this to the other two basal points of the system. These two lines are part of every cubic of the system.

If one of the remaining basal points be moved up to join the seven coincident ones, one of these fixed lines becomes indeterminate, and the system of cubics through eight coincident points consists of a fixed line through the eight coincident points and the ninth fixed point together with any two lines of the pencil through the eight points. If the nine basal points coincide, any three lines through it form a cubic of the system.

UNICURSAL QUARTICS.

The inverse of a conic from any point not on the curve is a nodal bicircular quartic. This is shown by inverting the general equation of the conic

$$ax^2+2hxy+by^2+2gx+2fy+c=0;$$

by substituting for x and y, $\frac{x}{x^2+y^2}$ and $\frac{y}{x^2+y^2}$, we get the equation

$$ax^2+2hxy+by^2+2(gx+fy)(x^2+y^2)+c(x^2+y^2)^2=0.$$

The origin is evidently a double point on the curve, and is a crunode, acnode, or cusp according as the conic is a hyperbola, ellipse, or parabola. The factors of the terms of the fourth degree, viz: $(x+iy)(x+iy)$ $(x-iy)$ $(x-iy)$, show that the two imaginary circular points at infinity are double points on the quartic, which is thus trinodal. Hence this nodal, bicircular quartic can be projected into the most general form of the trinodal quartic. Trinodal quartics are unicursal.

If the conic which we invert be a parbola, the quartic has two nodes and one cusp. If the conic be inverted from a focus, the quartic has the two circular points at infinity for cusps. This is best shown analytically as follows: let the equation of the conic, origin being at the focus, be written

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{2aex}{a^2}-\frac{b^2}{a^2}=0.$$

Inverting this we have

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{2aex(x^2+y^2)}{a^2}-\frac{b^2(x^2+y^2)^2}{a^2}=0$$

Now transform this equation so that the lines joining the origin to the circular points at infinity shall be the axes of reference. To do this let $x+iy=x_1$ and $x-iy=y_1$; $\therefore$ $x=\frac{x_1+y_1}{2}$, and $y=\frac{x_1-y_1}{2i}$.

Making these substitutions and reducing we have (dropping the subscripts),

$$\frac{x^2+2xy+y^2}{a^2}-\frac{x^2-2xy+y^2}{b^2}-\frac{4aexy\,(x+y)}{a^2}-\frac{b^2x^2y^2}{a^2}=0$$

Making this equation homogeneous by means of z, we have

$$z^2\left\{\frac{(x^2+2xy+y^2)}{a^2}-\frac{(x^2-2xy+y^2)}{b^2}\right\}-\frac{4aexyz(x+y)}{a^2}-\frac{b^2x^2y^2}{a^2}$$
$$=0,$$

which is the equation of the quartic referred to the triangle formed by the three nodes. We are now able to determine the nature of the node at the vertex (y, z). Factor x^2 out of all the terms which contain it; and arrange thus:

$$x^2\left\{\frac{z^2}{a^2}-\frac{z^2}{b^2}-\frac{4aeyz}{a^2}-\frac{b^2y^2}{a^2}\right\}+2x\left\{\frac{yz^2}{a^2}+\frac{yz^2}{b^2}-\frac{2aey^2z}{a^2}\right\}+$$
$$\frac{y^2z^2}{a^2}-\frac{y^2z^2}{b^2}=0$$

The quantity which multiplies x^2 represents the two tangents at the double point (y, z); but this quantity is a perfect square and hence we have a cusp. In this way the point (x, z) may be shown to be a cusp. Lastly, when a parabola is inverted from the focus, we obtain a tricuspidal quartic.

The trinodal quartic can be generated in a manner analogous to that shown for the nodal cubic. Let two projective pencils of rays have their vertices at A and B, the locus of intersection of corresponding rays is a conic through A and B. Invert from any point O in the plane, and we obtain two systems of coaxial circles, O A being the axis of one and O B of the other. The locus of intersection of corresponding circles is a bicircular quartic having a node at O. Projecting the whole figure we have the following theorem:—two projective systems of conics through O P Q A and O P Q B generate by their corresponding intersections a trinodal quartic having its nodes at O, P, and Q, and passing through A and B.

It is evident that the quartic generated in this way may have three nodes, one node and two cusps, two nodes and one cusp, or three cusps, dependingup on the nature of the conic inverted and the centre of inversion. Making this the basis of classification we thus distinguish four varieties of unicursal quartics. To these must be added a fifth variety, viz: the quartic with a triple point. Each of these varieties will be consided separately.

The method of treating unicursal quartics given in this and the next four sections is in some respects similar to that suggested by Cayley in Salmon's Higher Plane Curves. But the method here sketched out is very different in its point of view and much wider in its application, yielding a multitude of new theorems not suggested by Cayley's method.

TRINODAL QUARTICS.

The quartic with three double points is a curve of the sixth class having four double tangents and six cusps (Salmon's H. P. C. Art. 243). Hence its reciprocal is of the sixth degree with four double points, six cusps, three double tangents, and no points of inflection.

The locus of intersection of tangents to a conic at right angles to one another is a circle. Inverting:—the locus of intersection of circles through the node and tangent a nodal, bicircular quartic and at right angles to one another is a circle. Projecting:—through the three nodes of a quartic draw two conics, each touching the quartic and intersecting so that the two tangents to the conics at their point of intersection, together with the lines from it to two of the nodes, form a harmonic pencil; the locus of all such intersctions is a conic through these two nodes. Whenever the two tangents to the quartic from the third node, together with the lines from it to the other two nodes, form a harmonic pencil, this last conic breaks up into two right lines.

Any chord of a conic through O is cut harmonically by the conic and the polar of O. Inverting from O and projecting:—from one of the nodes of a trinodal quartic draw the two tangents to the quartic (not tangents at the node); draw the conic through these two points of contact and the three nodes; any line through the first mentioned node is cut harmonically by this conic, the quartic and the line joining the other two nodes.

If a triangle circumscribe a conic, the three lines from the angular points of the triangle to the points of contact of the opposite sides intersect in a point. Inverting and projecting:—through the three nodes of a quartic draw three conics touching the quartic; through the point of intersection of two of these conics, the point of contact of the third, and the three nodes draw a conic; three such conics can be drawn and they pass through a fixed point.

The eight points of contact of two conics with their four common tangents lie on a conic, which is the locus of a point, the pairs of tangents from which to the two given conics form a harmonic pencil. Inverting and projecting:—two connodal trinodal quartics have four common tangent conics through the three nodes; their eight points of contact lie on another connodal trinodal quartic; if from any point on the last quartic four conics be drawn through the nodes and tangent in pairs to the first quartics, any line through a node is cut harmonically by these four conics.

The eight common tangents to two conics at their common points all touch a conic. Inverting and projecting:—two connodal trinodal quartics intersect in four other points; eight conics can be drawn through the three nodes tangent to the quartics at these points of intersection; these eight conics all touch another connodal trinodal quartic.

A series of conics through four fixed points is cut by any transversal in a range of points in involution. Inverting and projecting:—a series of connodal trinodal quartics can be passed through four other fixed points; any conic through the three nodes cuts the series of quartics in pairs of points which determine at a node a pencil in involution. The conic touches two of the quartics and the lines to the points of contact are the foci of the pencil.

If the sides of two triangles touch a given conic, their six angular points will lie on another conic. Inverting and projecting:—if two groups of three conics each be passed through three nodes and tangent to the quartic, their six points of intersection (three of each group) lie on another connodal trinodal quartic.

If the two triangles are inscribed in a conic, their six sides touch another conic. Inverting and projecting:—if two groups of three conics each be passed through the three nodes of a quartic so that the three points of intersection of each group lie on the quartic, these six conics all touch another connodal trinodal quartic.

A triangle is circumscribed about one conic, and two of its angular points are on a second conic; the locus of its third angular point is a conic.—Inverting and projecting:—if three conics be drawn through the three nodes of two connodal trinodal quartics so that they all touch one of the quartics and two of their points of intersection are on the other quartic, the locus of their third point of intersection is a connodal trinodal quartic.

A triangle is inscribed in one conic and two of its sides touch a second conic; the envelope of its third side is a conic. Inverting and projecting:—if three conics be drawn through the three nodes of two connodal trinodal quartics so that their three points of intersection lie on one of the quartics and two of them touch the other quartic, the envelope of the third conic is another connodal trinodal quartic.

The theorems of this section are stated in the most general terms and are still true when one or more of the nodes are changed into cusps. It is therefore not necessary to give separate theorems for the case of one cusp and two nodes.

NODAL BICUSPIDAL QUARTICS.

A quartic with one node and two cusps is a curve of the fourth class, having one double tangent and two points of inflection (see

Salmon). Hence its reciprocal is also a nodal bicuspidal quartic, a fact of which frequent note will be made in this section.

The inverse of a conic with respect to a focus is a curve called Pascal's Limaçon. From the polar equation of a conic, the focus being the pole, it is evident that the polar equation of the limaçon may be written in the form:

$$r = \frac{e}{p}\cos x + \frac{1}{p};$$

where e and p are constants, being respectively the eccentricity and semi-latus rectum of the conic.

From the above equation it is readily seen that the curve may be traced by drawing from a fixed point O on a circle any number of chords and laying off a constant length on each of these lines, measured from the circumference of the circle. The point O is the node of the limaçon; and the fixed circle, which I shall call the base circle, is the inverse of the directrix of the conic. This is readily shown as follows:—the polar equation of the directrix is $r = \frac{p}{e\cos x}$. Hence the equation of its inverse is $r = \frac{e\cos x}{p}$, which is the equation of the base circle of the limaçon.

The envelope of circles on the focal radii of a conic as diameters is the auxiliary circle. Inverting:—the envelope of perpendiculars at the extremities of the nodal radii of a limaçon is a circle with its centre on the axis and having double contact with the limaçon. Projecting:—from any point on a nodal bicuspidal quartic draw lines to the three nodes and a fourth line forming with them a harmonic pencil; the envelope of all such lines is a conic through the two cusps and having double contact with the quartic; the chord of contact passes through the node and cuts the line joining the cusps so that this point of intersection, the two cusps, and intersection of the double tangent with the cuspidal line form a harmonic range. Reciprocating:—on any tangent to a nodal bicircular quartic take the three points where it cuts the two inflectional tangents and the double tangent, and a fourth point forming with these a harmonic range; the locus of all such points is a conic touching the two inflectional tangents and having double contact with the quartic; the pole of the chord of contact is on the double tangent; join this last point to the intersection of the inflectional tangents and join the node with the same intersection; these four lines form a harmonious pencil.

If the tangent at any point P of a conic meet the directrix in Q, the line P Q will subtend a right angle at the focus O; the circle P O Q has

P Q for a diameter and hence cuts the conic at P at right angles. Inverting:—from any point P on the limaçon draw O P to the node O; draw O Q perpendicular to O P meeting the base circle in Q; P Q is normal to the limaçon at P. Projecting:—from any point P on a nodal bicuspidal quartic draw lines to the three nodes and a fourth harmonic to these three; from O draw lines to the two cusps and a fourth harmonic to these two and the line O P; the locus of the intersection of the fourth line of each pencil is a conic through the three nodes. Call this the basal conic of the quartic. Reciprocating:—on any given tangent to a nodal bicuspidal quartic take its points of intersection with the double tangent and the inflectional tangents, and a fourth point harmonic with these; on the double tangent take its points of intersection with the given tangent and the inflectional tangents, and a fourth point harmonic with these; the envelope of the lines joining the fourth point of these two ranges is a conic touching the double and inflectional tangents.

The locus of the foot of the perpendicular from the focus on the tangent to a conic is the auxiliary circle. Inverting:—draw a circle through the node tangent to a limaçon; draw the diameter O P of this circle; the locus of P is a circle having double contact with the limaçon, the axis being the chord of contact. Cor.; the locus of the centre of the tangent circle is also a circle. Projecting:—through the three nodes of a nodal bicuspidal quartic draw any conic touching the quartic; the locus of the pole with respect to this conic of the line joining the two cusps is a conic; draw the chord O P of the first conic through the node O and the pole of the line joining the two cusps; the locus of P is a conic through the cusps, having double contact with the quartic.

If chords of a conic subtend a constant angle at the focus, the tangents at the ends of the chords will meet on a fixed conic, and the chords will envelope another fixed conic; both these conics will have the same focus and directrix as the given conic. Inverting:—draw two nodal radii of a limaçon O P and O Q, making a given angle at O; the envelope of the circle P O Q is another limaçon; the locus of the intersection of circles through O tangent to the limaçon at P and Q is another limaçon. These two limaçons have the same node and base circle as the given one. Projecting:—through the node O of a nodal bicuspidal quartic draw a pencil of radii in involution; let O P and O Q be a conjugate pair of these nodal radii; the envelope of the conic through P, Q, and the three nodes, is another quartic of the same kind: also draw conics through the three nodes tangent to the quartic at P and Q; the locus of their point of intersection is another quartic of the same kind. These three quartics all have the same node, cusps, and base conic.

Every focal chord of a conic is cut harmonically by the curve, the focus, and directrix. Inverting:—every nodal chord of a limaçon is bisected by the base circle. Projecting:—every nodal chord of a nodal bicuspidal quartic is cut harmonically by the quartic, the base conic, and the line joining the two cusps. Reciprocating:—from any point on the double tangent of a nodal bicuspidal quartic draw the other two tangents to the quartic and a line to the intersection of the inflectional tangents; the fourth harmonic to these lines envelopes a conic.

Since the limaçon is symmetrical with respect to the axis, it follows that the two points of inflection are situated symmetrically with respect to the axis. Hence the line joining the two points of inflection is parallel to the double tangent. Therefore by projection we infer the following general theorem for the nodal bicuspidal quartic: the line joining the two cusps, the line joining the two points of inflection, and the double tangent meet in a point. Also the fourth harmonic points on each of these lines lie on a line through the node. Reciprocating:—the point of intersection of the cuspidal tangents, the the point of intersection of inflectional tangents, and the node all lie on a right line. From the node draw a fourth harmonic to this right line and the tangents at the node; draw a fourth line harmonic to this right line and the inflectional tangents; draw a fourth harmonic to the cuspidal tangents and this right line; these three lines all meet in a point on the double tangent.

TRICUSPIDAL QUARTICS.

A tricuspidal quartic is a curve of the third class with one double tangent and no inflection. Its reciprocal is therefore a nodal cubic.

We shall begin by reciprocating some of the simpler properties of nodal cubics. Since the three points of inflection of a nodal cubic lie on a right line, it follows that the three cuspidal tangents of a tricuspidal quartic meet in a point. The reciprocal of the harmonic polar of a point of inflection is a point on the double tangent, found by drawing through the point of intersection of the three cuspidal tangents a line forming with them a harmonic pencil. Three such lines can be drawn and it is not difficult to distinguish them. All six lines form a pencil in involution, the lines to the points of contact of the double tangent being the foci. I shall call such a point on the double tangent the harmonic point of the cuspidal tangent. Since any two inflectional tangents of a nodal cubic meet on the harmonic polar of the third point of inflection, it follows that any two cusps of a trinodal quartic and the harmonic point of the third cuspidal tangent lie on a right line. Since the point of contact of the tangents from a point of inflection of a nodal cubic is on the harmonic polar of the point, it follows that the tangent to the tricuspidal quartic at the point where it is cut by a cuspidal tangent passes through the harmonic point of that cuspidal tangent.

The inverse of the parabola from a focus is the cardioid ; and the inverse of the corresponding directrix is the base circle of the cardioid. The cardioid projects into a tricuspidal quartic and its base circle projects into a conic through the three cusps which has the same general properties as the base conic of the nodal bicuspidal quartic.

The circle circumscribing the triangle formed by the three tangents to a parabola passes through the focus. Inverting :—three circles through the cusp, and tangent to a cardioid, intersect in three collinear points. Projecting:—three conics through the three cusps of a tricuspidal quartic and touching the quartic intersect in three collinear points. Reciprocating:—if three conics touch the three inflectional tangents of a nodal cubic and the cubic itself, their three other common tangents intersect in a point.

Circles described on the focal radii of a parabola as diameters touch the tangent through the vertex. Inverting and projecting:—from a point on a tricuspidal quartic lines are drawn to the three cusps and a fourth line forming a harmonic pencil; the envelope of this fourth line is a conic through the three cusps and touching the quartic at the point where the latter is cut by one of the cuspidal tangents. There are three such conics, one corresponding to each cusp. At any cusp the tangent to its corresponding base conic, the cuspidal tangent, and the lines to the other two cusps form a harmonic pencil. Reciprocating :—on any tangent to a nodal cubic take the three points of intersection with the inflectional tangents and a fourth point forming with these a harmonic range; the locus of this fourth point is a conic touching the three inflectional tangents and the cubic. The tangent to the cubic where it is touched by the conic goes through a point of inflection. On any inflectional tangent the point of contact of this conic, the point of inflection, and the points of intersection of the other two inflectional tangents form a harmonic range.

The circle described on any focal chord of a parabola as diameter will touch the directrix. Inverting :—the circle described on any cuspidal chord of a cardioid will touch the base circle. Projecting :—through a cusp C draw any chord of a tricuspidal quartic meeting the quartic in P and O ; draw a conic through P, O, and the other two cusps so that the pencil at P formed by the tangent to the conic and the lines to the cusps is harmonic; all such conics will touch the base conic of the cusp C. Reciprocating:—from O, on any inflectional tangent of a nodal cubic, draw two tangents P and Q to the cubic; draw a conic touching the tangents P and Q and the other two inflectional tangents so that the range on one of these tangents formed by the point of contact of the conic and the intersection of the three inflectional tangent is harmonic; the envelope of all such conics is a conic touching the three inflectional tangents.

The directrix of a parabola is the locus of the intersection of tangents at right angles to one another. Inverting and projecting:—through any point P on the base conic of a cusp C of the tricuspidal quartic, two conics can be drawn through the three cusps and touching the quartic; their two tangents at P and the lines to the other two cusps form a harmonic pencil; their two points of contact lie on a line through C. Reciprocating:—from any point on one of the inflectional tangents to a nodal cubic draw the two tangents P and Q; draw two conics each touching the cubic and the three inflectional tangents, one touching P and the other Q; the envelope of their other common tangent is a conic touching the three inflectional tangents; the two points of contact of any one of these common tangents and the points where it cuts the other two inflectional tangents form a harmonic range.

Any two parabolas which have a common focus and their axes in opposite directions cut at right angles. Inverting:—any two cardioids having a common cusp and their axes in opposite directions cut at right angles. Projecting:—two tricuspidal quartics having common cusps and at one of the cusps the same cuspidal tangent, but the cusps pointed in opposite directions, cut at such an angle that the tangents at a point of intersection and the lines to the other two cusps form a harmonic pencil. Reciprocating:—two nodal cubics have common inflectional tangents and on one of them the points of inflection common, but the branches of the curve on opposite sides of the line; any common tangent to the two curves is cut harmonically by the points of contact and the other two inflectional tangents.

Circles are described on any two focal chords of a parabola as diameters; their common chord goes through the vertex of the parabola. Inverting:—circles are described on any two cuspidal chords of a cardioid; the circle through their points of intersection and the cusp goes also through the vertex of the cardioid. Projecting:—through one of the cusps of a tricuspidal quartic draw two chords; draw conics through the other two cusps and the extremities of each of these chords so that the pole of the line joining the other two cusps with respect to each of these conics is on the corresponding chord; the conic through the points of intersection of these two conics and the cusps passes also through the point where the cuspidal tangent of the first mentioned cusp cuts the quartic. Reciprocating:—on one of the inflectional tangents, of a nodal cubic take two points P and Q; draw a pair of tangents from each of these points to the cubic; draw two conics each touching a pair of these tangents and the other two inflectional tangents, so that the polars of the point of intersection of the other two inflectional tangents with respect to each of those conics pass respectively through P and Q; the conic touching the common tangents to these two conics and the three inflectional tangents touches also the tangent from the first mentioned point of inflection to the cubic.

QUARTICS WITH A TRIPLE POINT.

Since a triple point is analytically equivalent to three double points, a quartic with a triple point is unicursal. Such a quartic is obtained by inverting a unicursal cubic from its node. The equation of such a cubic may be written $u_2+u_3=0$, where u_2 and u_3 are homogeneous functions of the second and third degree respectively in x and y. Hence the equation of the inverse curve is $u_3+u_2(x^2+y^2)$, which shows that the origin is a triple point and the quartic circular. By projecting this all other forms may be obtained.

The nature of the triple point depends upon the relation of the line at infinity to the cubic before inversion. Thus the line at infinity may cut the cubic in three distinct points all real, or one real and two imaginary, in one real and two coincident points (an ordinary tangent), or in three coincident points (an inflectional tangent). Hence the quartic may have at the triple point three distinct tangents all real, or one real and two imaginary, one real and two coincident, or all coincident.

This quartic may be generated in a manner similar to that used for the curves already discussed. We showed in the section on nodal cubics that a system of conics through A, B, C, D, and a projective pencil of rays with its vertex at A generate by the intersection of corresponding elements a cubic with a node at A. Invert the whole figure from A and then project:—the pencil of rays remains a pencil; the system of conics becomes a system of unicursal cubics having a common node at A and passing through five other common points; the cubic inverts and projects into a quartic with a triple point at A, passing through the five other common points of the system of cubics.

The three points of inflection of a nodal cubic lie on a right line. Inverting:—there are three points on a circular quartic with a triple point whose osculating circles pass through the triple point, and these three points lie on a circle through the triple point. Let these three points be designated by A, B, and C. The lines from the triple point O to the points A, B, C, and the common chord of the osculating circles at two of them form a harmonic pencil. Through one of these points, A, and the triple point draw a circle touching the quartic; the point of contact is on the common chord of the osculating circles at B and C.

From theorems which we have already proved for a system of cubics having a common node and passing through five others fixed points, we can infer other theorems for a system of quartics having a common triple point and passing through seven other fixed points. For example, any conic through the common double point and two of the fixed points is cut by the cubics in pairs of points which determine at the node a pencil in involution. Hence any cubic having its node at the common triple point and passing through any four of the fixed points is cut by the quartics in pairs of points which determine at the common triple point a pencil in involution. Again, the pairs of tangents to the cubics at the common double point form a pencil in involution, the two cuspidal tangents being the foci of the pencil. Inverting:—the line at infinity (which passes through two of the fixed points, i. e. the circular points) cuts the system of circular quartics in pairs of points in involution. Projecting:—a line through any two of the seven fixed points cuts the system of quartics in pairs of points in involution. Since the line at infinity touches the inverse of a cuspidal cubic, it follows that any line through two of the fixed points will touch two of the quartics of the system; these points of contact are therefore the foci of the involution.

Other theorems on such a system of quartics will be given in the next section.

SYSTEMS OF QUARTICS THROUGH SIXTEEN POINTS.

Let U and V represent a system of quartics through sixteen points. Since the discriminant of quartic is of the 27th degree in the coefficients it follows that there are 27 values of k for which the discriminant vanishes, and hence 27 quartics of the system which have double points. As in case of cubics these 27 points are called the critic centres of the system. Let the equation of the system of quartics be written

$$u_4+u_3+u_2+u_1+u_0=0.$$

In a manner similar to that employed for cubics, we find the equation of the polar cubics of the origin with respect to the system to be

$$u_3+2u_2+3u_1+4u_0=0.$$

The polar conics of the origin are given by

$$u_2+3u_1+6u_0=0;$$

and the polar lines of the origin, by $u_1+4u_0=0$.

The origin may be any point in the plane and hence we conclude that only one quartic of the system passes through a given point and that the polar cubics of any point form a system through nine points. The polar conics of any point form a system through four points and the polar lines meet in a point.

If one of the critic centres be taken for origin, we can readily see that such a point is also a critic centre on each of its systems of polar curves. It is thus at a vertex of the self-polar triangle of its system of polar conics and the opposite side of the triangle is the common polar line of the critic centre with respect to each of the systems of curves. The tangents at the node of the nodal quartic coincide with those of its polar cubic and these we know coincide with the lines which constitute its polar conic.

If two of the sixteen basal points coincide, such a point is a critic centre. The argument is the same as for a system of cubics. We can also see that two of the basal points of each of its systems of polar curves coincide at the critic centre. The sixteen basal points of the system of quartics may unite two and two so that it is possible to draw a system of quartics touching eight given lines each at a fixed point.

If three of the basal points of our system of quartics coincide, all the quartics have at such a point a common point of inflection and a common inflectional tangent. The demonstration is the same as that already given for cubics. The system of polar cubics of such a point also have this point for a common point if inflection and the same tangent for a common inflectional tangent. I prefer to show this analytically for the sake of the method. The equation of the system of quartics having the origin for a common point of inflection and the axis of y for a common inflectional tangent may be written

$$u_4+u_3+\{(B+kB_1)xy+(C+kC_1)y^2\}+(A+kA_1)y=0.$$

The equation of the polar cubics of the origin is therefore,

$$u_3+2\{(B+kB_1)xy+(C+kC_1)y^2\}+3(A+kA_1)y=0,$$

which proves the proposition. The properties of the system of polar conics of such a point are therefore the same as those already proved for cubics. One quartic of the system has a double point at the common point of inflection of the others.

When four basal points coincide they give rise either to a common point of undulation or a common double point on all the quartics of the system. The equation of the system having a common point of undulation may be written

$$u_4+(A+kA_1)x^2y+(B+kB_1)xy^2+(C+kC_1)y^3+(D+kD_1)xy+(E+kE_1)y^2+(F+kF_1)y=0$$

There is one value of k for which the last term vanishes, and hence the origin is a critic centre. The polar cubics of the point of undulation break up into a system of conics through four points and the common tangent at the common point of undulation. For the equa- of the polar cubics is

$$y\left\{(A+kA_1)x^2+(B+kK_1)xy+(C+kC_1)y^2+2(D+kD_1)x+2(E+kE_1)y+(F+kF_1)\right\}=0$$

The system of polar conics of the origin consequently breaks up into the line $y=0$ and a pencil meeting in a point. The common tangent at the common point of undulation is also the common polar line of the point of undulation.

When the four coincident basal points form a common double point on the quartic, it is not difficult to show that two of the quartics are cuspidal at this point. The polar cubics of the common double point form a system having the same point for common double point. The tangents to the quartics at the common node constitute the system of polar conics and form a pencil in involution. Twelve of the sixteen basal points may unite in three groups of four each and the system of quartics is then trinodal and passes through four other fixed points. This is the system obtained by inverting a system of conics through four points and then projecting.

A few special cases should be noticed here. If the four fixed points and two of the nodes lie on a conic, this conic together with the two lines from the third node to the first two constitute a quartic of the system. If the four fixed points lie on a line, the quartic then consists of this line and the sides of the triangle formed by the nodes. If the three nodes and three of the fixed points lie on a conic, the system of quartics then consists of this conic and a system of conics through the three nodes and the fourth fixed point. A special case of a system of quartics with three nodes is a system of cubics having a common node and passing through five other fixed points together with a line through two of them.

If a fifth basal point be moved up to join the four at the common node, the quartics have one tangent at the common node common to all. If six basal points coincide they have both tangents at the node common to all. In this case one of the quartics has a triple point at the common node of the others. If seven basal points coincide, one of these tangents is an inflectional tangent as well. If eight points coincide, both are inflectional tangents.

When nine of the basal points of a system of quartics coincide, the quartics have a common triple point. This is nicely shown by inverting a system of nodal cubics from the common node. The inverse curves form a system of quartics having a triple point and passing through seven other fixed points. The common triple point on two quartics counts for nine points of intersection and the seven others make the requisite sixteen. From our knowledge of a system of cubics having a common node it is readily inferred that three of the quartics must each break up into a nodal cubic and a right line through the node. If the seven fixed points of the system of quartics lie on a cubic having a node at the common triple point, the system of quartics then consists of this cubic and a pencil of lines through the node. If two of the seven fixed points lie on a line through the common triple point, the system of quartics then consists of this right line and a system of cubics through the other five points and having a common node at the common triple point.

The system of cubics having a common node may have one, two, or three of the other basal points at infinity; and these may be all distinct or two or three of them coincident. Whence we infer that if the system of quartics have ten coincident basal points, one of the tangents at the triple point is common to all the quartics of the system. If eleven basal points coincide, two of the triple-point tangents are common to all the quartics. If twelve coincide, all three triple-point tangents are common. These triple-point tangents may be all distinct, two coincident, or all three coincident.

If thirteen basal points coincide, the system of quartics then consists of the three fixed lines joining the multiple point to the other three, together with a pencil of lines through the multiple point. If fourteen points coincide, two lines are fixed and these with any two lines of the pencil form a quartic of the system. If fifteen points coincide, only one line is fixed and each quartic consists of this line and any other three of the pencil. When all sixteen points coincide, any four lines through it form a quartic of the system.

In this paper cubic and quartic curves only are considered. I expect in a future paper to extend the methods herein developed to curves of still higher degrees. Many of the present results can be generalized and stated for a unicursal curve of the nth degree. I have purposely omitted all consideration of focal properties of these curves. There are also many special forms of interest which do not properly belong to a general treatment of the subject.

NOTE A.

The theorem concerning the three points on a conic A, B, and C, whose osculating circles pass through a fourth point O on the conic, is due to Steiner. From the properties of the harmonic polars of the points of inflection on a nodal cubic we may infer many other theorems concerning the points A, B, and C on a conic. Let the cubic be projected into a circular cubic and then inverted from the node. Its points of inflection A_1, B_1, C_1 invert into the points A, B, and C. The harmonic polar of A_1 inverts into the common chord O P of the circles osculating the conic at B and C; and similarly for the other harmonic polars.

The pencil $O\{ABPC\}$ is harmonic. Any circle through A and O meets the conic in S and T so that the pencil $O\{ASPT\}$ is harmonic. The two circles through O and tangent to the conic at S and T intersecton O P. If two circles be drawn through O and A intersecting the conic one in S and T and the other in and U V, the circles O S U and O T V intersect on O P; so also the cirles O S V and O T U. But one circle can be drawn through O and A and tangent to the conic; its point of contact is on O P. Let l, m, and n be three points on the conic on a circle through O. Draw the circles O A l, O A m, and O A n intersecting the conic again in l_1, m_1, n_1; l_1, m_1, n_1, are also on a circle through O, and the circles through l, m, n and l_1, m_1, n_1 intersect on O P.

NOTE B.

From the fundamental property of the Cissoid of Diocles we can obtain by inversion an interesting theorem concerning the parabola. In the figure of the Cissoid given in Salmon's H. P. C. Art. 214, $AM_1 = MR$, whence $AM_1 = AR - AM$; or $AR = AM + AM_1$. Inverting from the cusp and representing the inverse points by the same letters, we have for the parabola

$$\frac{1}{AR} = \frac{1}{AM} + \frac{1}{AM_1}.$$

This result is interpreted as follows:—draw the circle of curvature at the vertex of a parabola; this circle is tangent to the ordinate B D which is equal to the abscissa A D; draw a line through A cutting the circle in R, the ordinate B D in M, and the parabola in M_1; then

$$\frac{1}{AR} = \frac{1}{AM} + \frac{1}{AM_1}.$$

Draw the circle with centre at D and radius A D; any chord of the parabola through the vertex is cut harmonically by the parabola, the circle, and the double ordinate through D.

Foreign Settlements in Kansas.

A CONTRIBUTION TO DIALECT STUDY IN THE STATE.

Explanatory.—Some years ago when the subject of dialect study in Kansas, or rather of Kansas dialect, was mentioned, Mr. Noble Prentis, a gentleman who is warranted in speaking with authority on Kansas, was inclined to think that he settled the question in short order by declaring that there is no Kansas dialect. Probably the majority of intelligent citizens of the state would turn off the subject with the same reply. In the sense of a mode of speech common to the inhabitants of Kansas and peculiar to them, Mr. Prentis was indeed right. There is no vocabulary, at least no extensive vocabulary, by which the native of Kansas may be recognized in the American Babel. We have no distinctive pronunciation by which we may be known from the inhabitants of Nebraska or set apart from the citizens of Missouri. The verb fails to agree with its subject and the participle is deprived of its final 'g' with about equal frequency in Western Kansas and Eastern Colorado.

But in the same sense it is true that there is no Kansas flora, no Kansas fauna; that is, there is no plant and there is no animal found quite generally in Kansas and found nowhere outside of Kansas. The remark that there is no such thing as a Kansas dialect rests upon a misapprehension of what is meant by the term. In just the same way that we speak of the flora and the fauna of Kansas we may speak of the dialect of Kansas. Yet to avoid popular misapprehension it may be better to speak of dialect in Kansas, rather than of Kansas dialect.

Dialect study involves the observation and description of all facts concerning the natural living speech of men, and especially those points in which the speech of individuals or groups differs from that of the standard literary language as represented in classic writers and classic speakers. Standard literary English is always a little behind the times. It is the stuffed and mounted specimen in the museum. Dialect is the live animal on its native heath. Most people, indeed, will think that their speech does not differ materially from standard English. They say, We speak near enough alike "for practical purposes." But a thousand years hence the pronunciation of our country may have changed so much that it will seem like another language, and our descendants will write learned theses to prove that we pronounced 'cough' like cow or like cuff. A new language will have grown out of an old one, but no one know how it came about. Careful dialect study will help explain it.

Kansas is a peculiarly favorable field for dialect study. We have here side by side representatives from nearly every state in the Union, and from a dozen foreign countries. The observer has here what elsewhere he must travel over half the world to find. In a district where the people are all natives, the speech is so nearly homogeneous that it is difficult to find any one who recognizes the peculiarities of his own language, but here the contrast of strange tongues strikes us immediately and we become conscious early of the fact that all men do not speak alike.

Study of dialect may be classified under the heads of pronunciation, grammar and vocabulary. Of these the last two are the easiest, and may be carried on by almost any one with pleasure and valuable results. Pronunciation is the most difficult of these matters to study, as competent observation and reports can be made only by one who has made a thorough study of Phonetics. To those who might wish to take up the study of this branch of the subject, Sweet's Primer of Phonetics, and Grandgent's "Vowel Measurements" and "German and English Sounds" are recommended.

In the study of dialect vocabularies it may become of the greatest importance to establish the exact locality of a word and the origin of the persons by whom it is used. For instance, in a family of my acquaintance the word 'slandering'=sauntering was familiar. It was a great puzzle to me until I learned that some of the children had been in the care of a German maid. The German word 'schlendern' suggested the unquestionable source of the peculiar word. As a source of information regarding the origin of the foreign elements of our population when their native speech shall have been forgotten, but when the influence of it will be left in vocabulary and pronunciation I have thought that a map of the state with the location of all the foreign settlements of even quite small size would be of interest and in time of great value. In the following pages I transmit the results of my inquiries so far as received. It is my intention to make the report complete and to publish the map, when as complete as it can be made, in colors. Unexpected difficulties have delayed the work and prevented its being complete. I depended for my information upon the County Superintendents of the State, a class of unusually intelligent and well-informed men and women. But in not a few cases there seems to have been a suspicion in the mind of my correspondent that I might be a special officer of the state trying to locate violations of the law requiring district schools to be conducted in English, and hence information regarding schools in foreign tongue was withheld or given but partially. And in some cases my informants were not well posted. A superintendent by the name of Schauermann in a county containing a town called Suabia, tells me that there are no foreigners in his county. In such cases time must be taken to secure a correct result.

The questions asked were: Locate, and give origin, date and approximate numbers of any settlements—six or more families—of foreigners in your county. Do they still use their language to any extent? Do they have church service and schools conducted in their native tongue? In many replies one or more of these points was neglected so that the information is not yet by any means what I desire to make it. However, for the purpose of dialect study approximate correctness in location is of chief importance, and accuracy as to numbers quite secondary.

Through the aid of ministers and others to whom I have been referred by the superintendents I hope to make this report complete in the following respects: The more exact limits of the settlement; the numbers of those foreign-born; the province as well as land from which they came; the number of churches; the number of schools and the length of time the same are conducted. I solicit the co-operation of everyone interested in this work, and also in the whole subject of dialect study. As intimated above, interested observers can without especial training do a service to science and at the same time find a fascinating pastime for themselves by making collections of words and constructions which they believe to be unusual or new. If any such are sent to the writer they will be duly acknowledged. They should in every case be accompanied by a statement of the age, condition and birth-place of the person using them.

I wish here to call attention to the work of the American Dialect Society which exists to promote this study. It desires as wide a membership as possible, and membership is open to all interested in the subject. The publication of the Society, Dialect Notes, contains reports of word-lists and other studies, and will be an aid to any who wish to undertake similar work. Subscriptions and membership fees should be sent to Mr. C. H. Grandgent, Treas., Cambridge, Mass.

REPORTS BY COUNTIES.

ATCHISON.—Reports no foreigners, by John Klopfenstein, Supt.

ALLEN.—Swedes and Danes, from 600 to 700, settled from 1873 to 1880. Have church service, and four to five months school in Swedish. Grove and Elsmore townships. Germans in and around Humboldt.

ANDERSON.—Irish in Reeder township, 1860 and 1874. Germans, 1860 in Putman township, 1880 in Westphalia township. Have both church and schools in German.

BARBER.—Reports "no foreigners worth making account of, by J. O. Hahn, Sup't.

BARTON.—No report.

BOURBON.—Reports no foreigners.

BROWN.—No report.

BUTLER.—Germans (Prussians), speaking Low German, in Fairmount and Milton townships. Hold church services but no schools in German.

CHASE.—Russian Mennonites, speaking both Russian and German, in Diamond Creek township, no church, but a portion of schooling in German. Germans at Strong City, with both church and schools in their native tongue.

CHATAUQUA.—Some Norwegians and Swedes, 1870, no location given. Neither schools nor churches in native tongue. One colony of 'Russians' (Mennonites?), who have also given up their language.

CHEROKEE.—Weir City, French and Italians, number considerable. Scammon, Scotch, also in large numbers. The French and Italians have neither schools nor church in the native tongue. Germans in Ross, twenty families; with church originally Lutheran, now Mennonite; school irregularly during past ten years. Swedes, a few families in Cherokee township, have entirely given up Swedish language. The Scotch, French and Italians in mines or mining industries.

CHEYENNE.—Germans settled in 1885-86 on Hackberry Creek, 160 persons; in the northeast corner of the county, 100; on west border of county, north of Republican river, 120; all with churches and the last two with occasional schools. Swedes are across the Republican adjoining last named German settlement, 120, entered 1886, having neither church nor school in Swedish.

CLARKE.—Reports no foreigners.

CLAY.—No report.

CLOUD.—Canadian French are scattered over much of the county, with considerable settlements in and around the towns of Concordia, Clyde, St. Joseph and Aurora. In all there are churches, in the first three schools also conducted in French.

Norwegians occupy portions of Sibley and Lincoln townships with two churches in their own tongue. They number about three hundred. Irish occupy portions of Solomon and Lyon, the south part of Meredith and the southeast corner of Grant townships.

COFFEY.—Germans in Liberty and on border of Leroy and Avon township. Have church service in German.

COMANCHE.—Germans. A few scattered families.

COWLEY.—A few Swedes and Germans, widely scattered.

CRAWFORD.—Irish and French in Grant township; Swedes in west part of Sherman township, have all given up their language. Italians, Austrians and other nationalities in south part of Washington, southeast part of Sheridan and all over Baker township, especially in Pittsburg, employed in mining and smelting.

DECATUR.—Swedes in Oberlin township; Mennonites in Prairie Dog township; Germans in and around Dresden, with Catholic church; Bohemians in Jennings and Garfield townships.

DICKINSON.—Germans, 500 in number settled in 1860 in Liberty, Union and Lyon townships. Have three churches and two schools in German. Also in Wheatland, Jefferson, Bonner and Ridge townships, one church and a school. Swedes, 100 settled in 1860 in Center and Hayes township, with two churches and one school in Swedish. Irish, several hundred in south part of Banner township.

DONIPHAN.—Germans in Wayne, Marion and southern part of Center. Burr Oak and Washington townships, with church service in native tongue. Norwegians in eastern part of Wolf River township.

DOUGLAS.—There are German settlements in Eudora township (300), Marion township (600), and Big Springs township (100), with churches in all and school in the first. There are about five hundred Germans in Lawrence, with three German churches. There are smaller settlements of Germans and Scandinavians at several points in the county.

EDWARDS.—Germans and Swedes in Kinsley, Jackson and Trenton townships, have church service in their mother tongue.

ELK.—Swedes in Painter and Hood townships; Irish in Falls township; Germans on the border of Elk and Wild Cat townships. None of these have church or school in the native tongue, but all use it at home.

ELLIS.—Germans from Russia, settled about 1876 in Catherine, Hartsook, Lookout, Wheatland and Freedom townships, about 3000 in number—one third of the population of the county in 1891. They are Catholics, and have both churches and parochial schools conducted in German. They are large wheat-growers.

ELLSWORTH.—Germans, (Methodists) in south part of Valley township; Germans (Lutherans) in north part of Columbia and Ellsworth townships; Germans (Baptists) from Prussia, in Green Garden and south west corner of Empire townships. These all have church service, and the Lutherans schools in their own tongue. Bohemians in Valley and Noble townships.

FINNEY.—Reports no foreigners.

FORD.—Germans in Wheatland and Speareville townships. Have church, and one school conducted in German.

FRANKLIN.—No report.

GARFIELD.—A few scattered families of Germans.

GEARY.—Irish (Connaught) came into Jackson, Jefferson and Liberty townships 1855, about 1500 in number. Germans (Anhalt) about 1500 came into Jefferson, Milford and Lyon townships in 1862. About 300 English from Sussex settled in Lyon township in 1870. The Germans maintain both churches and schools in German.

GOVE.—Swedes in Lewis and south part of Grinnell and south west corner of Gove townships.

GRAHAM.—A settlement of Canadian French (600) was made in adjacent parts of Wild Horse and Morelan townships about 1880. They conduct church service but no schools in French.

GRANT.—Reports no foreigners.

GRAY.—Reports no foreigners.

GREELEY.—Swedes in the north west part of the county, have church service and summer school in Swedish.

GREENWOOD.—Norwegians, about 200, in south part of Salem township, have church in their own tongue. Germans in Shell Rock township, about 300, also have church in their own language.

HAMILTON.—Reports no foreigners.

HARPER.—Germans about the town of Harper. Hungarians south of Bluff City. Both have church service in German. About 100 French in Odell and Stohrville townships.

HARVEY.—Germans (Russian Mennonites) from Odessa, a few from Prussia, the latter speaking Low German. They settled from 1874 to 1876 in Alta and Garden townships, in Pleasant and the eastern part of Newton townships, and about Halstead. They have church and school in German, but speak Russian also. French in north part of Emma township, engaged in raising silk worms.

HASKELL.—Reports no foreigners.

HODGMAN.—Germans, about 30 families, settled about 1884 in south east corner of Sterling township; have preaching in German. Swedes in north west corner of Marena township.

JACKSON.—Danes in Netawaca and Whiting townships; Irish in Washington township; neither continue to use their native tongue.

JEFFERSON.—Germans (Swiss) in Delaware, Jefferson and Kentucky townships, maintaining church but no schools in German.

JEWELL.—Swedes, widely scattered in Sinclair, Allen, Ewing and Ezbon townships.

JOHNSON.—No report.

KEARNEY.—No report.

KINGMAN.—A small settlement of Germans in Peters township, not using German to any extent. A few Irish in Union township.

KIOWA.—No report.

LABETTE.—Swedes and Norwegians settled in Valley and Canada townships about 1869. Still speak their language, but have neither church nor school in it.

LANE.—Reports no foreigners.

LEAVENWORTH.—German, in 1873 in Easton township; in Fair township in 1876; about 600 in each place. They have church service and schools in German.

LINCOLN.—Danes settled in Grant township in 1869 and since, 400 in number. Germans settled in Pleasant township in 1872, with 300, and in Indiana township in 1869 and later with about 375. Danes and Germans have good schools and churches in native tongue. Bohemians in Highland township in 1878 with thirty families. They speak their native tongue, but have no schools or churches.

LINN.—Reports no foreigners.

LOGAN.—Swedes, about 200, about Page City, in north part of county. Have church and school both in Swedish.

LYON.—Welsh, between 1000 and 1500 are located in and about Emporia, with three churches conducted in Welsh. There is a settlement of Skandinavians near Olpe in Centre township.

MARION.—Germans (Russian Mennonites), settled in Logan, Durham, Lehigh, Risley, Menno, West Branch and Liberty townships, from 1870 to 1875, some 5000 in number. They speak both Russian and German, and have church service and schools in the latter tongue. Bohemians, about 500 in number are settled in Clark township. They speak Czech and have church service in that language. French to the number of 200 settled soon after 1870 on the border of Grant and Doyle townships. They speak French still, but have no schools or church service in the language.

MARSHALL.—Germans (Pommeranians, Hanoverians, Frisians) to the number of 2000, settled in the west part of Marysville township from before 1860 to 1870. They have both church and school in their own tongue. In the north part of Murray and the south half of Vermillion townships are 1200 Irish, who use only English in church and school. They came before 1870. Bohemians in small numbers occupy the north part of Guittard, the north west corner of Waterville and the south part of Blue Rapids townships; Swedes a portion of the south part of Waterville township. No report as to their language.

MEADE.—No report.

MIAMI.—Germans occupy the north part of Wea and the west part of Valley townships, about 200 in each settlement; the first has a Catholic, the second a Lutheran church. Irish occupy the north part of Osage township, also about 200 in number.

MITCHELL—Germans to the number of 1200 occupy Pittsburg, Blue Hill, and Carr Creek townships. In the first there is a church, and a well-attended school (Catholic) at Tipton.

MONTGOMERY.—Germans to the number of 100 are settled in and about Independence. They have church service in German (Lutheran).

MORRIS.—Swedes occupy Diamond Valley, the west part of Creek, and the north part of Parker townships. They have several churches and occasionally a school conducted in Swedish.

MORTON.—Reports no foreigners.

MCPHERSON.—Swedes settled, about 1870, in Union, Smoky Hill, Harper, New Gottland, Delmore, and portions of other townships, in large numbers, several thousand. They have several churches and excellent schools conducted in Swedish. Germans (Russian Mennonites) occupy Superior, Turkey Creek, Mound, Lone Tree, King City, and portions of McPherson and other southern townships, with several churches and schools. The Mennonites number about 5000 and settled after 1876.

NEMAHA.—Germans (Swiss) occupy Nemaha and Washington, and a portion of Richmond townships, with German churches and schools. Irish are in Clear Creek and north east corner of Neuchatel townships. Most of Neuchatel township is occuppied by French (Swiss).

NEOSHO.—Germans have a considerable settlement in the south east corner of Tioga township, with church service (Lutheran) in German; another in the east part of Lincoln township, where the language is spoken, but without church or school. Swedes have settlements in the north west part of Tioga and the east part of Big Creek townships; church in the first only, though in both Swedish is spoken almost exclusively.

NESS.—No report.

NORTON.—Germans to the number of 100 settled about 1880 in Grant township. They have church service in German.

OSAGE.—Swedes, (700 in number,) settled in Grant township in 1871, where they have four churches conducted in Swedish. Welsh settled in 1869 in Arvonia township, and others in the north part of Superior township, 700 in number. They have six churches with services in Welsh. Germans are in the north part of Scranton and Ridgway townships, 200 in number; French in the central part of Superior township, 200 strong; Danes, 200, in north part of Melvern and Olivet townships; a considerable number of Scotch and Irish in and near Scranton. Most of these latter are engaged in coal mining. None of the foreigners have schools—except Sunday schools—in their native tongue.

OSBORNE—Germans settled in Bloom township, where they have both church and school in their mother tongue.

OTTAWA.—Bohemians are located about the border of Sheridan and Fountain townships; Danes in the south part of Buckeye township; Irish, arrived about 1885, in the south part of Chapman township. None of these have church or school in a foreign tongue.

PAWNEE.—Swedes settled about 1877 in the west part of Garfield and the north part of Walnut townships, about 500 in all. They speak their native languge at home almost exclusively, and have preaching in it.

PHILLIPS.—Germans occupy Mound and south part of Dayton townships, with preaching and parochial school in German. Dutch occupy east part of Prairie View with adjacent portions of Long Island, Dayton, and Beaver townships, with preaching in Dutch. Some Danes and Swedes in Crystal township, and some scattered Poles.

POTTAWATOMIE.—Germans, about 2500, in west half of Mill Creek and adjacent portions of Sherman and Vienna townships, also in Pottawatomie and adjacent portions of Union, Louisville, and St. George townships. There are a few families in Wamego and St. Mary's Mission. They have several schools and churches conducted in German. Swedes occupy the whole of Blue Valley and the west border of Greene townships, and have a small settlement in St. Mary township, numbering in all 1200. They have churce service and a parochial school conducted in Swedish. Irish, to the number of 2000 occupy Clear Creek, Emmet, St. Mary and the border of St. Clere townships. French (Canadian), numbering 200, are found in the north part of Mill Creek and in Union townships, also a few about St. Mary's Mission.

PRATT.—Reports no foreigners.

RAWLINS.—Germans in north east part of county with church and school in German. Swedes in east part of county, Bohemians and Hungarians in north and north east portion.

RENO.—Germans, about 300, came in 1880 to north east corner of Little River township, and about 200 to south east corner of Sumner township; alo a settlement in the west part of Hayes township; Dutch, about 350, came 1878 into Haven township; Russians are settled in Salt Creek and Medford townships. All have church service and schools in their native tongue. There are also a few French and Danes in the county.

REPUBLIC.—No report.

RICE.—There is a considerable settlement of Germans in Valley township, also Pennsylvania Germans in tne west part of Sterling township, with German churches in both. There are also some Germans in the town of Lyons, with a German church.

RILEY.—Swedes, about 2500, occupy Jackson, Swede Creek and adjacent portions of Mayday, Center, Fancy Creek and Sherman townships. They have church services and summer schools in their own tongue. Bohemians and Germans, about 500 together, occupy the north east part of Swede Creek township.

ROOKS.—Germans, 10 families, settled 1880 in north part of Northhampton township. Bohemians, 10 families, located in north part of Logan township in 1879. French, about 30 families, south west corner of Logan, and same number in Twin

Mound township, settled in 1878, speak French and have preaching in that tongue. The Germans have church service in German.

RUSH.—Germans (Russian Mennonites) are located as follows: in Big Timber township 75 families, in Illinois township 25 families, in Pioneer township 50 families, in Lone Star township 50 families, in Banner township 25 families, in Garfield township 25 families, in Belle Prairie township 30 families. In each township there is one church or more, but no German schools (?). Bohemians are found in Banner and Garfield townships, about 25 families in each.

RUSSELL.—No report.

SALINE.—Germans, (Bavarians and Swabians) about 200, in Gypsum and south part of Ohio townships; Swedes, 3000 to 4000, in Washington, Smolan, Falun, Liberty and Smoky View, and adjacent parts of Spring Creek, Summit and Walnut townships, also in Salina. The Swedes came in 1868. Both Germans and Swedes have preaching and the latter have schools in their tongue.

SCOTT.—No report.

SEDGWICK.—Germans, 3000 to 4000, settled from 1874–82 in Sherman, Grand River, Garden Plain, Attica and Union townships. Also about 2000 Germans in the ciy of Wichita. In both places schools and churches in German. Russians, Italians, French and Scandinavians are represented, a few hundred each, in Wichita. In the country townships a few Dutch and Swedes.

SEWARD.—Reports no foreigners.

SHAWNEE.—Germans (Moravians) in Rossville township, speak their native tongue almost exclusively, but have neither school nor preaching in German.

SHERIDAN.—No reports.

SHERMAN.—Germans, 20 families about the center of the county. Swedes, 10 families in north east corner and 25 families in south west corner. Both Germans and Swedes have schools and preaching in their native tongue

SMITH.—Germans in west part of Swan and Cedar townships, and on border of Harvey and Banner townships, in both churches, and in the first schools, in German. Dutch, in the south half of Lincoln township, have church but no schools.

STAFFORD.—Germans in Hayes and Cooper townships, three hundred in number, with two churches having service in German.

STANTON.—A few scattered Germans.

STEVENS.—No report.

SUMNER.—No report.

THOMAS.—A few foreigners scattered about the country; all anglicised.

TREGO.—No report.

WABAUNSEE.—Germans and some Swedes in Kaw, Newbury, Mill, Farmer, Alma and Washington townships, with both preaching and schools in the mother tongue.

WALLACE.—Swedes, to the number of 300, have settled since 1888 in the south west corner of the county. They have church and and schools in Swedish.

WASHINGTON.—Germans in Franklin, Charleston, Hanover and north part of Sherman townships, have both church and schools (6) conducted in German. Bohemians are numerous in Little Blue township; French about midway in Sherman township; Irish in Barnes, south part of Sherman and Koloko townships.

WICHITA.—No report.

WILSON.—Swedes have settled since 1870 in Colfax township. They have preaching but no schools in Swedish.

WOODSON.—No report.

WYANDOTTE.—Germans, 150, in north west corner of Prairie township; Swedes, 350, in Kansas City, Kas.; both have church service in the native language. Welsh, 200, in Rosedale, and Irish about midway in Wyandotte township.

SUMMARIES.

There are German settlements of thirty or more persons in the following counties: Allen, Anderson, Butler, Chase, Chautauqua, Cherokee, Cheyenne, Coffey, Comanche, Cowley, Crawford, Decatur, Dickinson, Doniphan, Douglas, Edwards, Elk, Ellis, Ellsworth, Ford, Garfield, Geary, Greenwood, Harper, Harvey, Hodgeman, Jefferson, Kingman, Leavenworth, Lincoln, Marion, Marshall, Miami, Mitchell, Montgomery, McPherson, Nemaha, Neosho, Norton, Osage, Osborne, Phillips, Pottawatomie, Rawlins, Reno, Rice, Riley, Rooks, Rush, Saline, Sedgwick, Shawnee, Sherman, Smith, Stafford, Stanton, Thomas, Wabaunsee, Washington, Wyandotte. Total, 60.

Skandinavians in settlements of thirty or over are found in: Allen, Chautauqua, Cherokee, Cheyenne, Cloud, Cowley, Crawford, Decatur, Dickinson, Doniphan, Edwards, Elk, Gove, Greeley, Greenwood, Hodgeman, Jackson, Jewell, Labette, Lincoln, Logan, Lyon, Marshall, Morris, McPherson, Neosho, Osage, Ottawa, Pawnee, Phillips, Pottawatomie, Rawlins, Riley, Saline, Sedgwick, Sherman, Wabaunsee, Wallace, Wilson, Wyandotte. Total, 40.

Settlements of Slavonic peoples, Bohemians, Poles, Russians, or Hungarians, in: Decatur, Ellsworth, Harper, Lincoln, Marshall, Ottawa, Phillips, Rawlins, Reno, Riley, Rooks, Rush, Sedgwick, Washington. Total, 14.

Settlements of Irish have been made in: Anderson, Cloud, Crawford, Dickinson, Doniphan, Elk, Geary, Jackson, Kingman, Marshall, Miami, Nemaha, Osage, Ottawa, Pottawatomie, Washington, Wyandotte. Total, 17.

French are found in settlements of thirty or more in: Cherokee, Cloud, Crawford, Doniphan, Graham, Harper, Harvey, Nemaha, Osage, Pottawatomie, Rooks, Sedgwick, Washington. Total, 13.

Italians are in Cherokee, Crawford, Sedgwick. Total, 3.

Welsh in Lyon, Osage and Wyandotte. Total, 3.

Dutch in Phillips, Reno, Sedgwick. Total, 3.

Scotch are reported from Cherokee and Osage. Total, 2.

English in Geary and Doniphan. Total, 2.

The following counties report that there are no settlements of people of foreign birth within their borders: Atchison, Barber, Bourbon, Clarke, Finney, Grant, Gray, Hamilton, Haskell, Lane, Linn, Morton, Pratt, Seward. Total, 14.

No reports have been secured from the following counties: Barton, Brown, Clay, Franklin, Johnson, Kearney, Kiowa, Meade, Ness, Republic, Russell, Scott, Sheridan, Stevens, Sumner, Trego, Wichita, Woodson. Total, 18.

Seventy-four of our Kansas counties report settlements of citizens of foreign birth in numbers above 30. In so many cases there is no report or estimate of numbers that it is not worth while to give summaries. Probably there are not actually ten counties that have not such settlements.

Church services in a foreign tongue are held as follows: Allen S.,* Anderson G., Butler G., Chase G., Cheyenne G., Cherokee G., Cloud F. S., Coffey G., Decatur G., Dickinson G. S., Doniphan G., Douglas G., Edwards G. S., Ellis G., Ellsworth G., Ford G., Geary G., Graham F., Greeley S., Greenwood G. S., Harper G. Hung., Harvey G., Hodgeman G., Jefferson G., Leavenworth G., Lincoln G. Du., Logan S., Lyon W. G., Marion G. Boh., Marshall G., Miami G, Mitchell G., Montgomery G., Morris S., McPherson S. G., Nemaha G., Neosho G. S., Norton G. Osage S. Welsh, Osborne G., Pawnee S., Phillips G. Du., Pottawatomie G. S., Rawlins G., Reno G. Du. Rus., Rice G., Riley S., Rooks F. G., Rush G., Saline G. S.,

*G=German, S=Skandinavian, F=Franch, W=Welsh, Du=Dutch.

Sedgwick G., Sherman G. S.. Smith G. Du., Stafford G., Wabaunsee G., Wallace S., Washington G. Wilson S., Wyandotte G. S.

Total, 58.

This total of fifty-eight counties in which church service is held in a foreign tongue does not at all indicate the number of such churches. In many of the reports received the number is not given, or merely in the plural. These very incomplete reports indicate one hundred thirty-eight such churches; it is safe to say that the number is nearly double this.

More interesting is the number of schools conducted in a foreign tongue. The counties having them are: Allen S., Anderson G., Chase G., Cheyenne G., Cherokee, G., Cloud F., Dickinson G. S., Douglas G., Ellis G., Ellsworth G., Ford G., Geary G., Greeley S., Harvey G., Leavenworth G., Lincoln G. S., Logan S., Marion G., Marshall G., Mitchell G., Morris S., McPherson S. G. Nemaha G., Osborne G., Phillips G., Pottawatomie G. S., Rawlins G., Reno G. Du. Rus., Riley S., Rush G., Saline S., Sedgwick G., Sherman G. S., Smith G. Du., Wabaunsee G., Wallace S., Washington G.

Total, 37.

The number of separate schools in a foreign language so far as reported is seventy-four, and here, too, it is safe to say that the actual number is much larger.

EXPLANATION.

The spaces indicating settlements are in many cases too small to admit a complete description of the inhabitants, and accordingly they have been marked by races rather than by nationalities and tribes. "German" is made to do duty for all inhabitants of Germany whether Low or High, as well as for Austrians, German Swiss, and Russo-German Mennonites. The last are reported simply as Mennonites, but are, I believe, in all cases of German origin. "Skandinavian" is used instead of Swede, Norwegian and Dane, because in some cases the distinction was not made in the reports, and in order to limit the number of colors on the map which is to come. In the case of Scotch I have been unable to secure information whether they are Highlanders or Lowlanders, and in case of Irish, to what extent, if at all, they speak the old Irish language.

W. H. CARRUTH.

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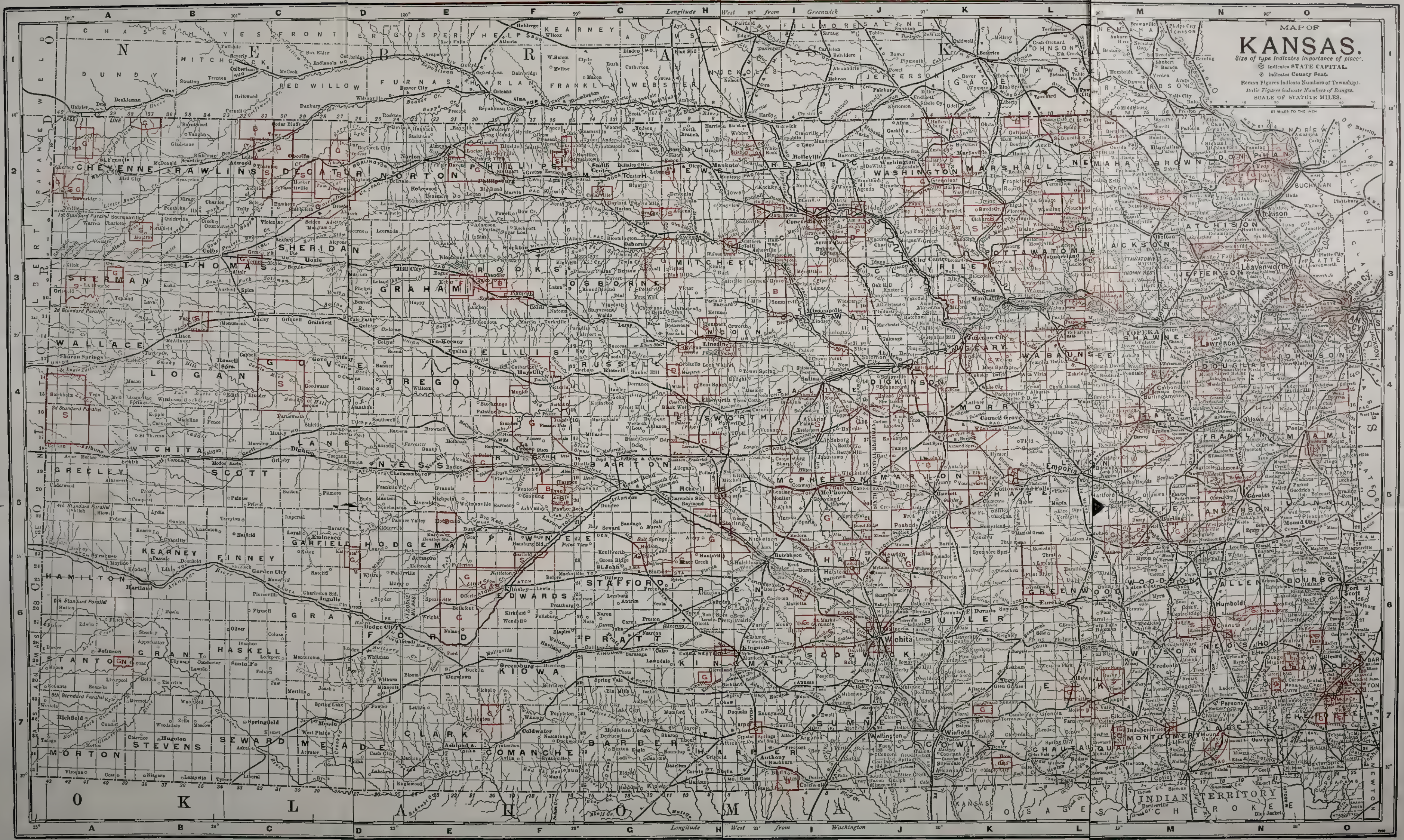
A PRELIMINARY MAP OF FOREIGN SETTLEMENTS IN KANSAS.



B – Bohemians (In a few cases a few other Slavs) G – Germans (including Dutch and Russian Mennonites) S – Scandinavians (Danes, Swedes & Norwegians) I – Irish. W – Welsh. It – Italians. F – French. H – Hungarians.

The Great Spirit Spring Mound.

BY E. H. S. BAILEY.

The "Waconda" or Great Spirit Spring, which is situated in Mitchell County, Kansas, about two miles east of Cawker City, has been described in detail by G. E. Patrick in vol. vii, p. 22, Transactions of the Kansas Academy of Science. An analysis of the water, and of the rock forming the mound on which the spring is located, is also given.

The spring is upon a conical, limestone mound 42 feet in height, and 150 feet in diameter at the top. The pool itself is a nearly circular lake about 50 feet in diamter, 35 feet deep, and the water rises to within a few inches of the top of the basin. There is a level space on all sides of the spring so wide that a carriage can be readily driven around it.

There is but little indication of organic matter in the water of the large spring, though there is a slimy white deposit adhering to the bottom and sides, but the water is colorless, clear, and transparent. The excess of water, instead of overflowing the bank, escapes by numerous small fissures, from 10 to 20 feet down on the sides, especially on the side away from the bluff. In these lateral springs there is an abundance of green algæ, and a whitish scum, which seems to be detached from the bottom and to float to the surface. This has a slimy, granular feeling suggesting in a very marked manner hydrated silica.

The mound is situated within about 200 feet of a limestone bluff, which rises perhaps 20 feet above the level of the spring. The natural inference would be that the harder material of the mound protected it from the erosion which carried away the rock in the valley of the Solomon on the south, and the rock between the spring and the bluff. Is it not possible however that the mound has been really made by the successive deposits from the spring? Although the mound is plainly stratified, this need not interfere with the theory, for the water may have been intermittent in its flow. The rock is very porous, and on being ground to a thin section is shown to be concretionary in structure.

An analysis of the water of the spring (loc. cit.) showed that it contained over 1120 grains of mineral matter per gallon, of which 775 grains were sodium chloride and 206 grains sodium sulphate, with 66 grains of magnesium sulphate, 41 grains of magnesium carbonate, and 31 grains of calcium carbonate. An analysis by the author shows that there are 0.874 grains of silica.

Samples of the rock composing the mound, and of the adjoining bluff were secured, and comparative analyses made, with the following results:

	COUNTRY ROCK.	GREAT SPIRIT MOUND.
Silica and insoluble residue	2.14	4.10
Oxides of Iron and Alumina	3.22	*2.66
Sulphuric Anhydride	.00	0.34
Carbon Dioxide	40.90	39.10
Calcium Oxide	51.90	49.28
Magnesium Oxide	0.63	1.15
Water and organic matter, undetermined	1.21	†3.37
	100.00	100.00
Specific gravity	2.52	2.79

The rocks are entirely different in appearance and structure, that of the mound being twice as hard as that of the bluff. The former contains much organic matter as is shown by blackening when it is heated in a tube and giving off the characteristic odor. The iron is practically of the ferrous variety, probably combined with carbonic acid, and the rock contains traces of chlorides. The particular sample taken was at some distance from the spring, and had been thoroughly exposed to the weather.

The rock of the mound is of just such a character as might have been built up by deposition from the water, as it contains the least soluble constituents of the water. The process of solidification would have been assisted by the silica in the water, forming insoluble cementing silicates, as noticed by Prof. Patrick. The analysis given above shows that there is abundant silica in the water for this purpose.

Mention has been made of the organic growth in the adjacent springs. The mixed scum on being heated changes from a dull green to a vivid grass-green, and if ignited it swells up and emits an ill-smelling vapor, which is evidently nitrogenous in its character. A grayish white ash is left, which contains much carbonate of lime. This is evidently freshly deposited, as it is entangled in the algæ in granular lumps.

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*Mostly FeO. and so calculated.
†With alkalies.

A specimen of the white scum, noticed above, only slightly mixed with the green algæ, was analyzed. The acid solution of the ash contains 1.26 per cent of soluble silica. This was of course a combined silica, probably calcium silicate, which becomes the cementing material in the rock. In another sample of ash, after removing all the substances soluble in hot water, the residue was found to contain 76.46 per cent of silica.

The siliceous residue from the scum was examined by Dr. S. W. Williston. It consists mostly of diatoms. He recognized

Navicula—2 species
Nitzschia—2 species
Asteronella— 1 species.

All three genera are found both in fresh and salt or brackish water.

The green material consists essentially of Oscillaria and Confervæ. If the scum is allowed to stand for a short time a very strong sulphuretted odor is developed, strangely suggestive of salt water marshes or mud flats; and indeed the same odor is noticed in the vicinity of the spring. No characteristic salt water organisms, that should occasion this peculiar odor have, however, yet been observed here. A more extended and special study of the organic life of these interior salt water marshes and springs would be of great interest.

On Pascal's Limaçon and the Cardioid.

BY H. C. RIGGS.

The inverse of a conic with respect to a focus is a curve called Pascal's Limaçon. From the polar equation of a conic, the focus being the pole, it is evident that the polar equation of the limaçon may be written in the form:

$$r = \frac{e}{p}\cos x + \frac{1}{p};$$

where e and p are constants, being respectively the eccentricity and semi-latus rectum of the conic.

From the above equation it is readily seen that the curve may be traced by drawing from a fixed point O on a circle any number of chords and laying off a constant length on each of these lines, measured from the circumference of the circle. The point O is the node of the limacon; and the fixed circle, which I shall call the base circle, is the inverse of the directrix of the conic. This is readily shown as follows:—the polar equation of the directrix is $r = \frac{p}{e\cos x}$. Hence the equation of its inverse is $r = \frac{e\cos x}{p}$, which is the equation of the base circle of the limacon.

If the conic which we invert be an ellipse, the point O will be an acnode on the Limaçon; if the conic be a hyperbola, the point O is a crunode. If the conic be a parabola, O is then a cusp and the inverse curve is called the Cardioid.

The limaçon may also be traced as a roulette.

Let the circle A C have a diameter just twice that of the circle A B. Then a given diameter of A C will always pass through a fixed point Q on the circle A B, (Williamson's Diff. Cal. Art. 286) and will have its middle point on the circle A B. Now any point P on the diameter of A C will always be at a fixed distance from C and will therefore describe a limaçon of which A B will be the base circle.

The pedal of a circle with respect to any point is a limaçon. This may be inferred from the general theorem that the pedal of a curve is the inverse of its polar reciprocal, (Salmon's H. P. C. Art. 122). For the polar reciprocal of a conic from its focus is a circle and hence its pedal is a limaçon.

The base circle is the locus of the instantaneous centre for all points on the limaçon. Let B O P be a line cutting a circle in B and Q. Let the line revolve about B, Q following the circle; the point P will trace a limaçon.

Now, for any instant, the instantaneous center will be the same whether Q be following the circle or the tangent at the point where the line cuts the circle. Therefore the instantaneous center for the point P is found by erecting a perpendicular to the line P B, through B, and a normal to the circle at Q. (Williamson's Diff. Cal. Art. 294). The intersection (C) of these two lines is the instantaneous center for the curve at the point P. But by elementary geometry C is on the circle. Now as the line P B revolves through 360^{0} around B, the line B C which is always perpendicular to it also makes a complete revolution and the instantaneous center C moves once round the base circle.

Below we give a list of theorems obtained by inverting the corresponding theorems respecting a conic. In these theorems any circle through the pole is called a nodal circle, any chord through the pole is called a nodal chord, and the line through the pole perpendicular to the axis of the curve is called the latus rectum. The letters *e* and *p* signify respectively the eccentricity and half the latus rectum of the inverted conic.

The locus of the point of intersection of two tangents to a parabola which cut one another at a constant angle is a hyperbola having the same focus and directrix as the original parabola.

The locus of the point of intersection of two nodal tangent circles to a cardioid which cut each other at a constant angle is a limaçon having the same double point and director circle.

The sum of the reciprocals of two focal chords of a conic at right angles to each other is constant.

The sum of any two nodal chords of a limaçon at right angles to each other is constant.

P Q is a chord of a conic which subtends a right angle at the focus. The locus of the pole of P Q and the locus enveloped by P Q are each conics whose latera recta are to that of the orignal conic as $\sqrt{2} : 1$ and $1 : \sqrt{2}$ respectively.

If P and Q be two points on a limacon such that they intercept a right angle at the node, then the locus of the point of intersection of the two nodal circles tangent at P and Q respectively, is a limaçon whose latus rectum is to that of the original limaçon as $\frac{1}{2}\sqrt{2} : 1$. And the envelope of the circle described on P Q as a diameter is a limaçon, whose latus rectum is to that of the original limaçon as $1 : \frac{1}{2}\sqrt{2}$

If two conics have a common focus, two of their common chords will pass through the point of intersection of their directrices.

If two limaçons have a common node, two nodal circles passing each through two points of intersection of the limaçons, will pass through the point of intersection of their base circles.

Two conics have a common focus about which one of them is turned; two of their common chords will touch conics having the fixed focus for focus.

Two limaçons have a common node about which one of them is turned; two of the nodal circles through two of their points of intersection will envelope limaçons having fixed node for node.

Two conics are described having the same focus, and the distance of this focus from the corresponding directrix of each is the same; if the conics touch one another, then twice the sine of half the angle between the transverse axes is equal to the difference of the reciprocals of the eccentricities.

If two limaçons are described having the same node and base circles of the same diameter, and if the limaçons touch each other, then twice the sine of half the angle between the axes of the limaçons is equal to the difference of the eccentricities.

If a circle of a given radius pass through the focus (S) of a given conic and cut the conic in the points A, B, C, and D; then SA. SB. SC. SD is constant.

If a circle of a given radius pass through the node (S) of a given limaçon and cut it in A, B, C, and D; then

$$\frac{1}{SA.\ SB.\ SC.\ SD}$$

is constant.

A circle passes through the focus of a conic whose latus rectum is 2 l and meets the conic in four points whose distance from the focus are r_1, r_2, r_3, r_4, then

$$\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}+\frac{1}{r_4}=\frac{2}{l}$$

A circle passes through the node of a limacon whose latus rectum is 2 l, meeting the curve in four points whose distances from the node are r_1, r_2, r_3, r_4, then

$$r_1+r_2+r_3+r_4=2l$$

Two points P and Q are taken, one on each of two conics which have a common focus and their axes in the same direction, such that P S and Q S are at right

Two points P and Q are taken one on each of two limacons which have a common node and their axes in the same direction, such that P S and Q S are at right an-

angles, S being the common focus. Then the tangents at P and Q meet on a conic the square of whose eccentricity is equal to the sum of the squares of the eccentricities of the original conics.

gles, S being the common node. Then the nodal tangent circles at P and Q intersect on a limacon the square of whose eccentricity is equal to the sum of the squares of the eccentricities of the original limacons.

A series of conics are described with a common latus rectum; the locus of points upon them at which the perpendicular from the focus on the tangent is equal to the semi-latus rectum is given by the equation

$$p = -r \cos 2x$$

If a series of limaçons are described with the same latus rectum, the locus of points upon them at which the diameter of the nodal tangent circle is equal to the semi-latus rectum, is given by the equation

$$pr = -\cos 2x$$

If $P O P_1$ be a chord of a conic through a fixed point O, then will tan $\frac{1}{2} P_1 S O$ tan $\frac{1}{2} P S O$ be a constant, S being the focus of the conic.

If $P O P_1$ be a nodal circle of a limacon passing through a fixed point O, then will tan. $\frac{1}{2} P_1 S O$ tan. $\frac{1}{2} P S O$ be a constant, S being the node.

Conics are described with equal latera recta and a common focus. Also the corresponding directrices envelop a fixed confocal conic. Then these conics all touch two fixed conics, the reciprocals of whose latera recta are the sum and difference respectively of those of the variable conic and their fixed confocal, and which have the same directrix as the fixed confocal.

Limacons are described with equal latera recta and a common node. Also the director circles envelop a fixed limacon having a common node. Then these limacons all touch two fixed limacons whose latera recta are the sum and difference respectively of the reciprocals of the variable limacon and of the fixed limacon, and which have the same base circle as the fixed limacon.

Every focal chord of a conic is cut harmonically by the curve, the focus, and the directrix.

Every nodal chord of a limacon is bisected by the base circle.

The envelope of circles on the focal radii of a conic as diameters is the auxiliary circle.

The envelope of the perpendiculars at the extremities of the nodal radii of a limacon is a circle having for the diameter the axis of the limacon.

Below we give a number of theorems respecting the cardioid obtained by inverting the corresponding theorems concerning the parabola.

The straight line which bisects the angle contained by two lines drawn from the same point in a parabola, the one to the focus, the the other perpendicular to the directrix, is a tangent to the parabola at that point.	The nodal circle which bisects the angle between the line drawn from any point on a cardioid to the cusp and the nodal circle through the point which cuts the director circle orthogonally, is a tangent circle at that point.
The latus rectum of a parabola is equal to four times the distance from the focus to the vertex.	The latus rectum of a cardioid is equal to its length on the axis.
If a tangent to a parabola cut the axis produced, the points of contact and of intersection are equally distant from the focus.	If a nodal tangent circle cut the axis of a cardioid, the points of intersection and of tangency are equally distant from the cusp.
If a perpendicular be drawn from the focus to any tangent to a parabola, the point of intersection will be on the vertical tangent.	If a nodal circle be drawn tangent to a cardioid, the diameter of such circle passing through the cusp will be a common chord of this circle and another described on the axis of the cardioid as diameter.
The directrix of a parabola is the locus of the intersection of tangents that cut at right angles.	The base circle is the locus of the intersection of nodal circles tangent to a cardioid, which cut orthogonally.
The circle described on any focal chord of a parabola as diameter will touch the directrix.	The circle described an any nodal chord of a cardioid as diameter will be tangent to the base circle.
The locus of a point from which two normals to a parabola can be drawn making complementary angles with the axis, is a parabola.	The locus of the point through which two nodal circles, cutting a cardioid orthogonally, and making complementaiy angles with the axis, can be drawn is a cardioid.
Two tangents to a parabola which make equla angles with the axis and directrix respectively,	Two nodal circles tangent to a cardioid which make equal angles with the axis and latus rectum,

but are not at right angles, meet on the latus rectum.

respectively but do not cut orthogonally intersect on the latus rectum.

The circle which circumscribes the triangle formed by three tangents to a parabola passes through the focus.

If three nodal circles be drawn tangent to a cardioid, the three points of intersection of these three circles are on a straight line.

If the two normals drawn to a parabola from a point P make equal angles with a straight line, the focus of P is a parabola.

If the two nodal circles cutting a cardioid orthogonally and pass-through the point P, make equal angles with a fixed nodal circle, the locus of P is a cardiod.

Any two parabolas which have a common focus and their axes in opposite directions intersect at right angles.

Any two cardioids which have a common cusp and their axes in opposite directions intersect at right angles.

A number of other theorems on the limacon and cardioid are given in Professor Newson's article in this number of the QUARTERLY, and these need not be repeated here.

Dialect Word-List.

BY W. H. CARRUTH.

The following are some of the dialect words that have come to one observer's ears within the past triennium. They are all from Kansas, unless otherwise noted. They are printed here to interest others, and to secure a basis for observation. The writer will be under obligations to any one who will note his familiarity with any of these words, insert others, or other meanings, and send them, with a statement of his place of birth and childhood, to him at Lawrence:

among: all of, as, Where are you going among you?

all: all gone, as, The corn is all. (Indiana, Penn.) Comp. German.

bat: a 'hard case.'

bid, in, to bid the time of day. (Indiana.)

beeslings: preparation of artificially curdled milk. (Indiana and Kansas.)

become: to look well in, as, He becomes that coat.

bad: desperate, as in, A bad citizen=a desperate fellow.

behave: to behave well, as in, Do behave now!

bump on a log: something lifeless, as, He sat there like a bump on a log.

bier: sham, as in pillow-bier. (Vermont.)

branch: a small stream.

breeze: a torrent of talk, as in, He gave me a breeze.

boo: dried mucous.

buckle down: to work persistently.

conniptions: a fit, also 'conniption fit.'

caba: an old valise. (Penn.)

craps: a game with dice; playing, it is called, 'shooting craps.'

crawl: to try to escape from an embarrassing situation without admitting one's mistake.

crawfish: same as 'crawl.'

crock: an earthenware vessel, a large bowl.

chuck: lunch.

chuck-a-luck: loaded (of dice).

coddy: odd, out of fashion.

chug: to strike a blow, as in, Chug him one.

could: to be able, as in, He used to could.

cod: a bit of deceit, as in, He gave the teacher a cod.

Chenuk: a Canadian. (Note the pronunciation.)

dast: to dare, as in, He don't dast to do it.

dew-claws: hands and knees (?), as in, Get down on your d., = apply yourself intensely.

Dick's hatband, in the phrase, As contrary as Dick's hatband. What is the origin of this?

dick-nailer: anything quite satisfactory, as in, He (it) is a dick-nailer.

drop: advantage, as in, to get the drop on a person (allusion to dexterity in drawing a revolver). Comp. also: bulge, inside-track, whip-handle, dead-wood, all used in the same way and with same sense.

diven, past participle of *dive.*

drug, pret. of drag.

east: yeast.

emptings: bread dough set to ferment. Note the expression "It will come out all right in the emptings," i. e. after it has had a chance to stand.

fat up: to increase a stake at cards.

find: to supply with board, as in, Pay five dollars a week and find him; I get five dollars and found.

fresh: impudent, (due to greenness).

fog: to filch.

fluke: to steal. (Indiana).

flat: plug tobacco. (Arkansas).

gallery: church, as in, He's in the gallery.

gag: an improbable story intended to deceive, as in, He tried to give me a gag.

go with: to become of, as in, What has gone with my hat? Ohio; also in Pall Mall Gazette.

grub-stake: to give board.

girling; a 'girl-boy,' in contempt.

gaumy; not neat. (Arkansas.)

gob, or gaub; a shapeless mass, as, a gob of mud, then sportively, gaubs of wisdom.

gray; an awkward fellow.

get to; to get an opportunity to, as in, He didn't get to do it.

go to; to intend to, as in, I didn't go (for) to do it.

gumbo: a peculiar, putty-like dark soil. (Kansas.)

hen: feminine, as in, hen-party; comp. stag-party, a gathering of men only.

honey: a fine fellow, generally ironically.

hump: to bestir, as, Hump yourself.

hole: bad condition financially; as, He is in the hole, i. e. he has lost.

huckleberry: indifferent, in, a huckleberry Christian.

huckleberry: the right person, as in, You're my huckleberry.

hornswoggle: to discomfit, as in, I'll be hornswoggled if I'll do it.

in it: on the successful side, as, He is not in it, i. e., He has no prospect of success. This phrase is universal in 1891.

infare: the reception after a wedding.

in: on the credit side, as, I was in five dollars.

jay: a green, conceited fellow.

jag: a bit of anything; a spree, a brief drunk.

jack mosquito, a large insect of the mosquito family, three times the size of the pestiferous kind; this one does not bite.

jimmy: to meddle, as, to jimmy with a thing or person, to 'fool with.' Comp., to 'monkey with.'

jump: to leave without notice, as to jump the town, to jump bail; to jump a board-bill is to leave it unpaid.

joint: an illegal saloon. What is the origin of it?

jigger or chigger: a minute red mite, which frequents weeds and lawns, burrows beneath the human skin and causes excruciating itching.

keep: board and lodgings, as, He works for his keep.

lay over: to surpass, as, That lays over anything I know.

larofamedlers, a phrase used generally as equivalent to, It's none of your business. (Maryland, Penn., Ohio, Arkansas.) The word is a corruption of Lay-over for medlers, a lay-over being a bear-trap consisting of a pit covered with boughs.

light out: to start on the run, as, He 'lit' out for home.

lagniap: the extra in a bargain, as, Five dollars, and a hat for lagniap. (Louisiana.)

lush: to drink heavily, to 'swill.'

mog: to move, as, Mog along with you.

mogle: the same.

main: very, as, It's main strange. (Worcester county, Mass.)

mosey. to move along with a strut.

move: motion, as in, Get a move on you.

mealer: one who takes only meals at a boarding-house.

mind off: to ward off (flies, etc.).

meet up with: to meet. (Tennessee.)

peter out: to dwindle.

pail: to milk, as, to pail the cow. (Penn.)

possessed: anything, as, He acted like 'all possessed.'

quill: to write. (*The Writer.*)

quill-wheel: a 'rattle-trap' wagon.

ruther: choice, as, If I had my ruther; also, druther.

ride and tie, verbal phrase, describing a mode of travel in which one vehicle is used by two sets of people, one riding ahead a given distance and tying the team where the others who have walked will come up to it, the first walking on ahead until overtaken and passed by the second, and so on. (Colorado.)

red up: to make tidy.

ring off: to desist or cease talking, technical phrase from the telephone, but passed into common usage. Comp., "saw off."

rucus: quarrel, rumpus.

saddy: thanks, thank you. (Penn.)

saw off: 'ring off;' a short person is said to look 'sawed off.'

shet, shut, shed: rid, as, to get shut of anything.

shear off: to pour off (water from settlings). (Ohio.)

shapin's: young peas and beans—the unfilled pod. (Arkansas.)

should have said: said, as, He should have said yes, i. e,, indeed he said yes.

shin: to climb, as, to shin up a tree.

shut off: to make to stop talking, as, Do shut him off.

shebang: anything run-down, as house, carriage, affairs.

scrooch or scrooge: to cringe.

skin-away: a small boy. (Civilized Sac Indians.)

skin: to run, as, Skin out, i. e., run away.

skid: to sneak through examinations. (Yale.)

skid: a sharp-pointed instrument.

skit: a mild lie.

skads: great quantities, as, Skads of money, of books, etc.; also = money, as, He hasn't the skads.

singed cat: a shrewd 'rustler,' of unpretentious appearance.

skulduggery: knavery.

skip: to run away, as, Now skip, i. e., Go away from here.

skip: to leave hastily, as, He skipped the town.

slouch: a gawky fellow; then anything imperfect, as, in the phrase, He's no slouch, i. e., He is an expert; no slouch of a horse, i. e., a first-rate horse.

sloomiky: not neat

slander: to saunter.

slump: to fail to meet requirements, as, in examinations.

slumps: great quantities. (Clark's Second Hand Catalogue, N. Y.)

sleep: to give lodgings. I have heard, We can eat and sleep him.

smoodle: a sycophant. (Kansas University.) Comp., 'swipe.'

smokewood: dried water-soaked wood used by small boys as substitute for cigars.

smearcase: a preparation of clabber, often called 'Dutch cheese.'

snake: to snatch stealthily.

snum: to vow, as in, Well, I snum. Reported as common among girls.

snouge: unfair, as, a snouge game.

snide: inferior, unfair, as, a snide game, a snide watch, etc.

so fashion: thus, as, Do it so fashion.

soap: bribe money in elections.

sugar: same as soap.

sugar, (explet): pshaw!

split: anything, as, He ran like split, also, lickety split.

spunky: pouting, incensed.

sprinkle } **sprinkling** } : a small number; also a considerable number.

stag: masculine, as, A stag-party.

stag: to go to an entertainment without a lady companion, as, to stag it.

Stoughton-bottle: an unimpressionable fellow. (From Stoughton's Bitters, common in the 50's.)

streak: rapid rate, as, He talked a streak, or more commonly, a blue streak.

streak: to run, as, He streaked it for home.

steer: to manage (votes), as, A steering committee, the same as 'whips' in Parliament.

striffin, or strifning: the membrane surrounding the abdominal viscera. (Missouri.)

swan: to vow, as, in exclamation, I swan!

swat: to slap or strike, as, Swat him in the eye.

suz, (excl.): me, as in, Dear suz, and Law suz.

swipe: a sycophant. (Harvard.)

tacky: not fashionably dressed.

tewed: harrassed, as, I'm tewed and fretted.

that; so, as in, Not that far.

throw over: to 'cut' (an acquaintance).

throw over: to stop, as, I threw her over, i. e., stopped talking. Common among railroad men; derived from the use of the reverse lever.

tear-down: to thrash, as, He gave the boy a good tearing down.

toad on a tussock: anything dull or lifeless. He sat there like a toad on a tussock.

tousle: to disarrange (hair).

tousey: frowsy.

topside: on top of, as in, The best man topside o' God's green earth.

trade-lash: an exchange of compliments. (Wellesley.)

trottin'-riggin's: best suit of clothes.

two sticks: anything, as, He's as cross as two sticks.

up above: up, as in, Up above stairs.

whootle-dasher: a 'rustler.'

want: for was not, were not, etc.

wamus, wampus, warmus; a close, generally knit jacket. (Illinois, Pennsylvania, Ohio, Wisconsin, New England.)

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On the Apioceridæ and their Allies.

BY S. W. WILLISTON.

With Plates IX and X.

Since the appearance of Baron Osten Sacken's papers (22, 23) on the Apiocerinæ the past year, in which he iterates his former opinions concerning this group, and in which he criticises papers by me, I have, as opportunity has presented itself, subjected my material to a careful study. The conclusions reached at this time are wholly in consonance with those previously held by me—conclusions agreeing well with those sustained by the eminent entomologists Mik and Brauer. The material which I have had for study has been, I think, more varied than any that has been previously studied, and offers new and pertinent facts bearing upon the discussion. I have spent much time in the careful dissection of the mouth-parts of this and allied groups—parts to which previously almost no attention has been paid by systematists, but which, I am sure, offer a rich and almost unutilized field for systematic research. My attention to their importance was first directed by the able and suggestive paper published by J. B. Smith on the mouth-parts of diptera (26), and I shall follow up the subject in other groups as opportunity permits. The conclusions reached from their study bear out in an ofttimes striking way the relationships indicated by more external characters. I am aware that objections have been made to the use of characters which can only be ascertained by the sacrifice of specimens; but I have always held that facts are more valuable than specimens, and do not hesitate to destroy those which will reveal their secrets in no other way. I regret that my material has not been ample enough to permit sectioning, but I believe that the dissections will be sufficient for the present purpose.

I have to thank Mr. D. W. Coquillett for kindly furnishing me with two of the very few specimens that he possessed of *Rhaphiomidas*, a form of the greatest rarity, as well as of the greatest value in the present discussion.

The group, whether it be a family or subfamily, includes about twelve known species, all from Australia and America. It is a group, moreover, of great interest to the systematist, and additional discoveries will be looked for with eagerness.

The first species described was by Wiedemann (31), under the name *Laphria brevicornis*. His description was meagre, and may not suffice for the recognition of the species. Nor can Wiedemann be credited with especial acumen in referring the form to the Asilidæ; he accepted both genera and families in a much wider sense than is now done. Macquart was sufficiently acute to perceive from the description that the species could not be a *Laphria*, and, as Osten Sacken has shown, after the fashion that was not at all rare with him, described a new genus from the data contained in the description, actually figuring the species without having seen a specimen or any figure (10)! He did not do very badly, *a la Macquart*, in the figure, except that he put on an ordinary Asilid palpus. Meanwhile, however, Westwood had described and accurately figured species under the generic name *Apiocera* (29, 30). I regret that Westwood's papers are inaccessible to me; all that I know concerning them has been derived from Osten Sacken (17). "As to the place of the genus, he hesitated between the Midaidæ and the Nemistrinidæ." Later (11), Macquart described from specimens the genus *Pomacera*, not recognizing in them his own genus *Tapinocera*, and erected a new family for it, located near the Therevidæ. Bigot, following Macquart, accepted the family, but rejected Macquart's name for Apioceridæ (1). This is the first place that I find the word Apioceridæ, though used rather in the sense of Apiocerinæ, as a subdivision of his "Asilides," which included the "Mydaidæ," "Apioceridæ," "Laphridæ," "Asilidæ" and "Dasypogonidæ." "Ce genre [*Apiocera*] me parait mieux placé parmi mes *Asilidii*."

In 1865, Philippi described the "hoechst ausgezeichnete Gattung" *Anypenus* as an Asilid, not recognizing the form in any previous description (24, p. 702). His genus has had a rather peculiar history, misleading both Brauer and Osten Sacken, its identity with *Apiocera* not being discovered till the type was examined.

Gerstaecker, in 1868, in his review of the Mydaidæ (7), refused the genus admittance to that family. "Die systematische Stellung dieser Gattung [*Apiocera*] naeher zu fixiren, muss einer spaeteren, ihren naechsten Verwandten vielleicht zu Tage fordernden Zeit vorbehalten bleiben; so wenig die sich im Augenblick einer der übrigen Familien überzeugend zuertheilen laesst, so wenig gehoert sie auch den Mydaiden an." In the same year, Schiner, though recognizing the discrepant characters, referred *Apiocera* to the Mydaidæ. "Sie gleichen im Habitus schon ganz den Asiliden, und bilden zu diesen hin ein ganz natürliches Bindeglied." (25)

In 1877, Osten Sacken described the sixth or seventh known species, from California (16) placing it under the Mydaidæ, though with certain reservations. The next reference to the subject was in 1883, when Osten Sacken, who had meanwhile skilfully worked out his chaetotactic system, brought arguments to show that *Apiocera* is an Asilid (17, 18), and a member of the Asilinæ.

Brauer accepted Macquart's view that the genus should constitute a family related to the Therevidæ. "Ich halte die Apioceriden für zunaechst verwandt mit *Thereva* und *Xestomyza*, durch die Rüsselbildung, Beine, und andere bereits früher hervorgehobene Momente. Bei *Apiocera* ist die Ænlichkeit mit den verwandten, aber durch ihre Rüsselbildung einer anderen Linie der heterodactylen Orthorrhaphen augehoerenden Asiliden ein verführendes Irrlicht gewesen (2).

Osten Sacken, more recently (21), admitted some doubt of its membership among the Asilidæ, as follows: "Since I have shown that *Apiocera* is not a Midaid, the only debatable question is whether it is an Asilid or an aberrant form allied to the Asilidæ."

Mik, in several papers, has expressed the opinion strongly that the genus should constitute a family: "Macquart war der Erste, welcher den Apioceriden die richtige Stellung in Systeme angewiesen hat; er brachte sie in die naechste Verwandtschaft zu den Thereviden" (12, 15).

Coquillett has expressed himself in favor of the relationship to the Therevidæ (4). I have held the opinion that the genus represents a family most nearly related to the Mydaidæ and the Asilidæ, and have so defined it (32, 33). Finally, Osten Sacken, after learning more of *Rhaphiomidas*, has so far receded from his first position as to admit the subfamily "Apiocerina" under the Asilidae (23).

The question then is: Should *Apiocera* and *Rhaphiomidas** be located under the Mydaidae, following Schiner; under the Asilidae, following Osten Sacken; or regarded as an independent family, in accordance with Macquart's, Brauer's, Mik's, Coquillett's, or my own views?

As regards the relationship to the Therevidae, I accept Osten Sacken's argument; and yet I believe the relationship is as great to that family as to the Asilidae. As is well known, structural differences in the wings are, almost always, of more importance the nearer they

* Since this was written, Coquillett has published (Canadian Entomologist, vol. xxiv, p. 314, Dec., 1892) a new genus, *Apomidas*, allied to *Rhaphiomidas*, but differing in the open anal cell.

approach the base. As is seen in the figure of the wing of *Psilocephala* (see plate), the first longitudinal vein is very short, terminating only a little beyond the middle of the wing, while in *Apiocera*, as well as the Asilidae, it terminates far beyond the middle. This difference is, I believe, of more importance than the resemblances in the structure of the head. The Nemistrinidae need not detain us. Any arguments in favor of relationship with this family will apply more forcibly to the Mydaidae.

Does *Apiocera* belong with the Mydaidae? Osten Sacken says not, for the following reasons:

"To sum up, *Apiocera* differs from the Midaidae: 1. In the presence of ocelli; 2. In the presence of macrochaetae on head and thorax; 3. In the structure of the scutellum; 4. In the structure of the legs; 5. In the presence of palpi; 6. In the venation; 7. In the structure of the male forceps; 8. In the usual character of the coloring" (17).

1. Hardly a family character. Among the Tabanidae, for instance, the presence or absence of well-developed ocelli is recognized as having a specific valuation only.

2. In all my four species of *Apiocera* and in *Rhaphiomidas*, there are no bristles on the front; the same is the case with the species described by Philippi (24). In *Rhaphiomidas* they are weak on the thorax.

3. There is a well-marked difference in the structure of the scutellum, but it is quite as much in the direction of the Nemistrinidae as of the Asilidae.

4. In my opinion, the weakness of the legs allies *Apiocera* more closely to the Mydaidae than to the Asilidae.

5. Well developed palpi, quite like those of *Rhaphiomidas*, occur in at least one genus of the true Mydaidae. Thomson describes the palpi of his genus *Harmophana* as biarticulate, but in this he is undoubtedly in error (27). Jaennicke recognized the palpi in *Triclonus bispinifer* (8), and Macquart in both *T. bispinifer* and *T. luripennis*. It is strange that Gerstaecker entirely overlooked this character.

6. The venation agrees closely with that of the Mydaidae, save in the shorter discal cell, a Nemistrinid character.

7. *Apiocera* differs noticeably from the Mydaidae in the general coloration, agreeing in this respect best with the Therevidae.

Had Osten Sacken been able to study *Triclonus* and *Rhaphiomidas*, I feel sure that he would have modified some of his views. In the first place, the neuration is remarkably alike, as will be seen by the examinations of the figures here given, and Thomson's figure of *Harmophana*. (27 pl. IX, fig. 5.) This marked neurational resemblance was observed by Osten Sacken in his original description of *Rhaphiomidas*, as follows: "Closely allied to *Mitrodetus* Gerstaecker, as there are three cells intervening between the forked cell and the margin of the wing, and as the structure of the proboscis is the same, long and linear, directed forwards, with very narrow lips at the end; differing, however, from that genus in the structure of the antennæ, in some minor characters of the neuration * * ; and in the presence of two [three] distinct ocelli" (16). The only difference in the neuration that can be expressed lies in the shorter discal cell, and it is on the strength of this that Osten Sacken traces a relationship with the Asilidæ. By comparing the figures it will be seen that the Nemistrinid neuration offers the same peculiarity.

"I believe that a natural arrangement [of families] must be the result of the study of those organs of the imago which are necessary for the functions of external life, principally, therefore, of the organs of orientation connected with the head (eyes and antennæ), and in the second line, of the organs of locomotion (legs and wings)."* To this Osten Sacken should have added, as among the most important, the mouth-parts. Certainly there can be nothing which affects the habits of the adult insect more intimately than do the organs by which food is taken into the body. Now, if we admit that the neurational resemblance between *Triclonus* and *Rhaphiomidas* is of secondary value only, we must find Asilid resemblances in the head to counterbalance it. The actual fact is, however, that the mouth-parts of the *Triclonince*, if I may use that term to indicate the three genera, *Diochlistus*, *Mitrodetus* and *Triclonus*, are, if *Triclonus* can be taken as a type, quite like those of *Rhaphiomidas* and *Apiocera*, and fundamentally different from the Asilid type. We have then left from among the important characters, according to Osten Sacken, only the antennæ, which are Asilid and not Mydaid, and the ocelli. But, the difference in the antennæ is not so radical as that which occurs between *Leptis* and *Arthroceras*, for example, and Osten Sacken has expressed the opinion more than once that these forms belong together, an opinion with which I coincide.

Another Asilid argument is left, one on which Doctor Osten Sacken places great weight,—I mean the presence of thoracic bristles in the Apioceridae and their entire absence in the *Mydaidæ*. Although fully admitting that too little attention has been given to the chaetotaxy of diptera, I cannot accept the argument as one outweighing those derived from the important differential characters in head and neuration. As Mik has pertinently said (12), the presence or entire absence of well-developed bristles among the Syrphidæ is of less than generic value.

*Entom. Monthly Mag. [3] p. 35, 1891.

There is yet another point of resemblance between *Rhaphiomidas* and *Triclonus* which appears to me to be a very remarkable coincidence, if we assume the forms to be unrelated. In his original description of the former genus Osten Sacken refers to a singular and remarkable metapleural process situated in front of the halteres, which he could not understand: "In front of the halteres there is a singular conical body, a little shorter than the halteres, the homology of which I do not attempt to explain." *Precisely the same process* occurs in *Triclonus*, as my specimens show, and as Thomson described and figured in *Harmophana* (*Triclonus*).

Taking all these facts into consideration, is it not rather forced to assume that the relationship to a form like *Triclonus*, possessing almost identical neuration, mouth-parts, metapleural process and habits, is less intimate than to the Asilidæ, where the neuration is very different, the mouth-parts and habits are entirely dissimilar, and the trichostical bristles replace the metapleural process, because the antennæ, ocelli and thoracic bristles agree!

Brauer is of the opinion that *Triclonus* is not a true Mydaid (2). With this view I cannot agree. But, even should we accept it as distinct from this family, it would weaken rather than strengthen Osten Sacken's position, for it is an eremochaetous form, and could not by any possibility be placed among the Asilidæ.

However, leaving *Triclonus* and *Rhaphiomidas* entirely out of account, there remain arguments against the union of *Apiocera* and the Asilidæ which seem to me insuperable. In the first place, the Asilidæ are pre-eminently a family of predaceous insects; not a species is known but what feeds upon the juices of insects. *Apiocera* is a flower-fly, as the mouth-parts, the legs, and Coquillett's observations show. This difference in habits might be overlooked in the presence of striking resemblances, as Osten Sacken justly says. But, aside from what has already been spoken of, there are fundamental differences in the structure of the mouth-parts, indicating a remote genetic identity of the two groups. I do not mean the differences as seen in the labella alone; Brauer and Mik have both used this argument with force. By referring to the figures and descriptions herewith given, it will be seen there is a radical difference in the sucking parts, the Therevidae, Nemistrinidae, Mydaidae, Apioceridae, and, I may also add, the Bombyliidae (6), agreeing closely on the one side, and the Asilidae presenting a markedly different and constant type on the other side.

Again, arguments drawn from the neuration are to me very strong. It is well known that the neuration of the Asilidae, and especially of the Asilinae, is very constant. In a large proportion of the species, the variation does not offer even specific differences. This means, if it means anything, that the family is comparatively recent geologically; the type is not in its decadence. On the other hand, let one compare the wings of the four species of *Apiocera* figured herewith. Every one would be placed in a different subfamily were they normal types of the Asilidae! One of the species (sp. *b.*) even violates a prominent family character! That the absence of the anterior branch of the third vein is not an accident, is evident from the fact that there are two specimens before me quite alike. That such a remarkable neurational character is not even generic in its value is shown by the figure of another species (sp. *c.*), likewise from Australia. In both of these species the veins of the outer wing are very thin and weak. The characters otherwise clearly prove that the two species are distinct. Here we have as a specific character a constant family character of the Asilidae! It is possible that these two species, differing as they do from the stronger-veined forms, may eventually require generic separation, but it is quite certain that the generic division cannot be placed between the two species.

What conclusions are we to deduce from such variations? Quite clearly to me they seem to show, as Brauer and I have already said, that the Apioceridae represent a geologically decaying type,—a conclusion borne out by their geographical distribution. I would repeat the statement, with some changes, previously made by me, to which Osten Sacken takes exception. The Apioceridae are most nearly related, genetically, to the Mydaidae and Nemistrinidae, less intimately to the Asilidae and Therevidae.

Mik has pointed out (13) that in none of the Apioceridae do we find enlarged facets on the anterior portion of the eyes, so common in the Asilidae. Osten Sacken will not admit that this character is of much, if any, importance (23), but it seems to me to be entitled to consideration, even though of minor value. Again, another character that seems never to have been noticed, is the difference in the width of the front in the two sexes, which is very marked in *Apiocera*, but is not found in the Asilidae. It must mean that, genetically, *Apiocera* is less remote from the holoptic type of male than are the Asilidae. It is possible that there are true bristles on the front of some species of *Apiocera*, but such are not present in the four species known to me, and do not occur in the Chilian species, according to Philippi; I believe that Osten Sacken is in error concerning this.

Upon the whole, it seems plain to me, that to unite the Apioceridae with the Asilidae is to do violence to real and distinctive structural characters, which, carried but a little further, would require the union of family after family,—that the step is retrogressive rather than progressive.

To sum up, the differences between *Apiocera* and the Asilidae may be expressed as follows:

APIOCERA.	ASILIDAE.
Front narrowed in the male.	Front of equal width in both sexes.
Front not excavated.	Front excavated between the eyes.
Front without bristles.	Front with bristles.
Face very short, without mystax.	Face descending below the eyes, usually with mystax.
Eye-facets never enlarged in front.	Eye-facets usually enlarged in front.
Paraglossae longer than ligula, deeply channeled.	Paraglossae very short, much shorter than the ligula, gently concave.
Ligula a slender semi-cylindrical channel, fitting for its whole length in the paraglossae, wholly without hairs.	Ligula stout, covered at base by the paraglossae, elsewhere forming a closed tube, uncovered by the paraglossae, and with backwardly directed short bristly hairs along its upper margin.
Palpifers slender, cylindrical.	Palpifers stout, lanceolate.
Labella broad, movable, with pseudo-tracheae.	Labella horny, immovable, wholly without pseudo-tracheae.
Neuration very variable in related species.	Neuration very constant in related species.
Anterior branch of the third vein sometimes wanting.	The presence of the anterior branch of the third vein hitherto recognized as a family character.
The fourth vein always terminates before the tip of the wing.	The fourth vein always terminates beyond the tip of the wing.
Legs not strong.	Legs strong, adapted for grasping.
Trichostical bristles wanting.	Trichostical bristles present.
Flower-flies.	Predaceous flies.

In nearly all these respects *Apiocera* agrees with the Mydaidae. *Apiocera* differs from the Mydaidae as follows:

APIOCERA.	MYDAIDAE.
Ocelli present.	Ocelli wanting.
Thorax with bristles.	Thorax without bristles.
Scutellum large, projecting beyond the metanotum.	Scutellum small, not projecting beyond the metanotum.
Legs with numerous bristles.	Legs with few or no bristles.
Antennae with a short simple style.	Antennae with a lamellate, jointed style.
Discal cell short.	Discal cell more elongate.
Male forceps enlarged.	Male forceps small.

In all these respects *Apiocera* agrees with the Asilidae. I would therefore propose the following as the definition of the Apioceridae:

Rather large, elongate, chaetophorous flower-flies. Ocelli present. Front not excavated; antennae with a simple short style. Face short. Proboscis with pseudo-tracheate labella; the paraglossae elongate; with one- or two-jointed palpi. Third longitudinal vein of the wing furcate or not; one or both of the veins from the discal cell terminating beyond the tip of the wing; five posterior cells. Empodia wanting. Male forceps enlarged.

Apiocerinae. Palpi two-jointed, large; the second vein from the discal cell terminates beyond the tip of the wing.

Rhaphiomidainae. Palpi one-jointed, small; the second vein from the discal cell terminates before the tip of the wing.

MOUTH-PARTS.

In the following pages, I give a rather brief description of the mouth-parts in the Apioceridæ and the allied families. It will be observed that I make use of the terms proposed by Smith, as the result of his comparative study of the mouth-organs. I believe that his studies show a real advance in the knowledge of the homologies of these parts, though in some instances his views may require modification or change. The corresponding terms used by Smith and Dimmock, so far as they affect our present purpose, are as follows:

Smith.	*Dimmock.*
Paraglossae	Labrum-epipharynx
Ligula	Hypopharynx
Palpifer	Maxilla
Maxillary palpus	Maxillary palpus
Galea	Labium
Labellum	Labellum

Apiocera.

The palpi are large, two-jointed in each of the four species examined, and very hairy. The first joint is nearly cylindrical, and is continuous with the basal plate, to which the membranous portion of the galea is attached. The second joint is large, sub-crescentic in outline, though somewhat variable in the different species, and flattened. It seems to be larger in those species with shorter proboscis. The palpifer takes its origin from the inner, upper side of the basal, palpal plate, or at the base of what may be called the first palpal joint. There is no joint in this place, though more or less mobility is permitted by the partially membranous connection. The palpifers are in all cases very slender, straight or gently curved, and are as long as the chitinous portion of the galea. They are pointed, with but little if any thin expansion, and are wholly without hairs or pubescence. They are, of course, enclosed within the groove formed by the galea, and lie by the side of the ligula.

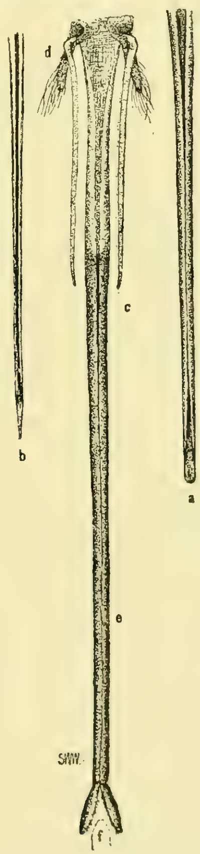
The paraglossae and ligula are very similar to the same organs in *Rhaphiomidas*, though each forms a less perfect tube. The upper organ is deeply channeled, and nearly cylindrical, but the borders are widely separated below throughout their length. The ligula is a slender, smooth, chitinous channel, forming something more than half a cylinder, and with a sharply pointed extremity. The two organs together form a complete tube. The united paraglossae is rather longer than the firm portion of the galea, and, in some, seems to present an indication of a median separation into two parts.

The galea has a variable membranous portion at its base, proportionally longer in those species with an elongate proboscis, thus permitting greater freedom in its use. A rather peculiar membranous process is seen at the base in one species; it may possibly occur in others. The chitinous portion is only moderately firm, and is nearly cylindrical in life. Its upper margins are more or less widely separated, especially in the species with short proboscis. On either side, is plainly seen the ribbon-like band of longitudinal fibres, indicated in the plate. The labella are especially large in *A. haruspex*, where they occupy the larger part of the galea. In other species they are smaller, but are in all adapted for attrition, having about twenty curved ridges on the inner side, very much as they are in the Nemistrinidae, though less numerous. On the outer side of each labellum, in the Australian species, there are numerous short, firm, bristly hairs, very much as in the Asilidae; they are wholly wanting, however, in *A. haruspex*. They are probably sense-organs.

While, of course, this structure of the labella does not preclude the possibility of the insect feeding upon animal juices, yet it certainly shows that such juices do not form the only food, as in the Asilidae.

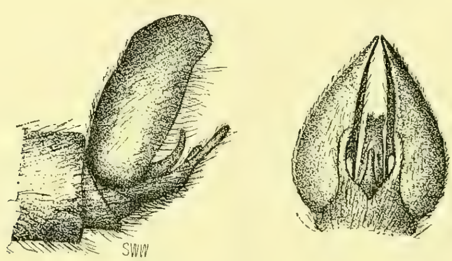
RHAPHIOMIDAS.

In *Rhaphiomidas* the palpi are short and rather stout, a projection of the basal plate, without joint. The palpifers are elongate, but much less so than the paraglossae and ligula. They taper gradually from the pointed, slightly curved extremity, and are inserted into the basal, palpal plate by a sharp curve. On their distal portion, there is a very delicate, narrow expansion. Just outside, or rather above, the insertion, there is an elongate pit, with a sharp border, extending over about one-half of the palpal portion. I have not seen this depression in any other species. There is no indication of segmentation anywhere on the palpus or palpifer.



Mouth-parts of *Rhaphiomidas Acton* Coq.
a, paraglossæ, from below; b, ligula, from above; c, palpifer; d, palpus; e, galea, from above; f, labella.

The basal fourth, or a little more, of the galea is membranous, and is very flexible, evidently permitting retraction of the firmer portion. Under a moderately high magnification, it shows both longitudinal and transverse striation. The flaps or edges approach each other above, though perhaps not as regularly as indicated in the drawing. The opaque, firm portion is about the three-fourths of the entire length, and is scarcely longer than the sucking parts above. The upper margins touch each other before the middle, and thence to the end are not easily distinguishable, forming a closed, cylindrical, somewhat irregular tube, for the reception of the palpifers, paraglossae and ligula. The tube is, of course, not united above, and the enclosed parts may be easily lifted out of it by the divergence of the flaps. At the tip, the elongate, spoon-shaped labella lie normally parallel, but are easily divaricate. They have each, on the inner approximated side, about twenty transverse, double rows of fimbriae. The outer side has each about fifty small, rounded transparent spots, more numerous near the tip. They are evidently sense-organs, though entirely destitute of bristles.

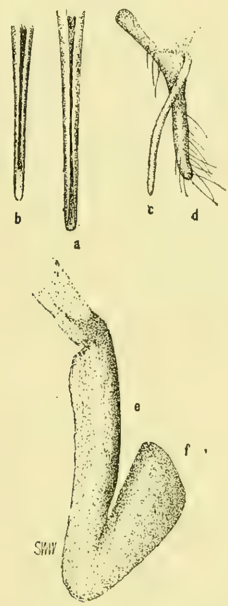


Male forceps of *Rhaphiomidas Acton* Coq.

The paraglossae form a smooth, slender, nearly cylindrical, tapering tube, the infolded margins below coming in contact throughout nearly the entire length, diverging at the base and tip. The tip is smooth and thin, like the half of a cylinder, and obtuse. There is no indication whatever of a median division. The ligula is a little shorter than the paraglossae, united with the upper organ by suture at the base. The distal extremity is sharply pointed and delicate, and, throughout its length, on the upper side, there is a slender, deep groove, forming, when inclosed within the paraglossae, a nearly perfect tube. The palpifers are evidently more functional here than in *Apiocera*, though it is difficult to say what that function is, as they are much shorter than the paraglossae. They may serve as a support for the basal membranous portion of the galea.

MYDAIDÆ.

In *Mydas*, and probably in all those species with but two posterior cells between the forked cell and the posterior margin of the wing, the mouth-parts are relatively small, the proboscis short, and the palpi extremely rudimentary. On the other hand, in the three known genera with three posterior cells behind the forked cell, *Diochlistus*, *Triclonus* (*Harmophana*) and *Mitrodetus*, the proboscis is more or less elongate, and, in one form at least, has well-developed palpi. In *Mydas*, there is a slight, wart-like protuberance from the basal plate, which probably represents the palpus. From its base, the short,



Mouth-parts of *Triclonus bispinifer* Westw.
a, paraglossæ, from below; b, ligula, from above; c, palpifer; d, palpus; e, galea; f, labellum.

dagger-shaped palpifer arises. The united paraglossae is longer than the ligula, and nearly twice the length of the palpifers. It is slender, nearly cylindrical, nearly truncate at the tip, and has its lower borders nearly contiguous. The slender, obtuse ligula fits within this tube, and itself forms nearly a complete tube. The short galea terminates in broad labella.

In *Triclonus*, the palpi are elongate and well developed, though unjointed. The paraglossae and ligula are slender, the palpifers only a little longer than the palpi, the galea more elongate, and freely open above; and the pseudo-tracheate labella very large and turned downward.

NEMISTRINIDÆ.

I have examined the mouth-parts in but two genera of this family. The structure, except the galea, is so nearly identical in these, however, that I believe it to be the family type. The paraglossae and ligula present only minor differences from those parts in *Apiocera* and *Rhaphiomidas*. Neither organ forms a complete tube. The paraglossae have a more thin, pointed extremity than in the other mentioned species, and the ligula is more rounded at the extremity. The palpifers are extremely slender, especially in the long-proboscid form. They are cylindrical, firm, without expansion distally, and bare. The palpi seem merely appendages of the palpifers. They arise at a considerable angle from the flattened, slightly expanded base, and, though apparently two-jointed, are long and whiplash-like. The galea is fully open on the upper side in the broadly labiate species, more closed, and more slender and firm in the long-proboscid species. The suctorial flaps in *Hirmoneura* are very large, with numerous curved ridges, and small, irregularly distributed, round, translucent spots. The outer side is covered with short hairs. The labella differ from those of *Apiocera* in the greater number and smaller size of the pseudotracheal ridges, and in their relatively larger size. In *Megistorhynchus*, the labella are terminal, long, narrow and divaricable—very much like the same organs in *Rhaphiomidas*.

THEREVIDÆ.

In *Thereva* and *Psilocephala*, the forms examined, the structure is essentially the same as in those already described. The paraglossae are longer than the ligula, both of which organs are deeply channeled, forming, in apposition, a closed canal. The palpi are one-jointed, elongate, irregular in outline, and very hairy. The palpifers are very slender, straight, and firm, arising from the base of the palpal projection. They are considerably shorter than the sucking parts above, and not as long as the palpi. In *Thereva*, the paraglossae and ligula are more elongate and slender than in *Psilocephala*. The galea is open above, and terminates in the large labella, which are provided with irregular ridges, as in *Apiocera*.

ASILIDÆ.

A uniform structure seems to prevail throughout the Asilidae, but with minor differences characteristic of species, genera and, apparently, subfamilies. I have been able to examine only a comparatively small number of the genera, but I feel sure that conclusions drawn from these will be applicable to the whole family. In *Mallophora*, *Promachus*, *Proctacanthus*, and *Asilus*, the palpi are large and but one-jointed. In *Stenopogon*, *Scleropogon*, *Deromyia*, *Cyrtopogon*, *Ospri-*

ocerus, Laphria, Lampria, and *Dasyllis,* the palpi are distinctly two-jointed. In *Leptogaster,* there is but a single joint. This character may be expressed as follows:

A. Palpi one-jointed.
  B. Marginal cell of the wing open—LEPTOGASTRINÆ.
  BB. Marginal cell closed—ASILINÆ.

AA. Palpi two-jointed.
  C. Marginal cell of the wings open—DASYPOGONINÆ.
  CC. Marginal cell closed—LAPHRINÆ.

The diminution of the number of palpal joints has been produced, evidently, by a greater specialization, and the general tendency in diptera is toward their entire loss. It may be safely assumed that the Asilinae and Leptogastrinae represent a more specialized type than do the Dasypogoninae and Laphrinae; a specialization further seen in the change from styliferous to the aristoid antennae. On this ground alone, it seems to me, the relationship of *Apiocera* with the Dasypogoninae is more intimate than with the Asilinae. It is true that we find the palpi sometimes wanting in families of lower type, even as they may be wanting in *Saundersia,* a genus closely related to *Dejaenia,* where they are very large. On the other hand, I predict that two-jointed palpi will be found very seldom in those genera having a well-developed arista.

In *Mallophora,* the palpi are very stout, cylindrical and hairy, and nearly as long as the palpifers. In the other genera of the Asilinae they are smaller. In *Laphria* and *Lampria* they are small, one might almost say sometimes rudimentary in the latter. Everywhere in the family their size seems to have some relation with the hirsuteness of the species. In many of the Dasypogoninae they are strongly developed, though perhaps nowhere so much as in *Mallophora.* In all cases they seem to be appendages of the palpifers, to which they are attached without articulation. The palpifers are in all cases stout, chitinous rods, much larger and stouter than in any of the forms previously described. Generic, and even specific, differences are shown in their shape, sometimes slender on the distal extremity, sometimes hooked or barbed, or with angular projections like a Roman battle-axe. They indicate a more distinct function than appears in the more simple forms occurring in the families already mentioned. The galea is strongly chitinous, with its base only, membranous. The terminal portion, corresponding to the labella, is variable in shape, sometimes extending far back on the upper side, and separated from the portion behind it by a more translucent line, as indicated in the section shown in the plate. The labella, however, are always horny, not at all dilated, wholly without pseudo-tracheae, and are covered on the outside with small pointed spines springing from a small eminence. This part seems almost functionless, so far as independent action is concerned.

It is in the suctorial organs that the characteristic Asilid structure is observed, and one which is remarkably constant in the family, and very different from that found in any of the related families.* The paraglossae are partly aborted, and serve simply to cover over the basal portion of the ligula. They present a shallow concavity, with the lateral margins turned down, and the anterior extremity rounded. Their paired origin seems to be indicated in the elongated chitinous plate on each side; no other indication is present, however. The ligula is peculiar, and it was not till after repeated sections and dissections that I felt sure of the identity. Lateral and top views of this organ, together with distal and proximal cross-sections, are given in the accompanying plates. The basal portion is dilated and concave, and widely open above, and is exactly covered in life by the short paraglossae. Immediately beyond this portion, the organ contracts, and the folded margins above come in contact, or nearly so, to the extremity. The canal thus formed is large, as is seen in the figure. The upper margins of the tube bear a row of rather firm, short, backwardly directed hairs. It will be seen in the figures that the palpifers lie close by the side of the ligula, and in such a position that pressure toward the inner side would tend to close the canal more firmly. In shape, the ligula varies somewhat in different species, being sometimes very slender, at other times more fusiform.

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DIPTERA BRASILIANA.

BY S. W. WILLISTON.

PART III.

A NEW GENUS OF BLEPHAROCERIDÆ.

The Blepharoceridae are one of those families of diptera whose wide structural variations and geographical distribution render of especial interest. Baron Osten Sacken's recent resumè of the known forms* gives only fourteen or fifteen as the entire number hitherto described: "Half a century has elapsed since the first species of the family was described; *Asthenia fasciata* Westwood, in Guerin's Magazin de Zoologie, 1842, Insectes, plate 94. Since then the number has gradually risen to thirteen described and two as yet imperfectly known species. Six of the thirteen belong to Europe, one to Asia, four to North America, one to South America. The two imperfectly described species are the two Paltostomae from South America and Mexico." It has only been very recently that I have become acquainted with the family *in natura*. Several specimens of a species of *Paltostoma* from the West Indies, which I have examined, seem to be different from *P. superbiens* Schiner, and may belong to the species referred to by Osten Sacken as occurring in Mexico. A full description, with figures, will be given of them at an early date. At present I wish to describe a new species from South America, which requires the erection of a new genus.

SNOWIA.—gen. nov.

Female. No incomplete vein near the posterior margin. Proboscis short. Hind tibiae with well-developed spurs. Ungues simple. Ocelli present. Front broad. Antennae composed of fourteen joints, closely united, the first two larger than the others. Proboscis directed downwards, a little longer than the vertical diameter of the head; palpi slender, about as long as the proboscis, apparently composed of four joints. Neuration nearly as in *Hapalothrix* Loew, as figured by Loew, Zeitschr, f. Entomol. n. Folge, H. VI, pl. I, fig. 8a, save that there is a strong, oblique cross-vein connecting the fourth vein before

*Berl. Entom. Zeitschr. XXXVI, p. 407, 1892.

the anterior cross-vein with the stem of the forked vein behind, somewhat as in *Liponeura*, except that the cross-vein joins the fifth vein before the sixth longitudinal branches from it. Legs elongate, the femora somewhat thickened (the hind pair decidedly thickened) before the extremity; ungues large, simple. Eye-facets uniform.

In Loew's synopsis (op. cit.) the genus would be located with *Liponeura*, from which it is at once distinguished by the wide difference in the neuration. Osten Sacken's grouping is a more natural one, yet not wholly satisfactory. The genus is evidently nearest allied to *Paltostoma* and *Hapalothrix;* to be distinguished from the former by the short proboscis; from the latter by the spurred hind tibiae; from both by the presence of the posterior connecting vein in the wing. There are no pulvilli, and the empodium is rudimentary. The species is nearly or quite bare, agreeing therein with *Paltostoma*, and differing from *Hapalothrix lugubris*. It gives me pleasure to name this genus in honor of the distinguished entomologist and naturalist, Prof. F. H. Snow, Chancellor of the University of Kansas.

Snowia rufescens, n. sp.

FEMALE. Bare. Front black, not shining, reddish below. Face reddish yellowish. Antennae blackish, the basal joints yellowish. Thorax yellow, opaque; the dorsum orange red. Abdomen deep red, the narrow margins of the segments brownish; venter lighter colored. Legs dark brown or blackish, the basal part of the femora yellowish. Wings nearly hyaline, the anterior veins blackish; the posterior ones lighter colored; furcation of fifth and sixth veins near the base of the wing—nearly opposite the axillary incisure. Length 8 millim.

One specimen, Rio de Janeiro (H. H. Smith).

THE AMERICAN SPECIES OF STYLOGASTER.

In the November number of the Wiener Entomologische Zeitung, page 216, Mr. V. von Roeder gave a synopsis of the known species of *Stylogaster*, in which he accepts three only,—*S. stylata* Fabr.; *S. neglecta* Will., and *S. leonum* Westwood. *S. biannulata* Say, he considers the same as *S. stylata*, on the strength of Wiedemann's determination. He may be right, but I think not.

In the Transactions of the Connecticut Academy, vol. vi, p. 92, I gave as my reason for employing Say's, rather than Fabricius' name for the North American species, that Wiedemann had confounded two species in his description, as was evident from the difference in the length of the antennal joints, which Wiedemann erroneously considered a sexual character. Since then I have received a female specimen of a Brazilian species, which enables me to clear up the confusion, so far as Wiedemann is concerned.

By comparing Wiedemann's text it will be seen that he drew his description from four or more specimens: a female which he called a male, presumably from North America; the original Fabrician type — *Conops stylata*—without abdomen, from South America, and which was undoubtedly a female; and specimens from South America in the Frankfort Museum, which he believed to represent both sexes, but which were in reality females. In a word, all his specimens were females, but, as we shall see, belonging to two different species.

To make this clear, I shall quote from the description fully: "Bei Maennchen ist die Faerbung ueberhaupt lichter und mehr gelblich, der Hinterleibsgriffel kurzer, an der Spitze kurz und schwarz borstig und queer gespalten, so dass der obere Theil einen schmaeleren, laengeren, etwas aufwaerts ragendeden Fortsatz, der unteren ein stumpferes, wie es scheint, zweilappiges Ende bildet. * * Bei Maennchen liegt er [der Hinterleibsgriffel] mit dem Hinterleibe in gerade Richtung." This description applies excellently well to my Brazilian female specimen. We may call the species *a*.

"Aus Fabricius Beschreibung des Hinterleibes, wie auch der Fühler, sollte man ein Maennchen [i. e. a female, sp. *a*] schliessen; aber bei dem Weibchen, welches uebrigens in Farbe der Beine und Zeichnung mit jenem voellig uebereinstimmt, ist der Griffel am After noch viel laenger, fast 6 Linien; * * das Ende ist walzenfoermig, mit ganz kurzer Spitze, und der ganzen Griffel geht unter einem weniger als rechten winkel vom Hinterleibe ab; * * Die Fuehler des Weibchens sind groesser, und zumal ist das fast breit saebelfoermig dritte Glied auf Kosten des zweiten so vergroessert, dass diese nur wenig groesser als das erste erscheint." This description applies perfectly to the female of *S. neglecta* Will., except in the length of the oviduct. (Compare Trans. Conn. Acad. vol. vi, pl. x, fig. 6.) We may call the species *b*.

The first question is: Are *a* and *b* identical with *biannulata* and *neglecta?* That *neglecta* occurs in South America is not improbable, but the only evidence we have so far is the above description of the Frankfort specimen or specimens, which of course could easily apply to an allied but distinct species I have but a single male of *biannulata*, from North America, and the above mentioned female from South America. It is not at all unlikely that they are the same, yet, from the peculiar secondary sexual chatacters in the hind legs of the male, and the remarkable oviduct of the female, I can venture no positive opinion. But, since Mr. Roeder has presumably compared my description of the male with his specimen, and because Wiedemann compared North and South American female specimens, it seems as though we might accept the identity.

The next question is: To which of the two species did the type belong? From Wiedemann's description, it seems that the antennae of the type were wanting when he saw it, as well as the abdomen. There is absolutely nothing in Fabricius' description that will furnish an answer, and it is doubtful whether the mutilated type, were it in existence, would relieve the doubt. Wiedemann's opinion was, that the specimen was possibly a "male," i. e. of the same species as, or one allied to, *biannulata;* but that is an assumption, and the description of the thorax applies much better to *neglecta.*

Under these circumstances I see no way but to abandon Fabricius' name, at least till there is more evidence, and accept the two names, *biannulata* and *neglecta,* as of species probably occurring in both North and South America.

It was no wonder that Wiedemann made the mistake that he did in the absence of real male specimens, so different are the oviducts in the two otherwise closely related species. In addition to the peculiar termination which Wiedemann describes, the oviduct in my Brazilian female is much more conical, stouter, shorter, and more posteriorly directed than in the female of *neglecta.* It is composed of three segments, as in *neglecta,* but the first and third segments are, together, somewhat longer than the second, whereas, in *neglecta,* they are exceedingly short, and the second segment is extraordinarily elongated. The peculiar processes at the tip, mentioned by Wiedemann, are also present in *neglecta,* but are very small, and easily overlooked, whereas in the South American female they are conspicuous. The male has no elongation whatever at the end of the abdomen.

Notes on Some Diseases of Grasses.

BY W. C. STEVENS.

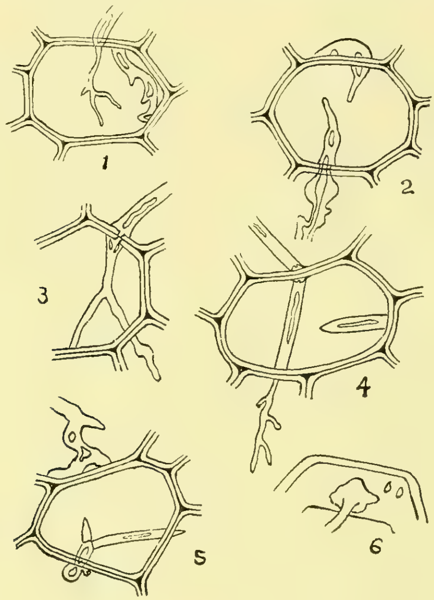
With Plates XI, XII and XIII.

Grasses are subject to attacks from various minute parasitic plants, resulting to the host in diminished vigor, accompanied by the destruction of tissues or the formation of abnormal growths. The number of these parasites catalogued for the grass family in Farlow and Seymour's Host Index is between four and five hundred. For corn alone sixty-nine parasites are listed, for wheat fourteen, and for oats six. This is for extra-tropical America.

One who gives only a passing notice to plants as he walks through the fields would hardly surmise, when vegetation is in its prime, that here and there disease is sapping the vitality of the sturdy grasses. But now, in December, when the blanched leaves and culms stand out above our first light snows, the scars of summer conflicts become conspicuous. Very evident are the rusts on *Panicum virgatum*, *Andropogon furcatuz*, *Bouteloua racemosa*, and *Tripsacum dactyloides*; while growing between clumps of these, large patches of *Setaria glauca* show leaves flecked over with blighted spots. The standing spikes of *Elymus Canadensis* and *E. virginicus* are interspersed with the slender black sclerotia of *Claviceps purpurea*, and frequently the glumes are glued together by the pink masses of a *Fusisporium*, hardly less destructive to the ovaries than the *Claviceps*. On the borders of the grain fields, among the few stalks of wheat and oats left standing by the reaper, the not infrequent blackened spots where the ovaries or glumes should have been, and the malformed masses in the standing corn suggest that, though unnoticed by the farmer, the loss in the aggregate, due to smut, has been no trifling amount.

If one is amazed at the long list of parasites in the Host Index, he is probably no less astonished when he notices for the first time their prevalence by his doorstep and through his fields. The fungus diseases of plants have been studied for many years, and activity in this line of research is now greater than ever. Investigations of the life-histories of parasites have brought to light some surprising facts and have led to the more intelligent application of remedies. These present notes relate chiefly to the visible effects of the parasite on the host.

The genus *Puccinia* embraces some of the most ubiquitous parasites. Sixty-three of its species are catalogued in the Host Index on grasses alone. To the unaided eye the presence of this class of parasites is indicated by elevated streaks or spots of a yellow, brown or black color. Discolorations sometimes extend from these well-defined areas, but usually the healthy color of the tissues



about them is preserved. Fig. 1, plate XI, illustrates thin sections through a leaf of *Eriophorum virginicum* parasitized by *Puccinia angustata*. The group of spores is seen to arise between two fibro-vascular bundles. The cuticle of the inner surface together with some of the parenchyma cells has been pushed up and broken, permitting the spores to protrude above the surface of the leaf. It is the protruding line of spores extending along the leaf between the fibro-vascular bundles that reveals so clearly to the naked eye the presence of this class of fungi. The mycelium from which the spores arise penetrates to the upper cuticle and is apparently confined on either side by the fibro-vascular bundles. The mycelium is seen through the colorless cuticle of the upper surface as brown streaks and spots. The parenchyma in *E. virginicum* is arranged in two or three comparatively dense layers against the upper and lower cuticles, while between these layers and the fibro-vascular bundles the parenchyma is open and spongy. This is shown more clearly in sections of unaffected leaves. The spores of the fungus are developed in the central spongy parenchyma, and for their liberation the under layers of dense parenchyma must be broken as well as the cuticle, so that the mere mechanical injury done to the host is not inconsiderable. This is somewhat clearly shown by the lower section of the figure (*loc. cit.*). The mycelium from which the spores arise is traceable as anastomosing brown filaments penetrating throughout the parenchyma. The chlorophyll corpuscles are still present in many of the parasitized cells, but they are not so numerous or so large as in the unaffected portions of the leaf. Some of the cells bordering adjacent fibro-vascular bundles are lined with thick brown incrustations. These do not appear in unaffected leaves, and are evidently due to the fungus. The spore clusters on the specimens studied sometimes reached a length of .8 m.m., but the majority were mere points, not exceeding .1 m.m. in length. These were so closely grouped that as many as three in the space of a millimeter were not infrequent. It is evident from the way these spore-groups or sori are thickly ranged up and down between two fibro-vascular bundles, while adjacent interspaces are free from them for considerable distances, that many sori are frequently produced from one mycelium developed from a single spore, and that the woody fibres of the bundles are, as a rule at least, effectual barriers against the lateral extension of the mycelium. *Uromyces* is a genus closely related to *Puccinia*. Fig. 2, plate XI, shows *U. spartinæ* parasitic on *Spartina stricta*. The leaves of this grass are densely ribbed on the upper or inner surface, the ribs extending to a height equal to or exceeding the thickness of the body of the leaf. At the bases of the ribs are fibro-vascular bundles bordered by large and mostly hexagonal cells. Against these, and extending to the cuticle, is a row of delicate palisade parenchyma. The mycelium of the parasite is confined in these parenchyma cells, forming there a dense network. In the figure (2, plate XI) the ridges of the leaf are seen to be thrust apart by the development of the spores. The mycelium penetrating the parenchyma is seen as a shaded narrow strip extending to the under surface of the leaf, where another spore cluster is forming. The sori in this instance are from two to six millimeters in length. In leaves of *Panicum varigatum* the parenchyma cells are arranged radially about the bundles. When parasitized by *Uromyces graminicola* the mycelium extends throughout the parenchyma and surrounds the bundles. The cells, although penetrated and lined on their interior by the mycelial filaments, retain an apparently normal condition. The relation of *Puccinia phragmitis* to *Spartina cynosuroides* is well shown in figure 1, plate XII. Here the ridges of the inner surface of the leaf are capped with a thicker layer of sclerenchyma than is the case with *S. stricta*, and the bundles are larger and project farther into the ridges. For this reason the growth of the fungus is more circumscribed laterally and the mechanical injury to the leaf is much less extended than is usually the case. Between the bundles are from two to three layers of parenchyma cells, and in the figure the mycelium is seen to permeate this tissue and form spore clusters on both surfaces. After the spores break through the cuticle they extend out laterally so that the sorus appears of considerable breadth. It is only in cross sections that the narrow limits of the mechanical injury of the leaf produced by a single sorus becomes evident. The section of a leaf of *Avena sativa* parasitized by *Puccinia coronata*, fig. 2, plate XII, is in striking contrast to fig. 1. In the leaves of oats the parenchyma has a broadly lateral distribution and the bundles are for the most part more deeply seated than in *Spartina*. For this reason they do not always serve as a check to the lateral extension of the mycelium, and the sori may even become confluent over them, as shown in the figure. The whole of the parenchyma in the region of the affected parts is permeated by the mycelium, and yet the chlorophyll corpuscles remain in an apparently healthy condition.

With these examples before us, we may say that the first visible injury due to this class of parasites is mechanical; the cuticle and in some cases a portion of the parenchyma is broken and pushed outward. The fibro-vascular bundles do not seem to be affected by the parasite. The mycelium is seen to extend throughout the parenchyma; but the tissues appear to be in a fairly normal condition, except that in many cases the cells have been crowded by the pressure of the developing spores. Injuries other than mechanical and locally visible must necessarily follow the presence of a parasite thus deeply seated in the vital parts of a plant. The mycelium permeating the parenchyma cells is undoubtedly appropriating for the development of its spores the food material elaborated by those cells, and the healthy nutrition of the whole plant must be measurably restricted thereby. Moreover, the undue evaporation caused by the rupture of the cuticle, and the osmotic conditions produced by the rapidly developing spores of the parasite must divert the salts brought up from the soil, and the sap elaborated in other parts of the plant from their proper distribution; and not only the leaves and culms where the parasite is localized, but the roots and inflorescence must be impaired in their development. The influence of the position and size of the fibro-vascular bundles on the extent of the mechanical injury done by the parasite is made evident by a comparison of the figures of plates XI and XII.

Smut on corn is one of the most conspicuous of plant parasites at the time of the formation of its spores. I presume nearly every farmer boy has looked on its silvery masses with feelings not unmixed with superstition. A section of one of these masses just forming on a leaf sheath is shown in fig. 1, plate XIII. It will be seen that the mass is an outgrowth of the tissues of the sheath, in which the parasite is already forming its masses of dark spores. The new growth is of great advantage to the fungus, since the latter can proceed with its development only in newly formed cells. A movement of elaborated sap must set in toward the new region of growth, and the fungus uses these favorable conditions to branch out rapidly and produce its spore masses. In the figure (1, plate XIII) the new growth is seen to have taken place between two primary bundles; the secondary bundles between them have been pushed upward by the abnormal enlargement and distortion of the cells beneath them, and have become centers for the outgrowth of irregular tracheids extending fitfully into the newly formed tissues. The new outgrowth consists chiefly of thin-walled cells containing starch grains in abundance. The outer cells, which are a continuation of the cuticle of the sheath, are elongate and comparatively thin-walled. As the spores mature, the surrounding tissues become compacted and ruptured, allowing the penetration of moisture and the consequent further swelling and bursting of the mass. In the somewhat distorted cells beneath the new growth, and to some distance laterally, the ramification of the mycelium can be distinctly made out. Brefeld has shown by his extensive experiments that the germ tube of the smut spores can penetrate the nascent tissues of any part of the plant, and is not restricted to the root node of the young seedling, as was formerly supposed. He states as his belief, that if the germ tube which enters at the root node does not develop rapidly enough to get into and keep pace with the growing point, that its further ascent in the plant is impossible. Indeed, his careful experiments, many times repeated, seem to prove that in the case of the rapidly-growing corn plant, those smut masses which appear on the ovaries or staminate flowers were produced by the inoculation of the inflorescence just as, or before it burst from its sheath. Once established in the host, the fungus has the power of irritating the tissues wherein it lies, into an abnormal growth, and in the new growing point thus established, it completes its development.

The mycelium of a fungus may penetrate the cells of its host either through openings already formed, or by piercing the cell membrane mechanically, or, the cell membrane may be dissolved by the secretion of some ferment by the growing point. The figures on page 124 represent cells from the sheath of a corn leaf sectioned through a smut outgrowth. Thin places or perforatious often occur in the cell walls, as shown in figs. 3 and 6, and the mycelium sometimes penetrates at such places; but more frequently it seems to pass through the cell walls independently of any natural openings. In fig. 1 the mycelium is seen to contract as it penetrates the wall, and to emerge into the cell with about half its former diameter. In the same figure a filament starts out suddenly, follows the contour of the cell for a short distance, and terminates without manifesting any disposition to penetrate the wall. Similar occurrences are seen in figs. 2 and 4. Cases of this kind are not infrequent. They seem to result from branches that have been confined between the walls of contiguous cells, but have at last made for themselves a passage into the cell. In fig. 2 the mycelium is again seen to contract as it passes through the upper wall. In the lower portion of the figure the mycelium has bulged out before penetrating the wall, as though new material were added to the growing point faster than it could penetrate the wall. Contraction has taken place, however, while penetrating the wall, and afterwards the filament has grown considerably thicker and formed a shoulder on the inner surface of the cell. In fig. 3 penetration has taken place at one of the natural openings, although on both sides of the wall the filament is much larger than the opening. After entering the cell the filament bifurcates, one branch penetrating into an adjacent cell without suffering any change in its diameter, the other evidently becoming lost in the interspace between the cell walls, probably to reappear abruptly at another place similarly to the sudden eruptions in figs. 1 and 4. The mycelium entering the cell from above, in fig. 4, does not have its diameter materially altered; it undergoes change in direction, however, and appears to cause the cell wall to protrude on both sides. As the filament leaves the cell it is abruptly reduced to almost one-third its former diameter, and soon terminates, after sending off short branches. In figs. 5 and 6 the plasticity of the growing point is illustrated. Here, for some reason, the penetration of the cell wall was not effected and the accretions of new material have become heaped up on the inner surface of the cell wall. These, and other sections which I have examined, appear rather to bear witness for the theory of the perforation of the cell wall by means of a ferment secreted by the fungus, than for the theory of mechanical puncture. The sudden emergence of a filament after evident meanderings between cells, does not occur under the proper conditions, it seems to me, for the puncture of the wall at a certain point by pressure. If the wall is punctured mechanically, the faster growth at the top takes place the quicker the perforation would be accomplished. On the other hand, rapid growth of the filament would not necessarily produce a correspondingly rapid perforation of the cell wall if the perforation were caused by a ferment, and we would find at times such accumulations of plastic material as those shown in figs. 2, 5, and 6. While mycelial branches such as those represented on page 124 are plentiful in the cells of the sheath adjacent to the abnormal growth, within the new growth the filaments are much smaller, and are discernible with difficulty except where the branches are massed together for the production of spores. The application of a solution of iodine to sections brings out prominently an abundance of starch grains in the cells of the sheath. These become very scarce, however, in the cells just beneath the new growth, but are found massed together again in the cells immediately surrounding the spore masses. Aside from the distortion of the cells, the tissues of the corn in the vicinity of the fungus do not seem to have suffered. There is no discoloration, no evident lack of healthy nutrition. However, the nutriment used up in the production of abnormal tissues, and in the formation of the large spore-masses of the fungus, might have gone toward the upbuilding of the essential parts of the plant. When the smut occurs in the pistillate flowers it is the young ovaries that become the seat of the abnormal growths for the formation of the spore-masses, and here the injury becomes more evident, because done to the very consummation of the plant's existence.

Another class of injuries to the tissues of the host plant is shown by leaves of *Panicum sanguinale,* parasitized by *Piricularia grisea.* Fig. 2, plate XIII, illustrates this. The affected portion of the leaf has shrunk to about one-third its natural diameter, and the collapsed tissues are blackened as though by fire. As the fungus extends its growth in a widening circle, the parenchyma cells, which radiate from the smaller fibro-vascular bundles, melt down and lose their identity in a darkened mass. Often the cuticle is blackened and shrunken, and even the lignified portions of the bundles do not escape the general discoloration. In this instance the spores are borne on pedicels which grow out through the stomata, and the mechanical injury caused by the parasite is slight. The chief injury is done to the chlorophyll-bearing parenchyma. It is the elaborating, rather than the conducting tissues that suffer, for frequently where a parasitized spot occupies over two-thirds the breadth of the leaf the portion of the leaf above the affected part retains its turgidity and apparent healthfulness. How much the fungus draws upon the general circulation of the host is not evident. It is clear, however, that it disintegrates and feeds upon tissues already formed.

The obliteration of the parenchyma of the leaf is sometimes caused by the formation of oospores in large numbers. This is shown by No. 64, in fascicle 11, of Seymour and Earle's Economic Fungi. The example is a leaf of *Setaria viridis* parasitized by *Peronospora graminicola.* The dried specimen crumbles easily to long shreds as though the fibro-vascular bundles were only lightly held together. Thin transverse sections reveal the bundles completely surrounded by the masses of oospores, the parenchyma cells being entirely absent, and only the fragile cuticle remaining to hold the bundles together and preserve the shape of the mummified leaf. Neither the cuticle nor the bundles are discolored. The parasite seems to have devoured the parenchyma utterly, and to have incorporated it in its own rich mass of oospores.

Claviceps purpurea and a species of *Fusisporium* have been widely spread in this locality for the past two years in *Elymus Virginicus* and *E. Canadensis*. Both parasites occur in the young ovaries and cause the complete destruction of their tissues. Even before the sclerotia of *Claviceps* have emerged from the inner glumes, no vestiges remain of the cell walls or cell contents of the ovaries. The presence of the *Fusisporium* is manifested by the outgrowth, from between the glumes, of a dark pink gelatinous mass. A section through a spikelet shows the glumes bound together by the growth of a dense mycelium and the tissues of the ovary almost or entirely replaced by the fungus. (In one section some fragments of the starch-bearing cells remained, but no starch grains.) Excepting the occasional discoloration of the cells contiguous to the fungus, the glumes do not seem to suffer. The spores, which are obscurely septate and curved-fusiform, are borne chiefly by that portion of the fungus which has replaced the ovary. Frequently the *Fusisporium* occurs in the same spikelet as the *Claviceps*, and then the pink gelatinous mass growing about and up the dark sclerotium produces a striking contrast.

With reference to their effect upon their hosts, the parasites on grasses embraced in these notes may be grouped as follows:

1. Those not preeminently destructive to tissues already formed, but which appropriate to themselves the currents of elaborated sap, and the nutrition of the whole plant suffers in consequence. The *Puccinias* are examples.

2. Those that produce abnormal outgrowths from the plant, in which to develop their spores. In this class all parts of the host suffer from the appropriation by the parasite of the elaborated sap, and frequently a normal growing point is caused to produce abnormal tissues, so that the proper development of fruit or foliage is interfered with. *Ustilago Zeæ-Mays* is an example of this class.

3. Those that attack the chlorophyll bearing tissues of the host, and disintegrate and feed upon their cells. In this class the nutrition of the host is curtailed by the destruction of a part of its elaborating tissues. *Piricularia grisea* belongs to this class.

4. Those that attack the developing ovaries, destroying their

tissues and using up the rich food supply sent up for the formation of the fruit. In this class the effects appear to be entirely local, the nutrition of other parts of the plant not being impaired. *Claviceps purperea* is a type of this class of parasites.

Many parasitic fungi have a wide range of host plants, and this fact must at times be considered by economic mycologists in devising preventive methods. It is quite likely that in some instances mistakes have been made in classifying similar forms on different hosts as identical. A study of the development of these forms in nutrient media, such as has already been done by Brefeld, will help to make a safer basis of classification. To illustrate the wide range of which some parasites are capable, I have arranged from Farlow & Seymour's Host Index a list of the Gramineæ which serve as hosts for a few of the parasites of frequent occurrence on some of our cultivated cereals.

CLAVICEPS PURPUREA, (Fr.) Tul.

Agropyrum divergens, Nees.
" glaucum, Roem. & Schult.
" repens, L.
" violaceum, Lange.
Calamagrostis Grœnlandica, Kunth.
Elymus Canadensis, L.
" condensatus, Presl.
" Virginicus, L.
Glyceria fluitans, R. Br.
Hordeum jubatum, L.
Kœleria cristata, P.
Phalaris arundinacea, L.
Poa sp. indet.
Spartina cynosuroides, Willd.
Tripsacum dactyloides, L.
Triticum vulgare, L.

ERYSIPHE GRAMINIS, DC.

Agropyrum glaucum, Roem. & Schult.
Agrostis exarata, Trin.
Avena sp. indet.
Beckmannia erucaeformis, Host.
Elymus condensatus, Presl.
Glyceria nervata, Trin.
Hordeum jubatum, L.
Poa pratensis, L.
" tenuifolia, Nutt.
Triticum vulgare, L.

PIRICULARIA GRISEA, (Cke.) Sacc.

Leersia oryzoides, Swz.
" Virginica, Willd.
Muhlenbergia glomerata, Trin.
Panicum dichotomum, L.
Poa pratensis, L.
Setaria glauca, Beauv.
" Italica, Kunth.

PUCCINIA GRAMINIS, P.

Agropyrum glaucum, Roem & Schult.
" violaceum, Lange.
Agrostis alba, L., var. vulgaris, Thurb.
" scabra, Willd.
Andropogon sp. indet.
Avena sativa, L.
Briza maxima, L.
Calamagrostis Canadensis, Beauv.
" longifolia, Hook.
Chrysopogon nutans, Benth., var. avenaceous, Gray.
Distichlis maritima, Raf.
Elymus Canadensis, L.
Hordeum jubatum, L.
" pratense, Huds.
Muhlenbergia glomerata, Trin.
" Mexicana, Trin.
Phleum pratense, L.
Phragmitis communis, Trin.
Poa pratensis, L.
Secale cereale, L.
Sporobolus asper, Kunth.
Triticum vulgare, L.

PUCCINIA RUBIGO—VERA, (D C.) Wint.

Agropyrum divergens, Nees.
" repens, L.
Avena sativa, L.
Calamagrostis Lapponica, Trin.
Eatonia obtusata, Gray.
" Pennsylvanica, Gray.
Elymus Canadensis, L.
" condensatus, Presl.
" Virginicus L.
Hordeum jubatum, L.
" pratense, Huds.
Koeleria cristata, P.
Secale cereale, L.
Triticum vulgare, L.

USTILAGO ZEÆ--MAYS, (DC.) Wint.

Euchlaena luxurians, Dur. & Asch.
Zea--Mays, L.

Modern Higher Algebra.

BY E. MILLER.

NOTE.—The Theory of Determinants, as a branch of Modern Higher Algebra, has taken its appropriate place in all of the best works on Higher Algebra. It is an instrument of great utility and power in the most complex mathematical operations, and as illustrative of its methods, the following problems, algebraic in their character, are herewith demonstrated. They were originally suggested by a French teacher of mathematics.

I.

Show that if a determinant equals zero, the minors corresponding to the elements of two parallel rows are proportional, and reciprocally.

SOLUTION.

Let $(a_1^1 a_2^2 \ldots a_n^n)$ be a determinant, D, whose value is zero.

We shall consider a homogeneous system of n equations of n unknown quantities, in which the coefficient of x_1 in the kth equation is a_k^1; the solution of these equations yields values of the unknown quantities other than zero.

Suppose that one at least of the coefficients of the pth row and one of the coefficients of the elements of the qth row have other values than zero.

By making B_i^j to be the coefficient of the element a_i^j, we know that the solution is general; so that

(1), $$x_1 = kB_p^1,\ x_2 = kB_p^2,\ \ldots,\ x_n = kB_p^n,$$

in which k may be any number.

In a similar manner u being an arbitrary number,

(2), $$x_1 = uB_q^1,\ x_2 = uB_q^2,\ \ldots,\ x_n = uB_q^n,$$

with one value of k in (1) corresponding to a value for u in (2) such that we have the following equations,

(3), $$kB_p^1 = uB_q^1,\ kB_p^2 = uB_q^2,\ \ldots,\ kB_p^n = uB_q^n.$$

What has thus been established with regard to the rows can, by a similar process, be shown to be true of the columns of a determinant.

Reciprocally, if the equations (3) hold between the elements of two rows, then the determinant Δ, which is the adjugate of D, has two parallel rows with elements proportional; then $\Delta=0$; and since we know, (see Muir), that $\Delta=D^{n-1}$, we must have the result $D=0$.

The reciprocal may be demonstrated in the following manner: suppose

$$B^1_q=kB^1_p,\ B^2_q=kB^2_p,\ \ldots\ldots, B^n_q=kB^n_p;\ \text{then}$$

$$D=a^1_qB^1_q+a^2_qB^2_q+\ \ldots\ \ +a^n_qB^n_q=k(a^1_qB^1_p+a^2_qB^2_p+\ \ldots\ \ +a^n_qB^n_p)=0$$

II.

Definition.—Every determinant whose elements verify the relation $a_{pq}+a_{qp}=0$, is called a symmetrical gauche determinant, when the elements of the principal diagonal are all zero.

Problem.—*To show* (1) *that the value of every symmetrical gauche determinant of an uneven degree is zero;* (2) *that every symmetrical gauche determinant of even degree is the square of a rational and entire function of the elements of the determinant.*

SOLUTION.

(1). If the gauche determinant is of an uneven or odd degree, with every term such as

$$(-1)^{I+I'}a^{B'}_B a^{y'}_y\ \ldots\ldots\ a^{k'}_k$$

in which I and I′ are the numbers of inversions of two sets of indices, we may associate the term

$$(-1)^{I'+I}a^{B}_{B'}a^{y}_{y'}\ \ldots\ldots\ a^{k}_{k'}$$

whose values are at once zero, or are equal and have contrary signs; their sum is, therefore, equal to zero, as is also the value of the determinant.

For the second part of the problem, let us begin with the following identity:

$$D\frac{d^2D}{da^r_m da^s_q}=\frac{dD}{da^r_m}\,\frac{dD}{da^s_q}-\frac{dD}{da^s_m}\,\frac{dD}{da^r_q}$$

D designating the determinant we are considering; $\frac{dD}{da^r_m}$ its derivative with regard to a^r_m, and $\frac{d^2D}{da^r_m da^s_q}$ its second derivative with regard to a^r_m first, and afterward to a^s_q.

Let the degree of D be represented by n, and suppose $m=r=n$, and $q=s=n-1$, the identity with which we started will then become

$$(1)\qquad D\frac{d^2D}{da^n_n da^{n-1}_{n-1}}=\frac{dD}{da^n_n}\,\frac{dD}{da^{n-1}_{n-1}}-\frac{dD}{da^{n-1}_n}\,\frac{dD}{da^{n-1}_n}.$$

We may show at once that D is a perfect square by putting, for example, $n=2$, thus:

$$D_2=\begin{vmatrix} 0 & a \\ -a & 0 \end{vmatrix}=a^2$$

If we include in the theorem all gauche determinants of a degree less than the even number n, it is also true of those of the degree n.

$\dfrac{d^2D}{da^n_n da^{n-1}_{n-1}}$ is a gauche determinant of the even degree $n-2$, and therefore a square.

Now $\dfrac{dD}{da^{n-1}_n} = -\dfrac{dD}{da^n_{n-1}}$; that is to say

$$\frac{dD}{da^{n-1}_n} = -\begin{vmatrix} 0 & -a^2_1 & \cdots & -a^{n-1}_1 \\ a^2_1 & \cdots & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & 0 \\ a^n_1 & & & a^{n-1}_n \end{vmatrix} =$$

$$-(-1)^{n-1}\begin{vmatrix} 0 & a^2_1 & \cdots & a^{n-1}_n \\ -a^2_1 & \cdots & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & 0 \\ -a^n_1 & \cdots & & -a^{n-1}_n \end{vmatrix} = \begin{vmatrix} 0 & -a^2_1 & \cdots & -a^n_1 \\ a^2_1 & \cdots & & \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ a^{n-1}_1 & \cdots & 0 & -a^n_{n-1} \end{vmatrix} = -\frac{dD}{da^n_{n-1}}$$

We therefore find that equation (1) becomes

$$D\frac{d^2D}{da^n_n da^{n-1}_{n-1}} = \left\{ \frac{dD}{da^{n-1}_n} \right\}^2$$

which clearly shows that D is the square of a rational function, Φ say, of its elements; the function Φ is an integral quantity, since the square of a rational function cannot be an integral quantity except as Φ itself is an integral.

III.

STATEMENT.—If u and v be eliminated from the equations

$$x = f_1(uv),\ y = f_2(uv),\ \text{and}\ z = f_3(uv),$$

we shall obtain another function that may be expressed thns: $F(xyz) = 0$.

The Problem then is to compute the numbers that are proportional to the derivatives of the first order of the function F(xyz).

Suppose that in the list of values of u and v which are now under consideration, $f_1(uv)$, $f_2(uv)$, and $f_3(uv)$, allow of partial derivatives with regard to u and v; and in the list of values of x, y, and z, which correspond to the values of u and v, F(xyz) also allows of the partial derivatives F'_x, F'_y, and F'_z.

The supposition just made being allowed, we shall then have

$$(1)\qquad F'_x \frac{df_1(u, v)}{du} + F'_y \frac{df_2(u, v)}{du} + F'_z \frac{df_3(u, v)}{du} = 0,$$

$$(2)\qquad F'_x \frac{df_1(u, v)}{dv} + F'_y \frac{df_2(u, v)}{dv} + F'_z \frac{df_3(u, v)}{dv} = 0.$$

These equations (1) and (2) show that F'_x, F'_y, F'_z are proportional to

$$\frac{D(f_2, f_3)}{D(u, v)}, \quad \frac{D(f_3, f_1)}{D(u, v)}, \quad \frac{D(f_1, f_2)}{D(u, v)},$$

abbreviating the work with the help of the notation of functional determinants. This supposes one of the three determinants to have some other value than zero; if one or two of them have a value of zero, the corresponding partial derivatives of F will be zero.

If they are all of the value of zero, these equations then become all alike; that is they reduce to but one equation, and they no longer determine F'_x, F'_y, and F'_z; but, whatever u and v may be, this can take place only when f_1, f_2, f_3 are connected by certain relations, by virtue of a known theorem under the head of functional determinants.

Dialect Word-List.—No. 2.

BY W. H. CARRUTH.

In response to the request for contributions in connection with the word-list in No. 2 of the QUARTERLY, several persons have sent me lists of new words or comments on those given. From the first class, given by Mr. C. S. Gleed, of Topeka, Kansas, Mr. Theo. S. Case, of Kansas City, Missouri, Mr. E. E. Soderstrom, of Osage county, and Mr. E. E. Slosson, of Laramie, Wyoming, together with additions of my own, this second list is made up.

The locality following an expression is simply the one from which it is reported, not its exclusive habitat. When none is given, the expression is from Kansas without earlier origin given. "B" marks words found in Bartlett's Dictionary of Americanisms.

The recent political campaign furnished several new words, and I believe they originated in Kansas: calamityite, calamity-howler and demopop.

Some of my correspondents, and many with whom I talk, try to make a distinction between dialect and slang. While the one has commonly been used in application to local variations from the standard usage, the other to class peculiarities, our more perfect means of communication have gone far toward breaking down these distinctions. In its constitution the American Dialect Society devotes itself to the study of "spoken English." Do not be afraid of slang. Make notes of any words and meanings not in standard dictionaries.

I wish to call attention of all interested to the publications of the American Dialect Society, E. S. Sheldon, Secretary, Cambridge, Mass.

act, doing the —— act: acting as or like ——, 'He is doing the enraged father act,' or 'He is doing the pious act.'

bat: a queer fellow, a night-worker.

beestings: artificially curdled milk. Is it ever *beeslings*, as given in former list?

begin with: compare with, as, 'He doesn't begin with Jones.' (N. Y.)

bid: invitation, as, a bid to the wedding.

big-bug: an aristocrat. B.

boom: a sudden and artificial prosperity, or activity in business.

boomer: a cultivator of 'booms'; second, one of a multitude prepared to rush upon government land about to be opened for settlement.

break: blunder, especially in 'a bad break.'

break: to soften (of water).

budge: liquor, as 'He was full of budge.'

bugger: fellow, as, a jolly bugger.

buzz: to converse tête à tête, as 'He buzzed me a straight hour.'

cahoots: collusion, partnership, as, to go cahoots. B. cahoot.

calamity-howler: opposition name for members and especially speakers of the People's Party, referring to their dwelling on the dark side of the economic and political situation. (Kansas.)

calamityites: opposition name for members of the People's party (Kansas).

case: dollar, as 'It cost me two cases.'

chump: a stupid fellow.

cinch: a tight hold, as 'I've got the cinch on him.'

clip ahead: to hurry along.

come up with: to get even with.

come-upence: deserts, as 'He got his come-upence.' (N. E.)

count ties: to walk on the railroad track.

cold: without apology or explanation, as, 'He gave it out cold that he was worth a million.'

cool: complete, unqualified, as, a cool thousand.

crank: a monomaniac, an enthusiast.

cuss-word: oath. Very common. B.

daisy: same as 'dandy.'

dandy (adj. and n.): anything approved, as a dandy book, game, hat, girl, run, etc.

demopops: opposition name for the united forces of the Democrats and People's Party. (Kansas.)

Dennis: failure, as 'His name is Dennis.'

Dick's hat-band, in as *odd* as Dick's hat-band. What other comparisons are made?

dive: a low resort.

divvy: to divide.

do up: to overcome, as 'He did me up.'

Dod-gasted: accursed, a mild form of God-blasted.

door-slammer: a railway conductor.

dope: paste; gravy; drug, and to drug, as 'He won the race by doping the other horse.'

draw: a shallow ravine.

drive: a venture, speculation, also a covert witticism, a 'hit.'

drive: go, in 'I let drive with both barrels,' i. e. fired.

drop: to lose in gambling or speculation.

dust: to whip, in, to dust one's jacket.

dust: to run, as 'Get up and dust.'

Ely: success, in 'My name is Ely.' Comp., Dennis.

fall down: to make a blunder, as 'He fell down badly.'

fizzle or **fizzle out**: to fail, to 'Peter out.'

flip: pert, as 'He's too flip for me.'

flub-dub: a snob, a pretender. (Boston.)

fly: alert and a little 'fast,' as, a fly young man.

flyer: a venture, as 'How's that for a flyer?' (on 'change) B.

gag: local hit, used by variety actors.

gas (v. and n.): unnecessary or insolent talk, as 'He's been gassing away all the evening.'

get away with: to overcome, and to get possession of, as 'He got away with me,' and 'They got away with his tin.'

gob: mouth, 'Hit him on the gob.'

gobble up: to snatch or appropriate greedily, as 'The back seats were soon gobbled up.'

go-devil: a kind of large rake used for drawing cocks of hay, several at a time, to the stack. It is pulled by two horses, each mounted by a boy; also, a work wagon used in street railway construction.

gone: empty, weak, as 'I had such a gone feeling.'

gone on: smitten with, as 'I'm gone on your neck-tie,' Comp., stuck on, mashed on.

gone Democratic: failed, gone against one, as 'The game went Democratic,' i. e. the other side won; or 'Things have been going Democratic all day.' (East Tennessee negroes.)

grouty: pouty, cross. B.

grub-stake (v. and n.): to furnish board or support to a worker, especially prospector, on condition of a share in the results.

guff: banter, 'Give me none of your guff.'

hair-pin: person, as 'That's the sort of a hair-pin I am.'

hand-me-down: ready-made, as, a hand-me-down suit of clothes.

heapy: very. (Indiana.)

herd book: a kind of local universal biography in which glory is meted out in proportion to the number of copies the subjects subscribe for.

high: a spree, as, 'He's off on a high.'

hold up: to rob, by physical force or by solicitation.

horning: a 'chivaree.'

hook up: to harness up.

hoodoo: a bringer of bad luck.

hoof it: to walk.

hot: wide-awake and, further, expressing general admiration, coupled with warning. 'A hot man' is about the same as a 'bad' man, though the former does not bluster.

hole, in 'in the hole': short on a speculation, as 'I'm in the hole,' i. e. I have lost, or 'How much are you in the hole?'

honest Injun: honestly, a common phrase of asseveration among boys. Comp., 'Hope to die' and 'Cross my heart.'

honey: anything well approved, see 'dandy'; also, the person sought, as 'you're my honey,' i. e. the one I am looking for.

horse-shed: to try to win over by personal appeal or bribery, as, 'I concluded to horse-shed the judge and try to get a pointer on his decision.'

hustle: rustle.

hustler: rustler.

into: in, as 'Is there any milk into that pail?'(N. J.)

jigger: a small glass of whiskey as dealt out to railroad hands.

jim-jams: delirium tremens. Comp., 'horrors,' and 'snakes.' B.

jo-dandy: intensified form of 'dandy,' q. v.

josh: to knock about, to 'bum.'

Jonah: a bringer of bad luck. Comp., hoodoo.

jug: to catch fish by a certain method. (Missouri.)

kid: a child.

lay-out: prospect, opening.

lickety-clip, v.: to go fast, as 'He lickety-clipped it.'

lickety-brindle: at headlong speed.

licking good: very good.

like: like to have, as, 'I'd like you to do this.'

lint one's jacket: to 'dust' one's jacket.

listen at: listen to.

lulu: same as 'daisy' and 'honey.' Is it *Loo-loo*, or *Lou-lou?*

mash: to make an impression on one's heart.

masher: a street-corner ogler and lady-killer.

Maverick: a waif, any unclaimed article. Maverick was a cattle-man who claimed as his brand no brand at all. Of course on the range many calves escaped branding, and at the 'round up' all un-branded calves were claimed as 'Maverick's.' A boy in Wyoming calls a book without the owner's name a maverick. Bartlett has not the 'straight' of the story of its origin.

Methodist Church West: No church. (Southern Kansas.)

moke: a clumsy, would-be 'fly' young man.

mud: failure, as 'His name is mud.'

mux: to mix, to confuse. B.

muxy: awry, mixed.

neighbor: to be neighborly, as, 'He doesn't neighbor with anybody.'

Nick-nailer: complete, approved, same as 'Dick-nailer' in first list.

out: on the debit side, as 'I am out a quarter,' i. e., I have lost, or it has cost me a quarter.

pants, in 'My name is pants': I have failed.

paralyze: to astonish, confound, out-do.

pick (onto or at): to tease, to talk overbearingly, as 'Pick onto one of your size;' 'He's always picking at me to sell out.'

plunk: dollar, as 'I drop ten plunks,' i. e., lose ten dollars.

pointer: a hint or clue.

poke: a small bag.

power: a great deal. (Missouri and Kansas.)

pull off: to remove one's wraps.

queer: to surprise, to make to go wrong; also reflexive, to put in a bad light, as 'He has queered himself,' i. e., gotten into bad odor.

ragged out: well dressed.

rally-kaboo: irregular, not according to the standard.

rattled: confused.

rats: expression of disgust or incredulity.

razee: to annoy raspingly.

razzle-dazzle: to delude, to confuse, to dupe.

redding-comb: a coarse comb. (Ohio.)

rig: a horse and carriage, as, a livery rig.

right smart: a great deal, also right smart chance, as, 'I have raised a power of corn, and have got right smart left.

right mind: senses, as 'Are you in your right mind?'

roll (them) **over**: to drive fast (of locomotives), as 'The engineer is rolling them over in great shape,' i. e., making good time.

rope: room, as 'Give him more rope.' 'Give that calf more rope,' (said to a noisy fellow).

ruction: a quarrel.

salt: to lay away as profit, to salt down.

savey, n. and v.: to understand, understanding (like French *savoir faire*), as 'He didn't seem to have any savey.' From Spanish *sabe*. Used chiefly at close of sentence or explanation, like 'See?' or 'Do you see?'

scald: preparation, as 'I didn't get a good scald on that speech.'

shack: to run after an errant ball. Also, the one who does this. Also, to shift for themselves. Used of cattle.

shake, v. and n.: to get rid of, and in, to give one the shake.
side-show: a matter of secondary importance.
side-track: to lay aside, to delay. (From railroad usage.)
skin full: very drunk.
slews } large quantities or numbers.
stacks }
slug: to strike viciously.
smouge: to steal. (Missouri.)
Socky: a Sac and Fox Indian, then, any Indian. (Osage Co., Kas.)
spec(k): speculation, also profit, as 'He made a neat speck in wheat.' B.
spondulics: money. (Ohio, Kansas.)
stand in with: to get, or keep on the right side of.
stogy: a sort of boot; also a kind of cigar.
strike: same as 'touch.'
stuffin': conceit, as 'He got the stuffin' knocked out of him.'
sugar: profit.
take and (do anything): proceed to, as 'I took and threw the book away.'
take up: begin school; tr. and intr.
taken: took. (Linn Co., Kas.)
tear: a spree, or a passion, as 'He's on one of his tears.'
that: so, as 'He's that sick he can't speak.'
tin-horn gambler: one who resorts to cheap devices and lacks courage.
tinker-tonker: a small boy.
touch: to solicit, or to swindle, as 'I touched him for ten.'
trade-lasts: an exchange of compliments (instead of 'trade-lash,' as formerly printed).
turn down: to pass above in the spelling-class; to lay on the shelf, as 'Mr. B. was turned down,' i. e., defeated in the election.
want: want to go, as 'He wants out,' 'I want in.'
whack: gear, as 'The clock is out of whack,' and also of persons.
whack up: to pay one's share, especially raise the stakes in 'poker.'
whack it up to one: to lay on heavy charges.
whang leather: coarse undressed leather used for cord.
whip-hand, to have the w. of any one: to have control of him. (New England.)
wic-i-up: wigwam. (Sac word now common among the whites in Osage Co., Kas.)
work: to dupe, as 'We worked him for a five,' 'He tried to work me.'
wrangle: to manage sheep or other stock. (Wyoming).
wrangler: a herd manager.

Maximum Bending Moments for Moving Loads in a Parabolic Arch-Rib Hinged at the Ends.

BY E. C. MURPHY.

As a moving load passes over a prismatic beam resting on supports at the ends the bending moment at every point of the beam changes as the load passes from point to point over the beam. It is zero at the supports or hinges and at no other points, and is a maximum at the center of the span when the concentrated load is at the center, or when the uniformly distributed load covers the whole span. The change in the bending moment at any point of the arch-rib we are considering as the load passes over it is very different from that of a simple beam: It is the object of this paper to bring out some of these differences.

We consider two cases: first, a concentrated load; and second, a uniformly distributed load.

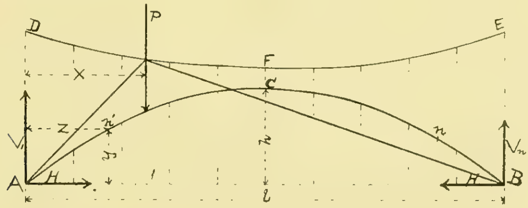


FIG. 1.

Let A C B, Fig. 1, represent a parabolic arch-rib hinged at the abutments; V_1 and V_n the vertical reactions and H the horizontal reaction at the ends; h the rise, l the span, z, y the coördinates of any point on the curve and x the distance of P, the concentrated load, from A.

The equation of this parabola referred to the point A as origin and axes x and y, as shown in Fig. 1, is $y = \frac{4h}{l^2}(zl - z^2)$.

Taking moments about A, considering the whole rib as a free body, we find $V_n=\frac{Px}{l}$. From Σ (vertical components)=o we find $V_n=P\left\{1-\frac{x}{l}\right\}$.

These vertical reactions are independent of the shape of the rib as they do not involve z or y and are the same as for a straight beam.

Making a section at any point n to the right of the load, considering the left portion of the rib as a free body and denoting the moment by M_r, we have

$$M_r=V_1 z-P(z-x)-Hy.$$

Substituting for V_1 and y their values in this equation we have

$$M_r=Px\left\{1-\frac{z}{l}\right\}-\frac{4h}{l^2}(zl-z^2)H\ldots\ldots(1)$$

Making a section at any point to the left of the load and denoting the moment by M_l, we have

$$M_l=V_1 z-Hy=P\left\{\frac{l-x}{l}\right\}z-\frac{4h}{l^2}(zl-z^2)H\ldots\ldots(2)$$

In equations (1) and (2) H is a function of P and x but not of y or z. To find its value we make use of the equation of the "x displacement," viz., $\triangle x=\frac{1}{EI}\int Myds$, ds being the increment of arc, E the modulus of elasticity and I the moment of inertia. Since this displacement is zero we have the equation $\int Myds=0$ from which to find value of H.

If the rib is quite flat we may use dz in place of ds. Making this assumption, substituting for M and y their values, and integrating between limits x and o on the left of the load, and l and x on the right of the load we have

$$\int_0^x M_l ydz+\int_x^l M_r ydz=P\left\{\frac{l-x}{l}\right\}\int_0^x(lz^2-z^3)dz-\frac{4hH}{l^2}\int_0^x(lz-z^2)^2 dz+P\left\{\frac{l-x}{l}\right\}\int_x^l(lz^2-z^3)dz-P\int_x^l(z-x)(zl-z^2)dz-\frac{4hH}{l^2}\int_x^l(lz-z^2)^2dz=0.$$

Integrating and simplifying this equation we have

$$\frac{Px^3}{12}(x-2l)+\frac{1}{12}Pxl^3-\frac{4hHl^3}{30}=0\ldots\ldots\ldots(3)$$

Solving (3) we have

$$H=5/8\,\frac{Px}{h}\left\{\left[\frac{x}{l}\right]^3-2\left[\frac{x}{l}\right]^2+1\right\}=5/8\frac{Px}{h}k\ \ldots\ldots\ldots(4)$$

Table I gives values of k for values of $\frac{x}{l}$.

TABLE I.

$\frac{x}{l}$	.01	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
k	.999	.980	.928	.847	.744	.625	.496	.363	.232	.109	0.0

Substituting for H its value in (1) and (2) we have

$$M_r = Px\left\{1-\frac{z}{l}\right\} - \frac{5Px}{2l^2}(zl-z^2)k \ldots\ldots (5)$$

$$M_l = P\left\{\frac{l-x}{l}\right\}z - \frac{5Px}{2l^2}(zl-z^2)k \ldots\ldots (6)$$

Differentiating H with respect to x to find the position of the load when H is a maximum, we have

$$\frac{dH}{dx} = \frac{5}{8}\frac{P}{h}\left\{4\left[\frac{x}{l}\right]^3 - 6\left[\frac{x}{l}\right]^2 + 1\right\} = 0 \ldots\ldots (7)$$

solving (7) we have $\frac{x}{l} = \frac{1}{2}$ and $\frac{1}{2} \pm \frac{1}{2}\sqrt{3}$. The first of these roots is the only one which satisfies the conditions of the problem and since it makes the second derivative of H with respect to x in (7) negative it corresponds to a maximum value of H. H is a maximum then, when the load is at the middle of the span.

Equation (1) can be put in the form

$$M_r = \frac{5}{8}\frac{Px}{h}k\left[\frac{1-\dfrac{z}{l}}{\dfrac{5}{8}\dfrac{k}{h}} - y\right] = H\left[\frac{8h}{5k}\left\{1-\frac{z}{l}\right\} - y\right] \ldots\ldots (8)$$

The second factor in (8) is the distance from the moment curve to the rib and the first term of this second factor is the distance from the axis of x to the moment curve. This term being of the first degree in z the moment curve on the right of the load, for any position of the load is a straight line.

In the same way (2) can be put in the form

$M_l = H\left\{\frac{8h(l-x)}{5lk}z - y\right\}$ which shows that the moment curve on the left, for any position of the load, is a straight line passing through the origin.

To find the locus of the intersection of these two moment curves: Let the ordinate of the moment curve be denoted by u, then

$u_l = \frac{M_l}{H_l} = \frac{8h}{5lk}(l-x)$, and $u_r = \frac{M_r}{H_r} = \frac{8h}{5k}\left\{1-\frac{z}{l}\right\}$. These two ordinates are equal, and either is the ordinate of the locus when $z=x$. Hence if u' denote the ordinate of the locus we have

$$2u'=\frac{8h}{5lk}(2l-2x) \text{ and } u'=\frac{8hl^2}{5(l^2+lx-x^2)} \quad \ldots\ldots (9)$$

We notice that this equation is not a function of P but is a function of h and l. The shape of the locus depends on the shape of the rib and not at all on the loading.

The curve D F E, Fig. 1, shows this locus for the rib whose rise is 10 feet and span 50 feet.

The moment at any point of the rib can be easily found when this locus is constructed. For, if at the point where the load P, represented as in Fig. 1, cuts the locus lines be drawn to the hinges they form two segments of the special equilibrium polygon for this position of the load. If through the extremities of P, drawn to scale, lines be drawn parallel to these two segments and from their intersection a perpendicular be dropped on P, this line represents H on the same scale that P is drawn. Then the moment under the load is H multiplied by the distance between the locus and the rib measured on P, and the moment at any other point of the rib equals H multiplied by the vertical distance from the point to the equilibrium polygon.

From $M_r=0=\frac{Px}{l}\left\{l-z\right\}\left\{1-\frac{5z}{2l}k\right\}$ we have

$$z=l \text{ and } z=\frac{2l}{5k}.$$

The value $z=l$ is independent of x, that is, the moment at the right hinge is zero for all values of x. The other value of z is a function of x which approaches $\frac{2}{5}l$ as its limit as x approaches zero and equals l when $\frac{x}{l}=.67$ approx. Hence this second point of zero moment on the right of P moves from $\frac{2}{5}l$ to l, while P moves from $x=0$ to $x=.67l$.

From $M_l=0=z\left\{P\left[\frac{l-x}{l}\right]-\frac{5Px}{2l^2}k(l-z)\right\}$ we have

$$z=0 \text{ and } z=l\left\{1-\frac{2}{5}\frac{l-x}{xk}\right\}.$$

From $z=0$ we see that the moment is zero at the left hinge for all values of x. The other value of z is negative while x varies from 0 to $.34l$ [found from $1-\frac{2}{5}\frac{l-x}{xk}=0$] and it moves from 0 to l while x varies from $.34l$ to l.

This value of z can be put in the form

$$z=\tfrac{2}{5}\frac{l}{k}+l\left\{1-\tfrac{2}{5}\left[\frac{l}{x}\right]\frac{1}{k}\right\}\ldots\ldots(10)$$

The first term in the second member of (10) is the distance to the point of zero moment on the right of P, hence, the second term in the second member of (10) is the horizontal distance between the variable points of zero moment.

The maximum moment may occur under the load or on either side of the center when the load is on the other side. The moment under the load may be found from $M_x=(u-y)H$, or from M_l or M_r by putting $z=x$. From the latter we have

$$M_x=Px\left\{1-\frac{x}{l}\right\}-\tfrac{5}{2}\frac{Px}{l^2}(xl-x^2)k\ldots\ldots(11)$$

$$\frac{dM_x}{dx}=\frac{P}{l}\left\{l-2x\right\}\left\{1-\frac{5x}{2l}k\right\}+\frac{P}{l}\left\{lx-x^2\right\}\left\{-\frac{5}{2l}\left[4\left[\frac{x}{l}\right]^3\right.\right.$$
$$\left.\left.-6\left[\frac{x}{l}\right]^2+1\right]\right\}=0\ldots\ldots(12)$$

Simplifying (12 we have

$$30\left\{\frac{x}{l}\right\}^5-75\left\{\frac{x}{l}\right\}^4+40\left\{\frac{x}{l}\right\}^3+15\left\{\frac{x}{l}\right\}^2-14\left\{\frac{x}{l}\right\}+2=0$$
$$\ldots\ldots(13)$$

One root of (13), found by trial is $\frac{x}{l}=.22+$. This root makes the second derivative of (13) negative and makes M_x a maximum. Substituting this value of $\frac{x}{l}$ in (11) we have

$$(M_x)max=.086Pl\ldots\ldots(14)$$

Differentiating (5) with respect to x to find for what position of the load the moment of the load is a maximum we have

$$\frac{dM_r}{dx}=P\left\{1-\frac{z}{l}\right\}-\tfrac{5}{2}P\left\{\frac{lz-z^2}{l^2}\right\}\left\{4\left[\frac{x}{l}\right]^3-6\left[\frac{x}{l}\right]^2+1\right\}$$
$$=0\ldots\ldots(15)$$

From (15) we find

$$z=\frac{2l}{4\left[\frac{x}{l}\right]^3-6\left[\frac{x}{l}\right]^2+1}\ldots\ldots(16)$$

Differentiating (5) with respect to z we have

$$\frac{dM_r}{dz}=-\frac{1}{l}-\frac{5k}{2l^2}(l-2z)=0$$

Solving this equation we find

$$z=\frac{l}{2}\left\{1+\frac{2}{5k}\right\}\ldots\ldots(17)$$

Placing the value of z in (16) eqnal to that in (17) and simplifying we have

$$20\left\{\frac{x}{l}\right\}^6-70\left\{\frac{x}{l}\right\}^5+60\left\{\frac{x}{l}\right\}^4+29\left\{\frac{x}{l}\right\}^3-44\left\{\frac{x}{l}\right\}^2+3$$
$$=0\ldots\ldots(18)$$

One root of (18) is $\frac{x}{l}=.316$. Substituting this value of $\frac{x}{l}$ in (17) we have $z=.724l$

Substituting these values of x and z in (5) we have

$$(M_r)max=-.044Pl\ldots\ldots(19)$$

Hence the maximum moment occurs under the load; is positive, and equals .086Pl.

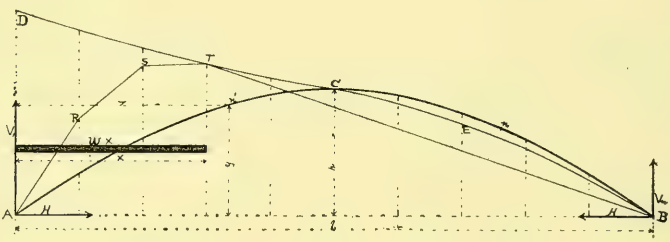


FIG. II.

CASE II. The moving load uniformly distributed per horizontal foot.

Let the notation be as in case one as far as applicable with w equal to the intensity of loading and x the portion of the span covered with the load, measured from A.

Proceeding as in case one we find that

$$V_n=\frac{wx^2}{2l}\text{ and }V_1=wx\left\{1-\frac{x}{2l}\right\},$$

both of which are independent of the shape of the rib.

The moment about any point of the rib to the right of the load is

$$M_r=V_1z-\left\{z-\frac{x}{2}\right\}wx-Hy\ldots\ldots(20)$$

The moment about any point of the rib under the load is

$$M_l=V_1z-w\frac{z^2}{2}-Hy\ldots\ldots(21)$$

From the equation of the "x displacement we have

$$\int_0^x M_l y dz + \int_x^l M_r y dz = 0 \ldots\ldots (22)$$

Substituting for M_l and M_r their values and simplifying we have

$$-\frac{w}{2}\int_0^x z^2 y dz + V_1 \int_0^l zydz - wx \int_x^l \left\{ z - \frac{x}{2} \right\} ydz - H \int_0^l y^2 dz = 0$$

$$\ldots\ldots (23)$$

Substituting for y its value in (23), integrating and simplifying we have

$$\frac{wx^2 l^3}{24} - \frac{wx^4 l}{24} + \frac{wx^5}{60} = \tfrac{2}{15} hHl^3 \ldots\ldots (24)$$

From (24) we find

$$H = \frac{wx^2}{16h}\left\{ 2\left[\frac{x}{l}\right]^3 - 5\left[\frac{x}{l}\right]^2 + 5 \right\} = \frac{wx^2}{16h}k' \ldots\ldots (25)$$

Table II gives values of k′ for values of $\frac{x}{l}$.

TABLE II.

$\frac{x}{l}$	.01	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
k′	4.999	4.952	4.816	4.601	4.328	4.000	3.632	3 236	2.824	2.408	2.000

Substituting for V_1 and H their values in (20) and (21) we have

$$M_r = \frac{wx^2}{2}\left\{ 1 - \frac{z}{l} \right\} - Hy = \frac{wx^2}{2}\left\{ 1 - \frac{z}{l} \right\} - \frac{wx^2}{4l^2}k'(zl - z^2)$$

$$\ldots\ldots (26)$$

$$M_l = \left\{ wx - \frac{wx^2}{2l} \right\} z - w\frac{z^2}{2} - Hy = \left\{ wx - w\frac{x^2}{2l} \right\} z - w\frac{z^2}{2} - \frac{wx^2}{4l^2}$$
$k'(zl - z^2) \ldots\ldots (27)$

Differentiating H with respect to x to find the position of the load when H is a maximum we have

$$\frac{dH}{dx} = 10\frac{x^4}{l^3} - 20\frac{x^3}{l^2} + 10x = 0 \ldots\ldots (28)$$

From (28) we find $x = 0$, $x = l$ and $x = \frac{1}{2} \pm \frac{1}{2}\sqrt{5}$.

The second of these, viz., $x = l$ satisfies the conditions of the problem and makes the second derivative of H negative; hence, H is a maximum when the load covers the whole span.

Equation (26) can be put in the form

$$M_r = \frac{wx^2 k'}{16h}\left\{ \frac{8h}{k'}\left[1 - \frac{z}{l} \right] - y \right\} = H\left\{ \frac{8h}{k'}\left[1 - \frac{z}{l} \right] - y \right\}$$

$$\ldots\ldots (29)$$

The first term of the second factor of (29) is the ordinate of the moment curve on the right of the load, and since it is of the first degree in z we see that the moment curve on the right for any position of the loading is a straight line.

Equation (27) can be put in the form

$$M_l - \frac{wx^2k'}{16h}\left\{\frac{16h}{wx^2k'}\left[\left\{wx - \frac{wx^2}{2l}\right\}z - \frac{wz^2}{2}\right] - y\right\} = H\left\{\frac{16h}{wx^2k'}\left[\left\{wx - \frac{wx^2}{2l}\right\}z - \frac{wz^2}{2}\right] - y\right\} \ldots\ldots (30)$$

From (30) we see that the moment curve under the load is a parabola whose equation is

$$y' = \frac{16h}{wx^2k'}\left\{wx - \frac{wx^2}{2l}\right\}z - \frac{16h}{2x^2k'}z^2 \ldots\ldots (31)$$

For $x=15$ feet, $h=10$ feet and $l=50$ feet, (31) reduces to

$$y' = 1.97z - .077z^2 \ldots\ldots (32)$$

The curve A R S T, Fig. 2., represents equation (32).

Substituting l for x in (32) we have

$$y' = \frac{4h}{l^2}(zl - z^2)$$

that is, the moment curve under the loading coincides with the rib when the load covers the whole span and, hence, the moment at every point of the rib is zero for this case.

To find the locus of the point of intersection of the two moment curves: Let u denote the ordinate of any point on the locus. Then

$$u = \frac{M_x}{H_x} = \frac{\frac{wx^2}{2}\left\{1 - \frac{x}{l}\right\}}{\frac{wx^3k'}{16h}} = \frac{16h}{lk'}(l-x)$$

$$u = \frac{16h\left\{1 - \frac{x}{l}\right\}}{2\left\{\frac{x}{l}\right\}^3 - 5\left\{\frac{x}{l}\right\}^2 + 5} \ldots\ldots (33)$$

We see from (33) that the shape of the locus is independent of the magnitude of w.

The curve D T C E B, Fig. 2, represents this locus for $h=10$ feet and $l=50$ feet.

Putting $M_r=0$ in (26) we have

$$\frac{wx^2}{2}\left\{1 - \frac{z}{l}\right\} - \frac{wx^2}{4l^2}k'(zl - z^2) = 0 \ldots\ldots (34)$$

Solving (34) for z we have $z=o$ and $z=\frac{2l}{k'}$.

The value $z=o$ shows that the moment at the right hinge is zero for all value of x. The second value of z is a function of x whose limits from Table II are $\frac{2}{5}l$ when $x=o$, and $\frac{l}{2}$ when $x=\frac{l}{2}$. As $\frac{x}{l}$ varies from $\frac{l}{2}$ to l there is only one point of zero moment on the right, viz., the hinge. Hence this second point of zero moment on the right moves from $\frac{2}{5}l$ to $\frac{1}{2}l$ as x increases from zero to $\frac{l}{2}$.

From $M_l=o$ in (27) we have

$$z\left\{wx-\frac{wx^2}{4l}(2+k')\right\}-\frac{w}{4}\left\{2-\frac{x^2k'}{l^2}\right\}z=o \ldots\ldots (35)$$

Solving (35) we have

$$z=o \text{ and } z=\frac{4x\left\{1-\frac{x}{4l}(2+k')\right\}}{2-\left\{\frac{x}{l}\right\}^2k'} \ldots\ldots (35)'$$

The value $z=o$ shows that the moment is zero at the left hinge for all values of x. The second value of z can be put in the form

$$\frac{z}{l}=\frac{x}{l}\left\{\frac{4-\frac{x}{l}(2+k')}{2-\left\{\frac{x}{l}\right\}^2k'}\right\}$$

and from Table II we find that the ratio $\frac{z}{l}$ is greater than the ratio $\frac{x}{l}$ until $\frac{x}{l}=\frac{1}{2}$, that is, this point of zero moment is not under the load until x becomes equal to $\frac{l}{2}$. As x varies from $\frac{l}{2}$ to l this point moves from $\frac{l}{2}$ to $\frac{3}{5}l$. That is, this movable point of zero moment moves from $\frac{2}{5}l$ to $\frac{3}{5}l$ while x varies from o to l.

The maximum moment may be under the load or to the right of the load.

To find the maximum moment on the right of the load we have

$$M_r=\frac{wx^2}{2}\left\{1-\frac{z}{l}\right\}-w\frac{x^2}{4l^2}k'(zl-z^2)$$

$$\frac{dM_r}{dz}=-\frac{wx^2}{2l}-\frac{wx^2}{4l^2}k'(l-2z)$$

$$z=\frac{l}{2}\left\{1+\frac{2}{k'}\right\} \ldots\ldots (36)$$

Also $\dfrac{dM_r}{dx}=\dfrac{(l-z)}{2l}w\left\{2x-\dfrac{2xk'z}{2l}-\dfrac{x^2z}{2l}\left[6\dfrac{x^2}{l^3}-10\dfrac{x}{l^2}\right]\right\}$

$$z=\frac{2l}{5\left\{\left[\dfrac{x}{l}\right]^3-2\left[\dfrac{x}{l}\right]^2+1\right\}}=\frac{2}{5}\frac{l}{k}\ldots\ldots(37)$$

Equating the values of z in (36) and (37) and simplifying we have

$$10\left[\frac{x}{l}\right]^6-45\left[\frac{x}{l}\right]^5+50\left[\frac{x}{l}\right]^4+37\left[\frac{x}{l}\right]^3-75\left[\frac{x}{l}\right]^2+15=0\ldots\ldots(38)$$

One root of (38) is $\dfrac{x}{l}=.58+$ and it makes M_r a maximum.

Substituting this value of $\dfrac{x}{l}$ in (36) we have

$$z=.766l$$

Substituting for x and z their values in (26) we have

$$(M_r)\max=-.0165wl^2\ldots\ldots(39)$$

To find the maximum moment under the load we have

$$M_l=\left\{wx-\frac{wx^2}{2l}\right\}z-\frac{wz^2}{2}-\frac{wx^2}{4l}k'z+\frac{wx^2}{4l^2}z^2$$

$$\frac{dM_l}{dz}=wx-\frac{wx^2}{2l}\left\{1+\frac{k'}{2}\right\}-\frac{w}{2}\left\{1-\frac{x^2}{2l^2}k'\right\}z=0$$

$$z=\frac{x\left\{2-\dfrac{x}{l}\left[1+\dfrac{k'}{2}\right]\right\}}{1-\dfrac{x^2}{2l^2}k'}\ldots\ldots(40)$$

This value of z in (40) is the same as that in (35)' and hence gives minimum values of z instead of maximum values.

If in (27) we substitute for x and z values in terms of l it reduces to the form

$$M_l=Cwl^2\ldots\ldots(41)$$

In (41) C is a constant for given values of x and z.

Table III gives values of C in (41) for values of $\dfrac{x}{l}$ and $\dfrac{z}{l}$.

TABLE III.

$\frac{z}{l}$	$\frac{x}{l}=.1$	$\frac{x}{l}=.2$	$\frac{x}{l}=.3$	$\frac{x}{l}=.4$	$\frac{x}{l}=.5$	$\frac{x}{l}=.6$	$\frac{x}{l}=.7$	$\frac{x}{l}=.8$	$\frac{x}{l}=.9$
0	0	0	0	0	0	0	0	0	0
.1	.0034	.0087	.0112	.0110	.0100	.0076	.0045	.0023	.0008
.2		.0083	.0144	.0163	.0150	.0117	.0075	.0037	.0012
.3			.0098	.0146	.0150	.0124	.0082	.0041	.0014
.4				.0064	.0100	.0096	.0067	.0036	.0014
.5					.0000	.0033	.0013	.0020	.0010
.6						−.0064	−.0023	−.0005	.0004
.7							−.0099	−.0039	−.0004
.8								−.0083	−.0018
.9									−.0032

From Table III it is easily seen that M_l is a maximum for a value of $\frac{x}{l}$ greater than .4 and less than .5, or approximately .43, and $\frac{z}{l}=$ approximately .23. For these values

$$(M_l)\max = .0165wl^2 \quad \ldots\ldots (42)$$

Comparing $(M_r)\max$ with $(M_l)\max$ we see that they are equal with opposite signs.

Comparing the maximum moment produced by a concentrated moving load (.086Pl) with the maximum moment produced by an equal, uniformly distributed, moving load ($.0165wl^2$) we see that the former is about 5.2 times greater than the latter, or the maximum moments wilt be equal in these two cases if $wl=5.2P$.

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PENOLOGY IN KANSAS.

BY F. W. BLACKMAR.

The Kansas State Penitentiary at Lansing has been noted as one of the best prisons in the far west. And indeed in some particular features it is quite remarkable. Among its especially good qualities, as compared with other prisons of similar nature, are its financial and economic management and its thorough discipline. Its financial management shows it to be practically a self-supporting institution. The institution has been fortunate in securing good management and in the utilization of the labor of the prisoners, by means of the contract system of labor, as well as in performing nearly all of the work in connection with repairs, improvements, etc. But especially has it been fortunate in its location immediately above a rich vein of coal, so that a shaft could be sunk within the prison walls for the working of the mine. (See figure 4.)

The mine has thus been made to yield a handsome income for the benefit of the State. The running expenses of the penitentiary for the biennial period of 1891 and 1892 were $297,409.47, while the receipts from contract labor, coal sales and other sources were $215,190.35. Thus making an expenditure over and above cash receipts of $81,-939.94. But if it be considered, as it ought to be, that coal to the value of $4,420.78 was furnished the western sufferers, and that coal to the value of $42,533.68 was furnished to State institutions by the prison management, and also that $50,106.46 were spent in permanent improvement,* it will be seen that the income of the prison has exceeded its current expenses by a margin of over $5,000 for the biennium of 1891 and '92. The total income from the coal mines for two years was $168,993.57 and the total income from contract labor in

* Eighth Biennial Report of Kansas State Penitentiary, p. 7.

the same period was $78,225.80. This is a remarkable showing for a prison containing on an average about 900 prisoners of all grades and classes.

A close inspection of the prison management will convince one that a strictly military discipline prevails within the prison.* It is a busy place at the penitentiary. All able-bodied men not undergoing special punishment are employed. It is not a place for idlers, for the law permits and requires service. The management of the different industries, the hospital, the library, the insane department, the kitchen and dining room all show care and system. So, also, for cell-ventilation and other forms of sanitation there is great care exercised by those in authority. While it is well to acknowledge the excellent management of the prison during the past, it is also pertinent to consider what progress may be made in the future. As there has been such great advancement in prison science in the past twenty years, it may be well to measure the Kansas penological system by ideal systems, as well as by the foremost practice in the best regulated prisons in Europe and America, to ascertain in what especial lines Kansas needs to develop her penological system.

No doubt it is highly gratifying to the tax-payers of Kansas that the institution is on a self-supporting basis. Especially is this to be approved in a new state where so much must be done in a short time; where schools, churches, hospitals, asylums, and penal institutions must be built and maintained by the people almost before they have made themselves comfortable in a new country. These must be provided for, while railroads, roads, bridges and court houses must be built and the native resources be made productive for the support of all.

But admitting all this, the management of prisons must consider reform as the ultimate service to be performed in all penal institutions. The new prison law of New York has admitted that reform is the ultimate end of all confinement. But it views reformation as the only radical means of protection to society. Reformation consists in "the reasonable probability that the prisoner will live and remain at liberty without violating the law."† In this the law rests on the political basis of protecting society rather than upon the moral basis of converting and improving the qualities of the individual for his own sake. Much progress has been made in the past fifty years in the treatment of prisoners respecting discipline and reform. Indeed, an

* The writer is much indebted to the present Warden, Hon. Geo. H. Case, and to his able assistants for their courtesy in showing him the working details of the prison.

† Quoted from Prison Science, by Eugene Smith, p. 7.

entirely new light has been thrown upon the subject of penology. A careful inquiry has been made into the question of what men are confined for, how they are to be managed while under confinement, and what is to be done with them after confinement. Although the fundamental principles of penology are quite well established concerning the object and nature of discipline, yet there are many questions of detail respecting the methods to be pursued in carrying out these principles of punitive and reformatory measures. In other words, the practical application of theory, in spite of all the progress that has been made, leaves serious difficulties to be met and mastered. It is generally considered by all right-thinking persons versed in prison science that the following objects of confinement are essential in every case: First, the protection of society; second, punishment of the offender; third, prevention of crime; and fourth, reform of criminals. Doubtless no theory of prison discipline may be considered complete which lacks any one of these four great fundamental principles. Yet it is true that we shall find, even at this day, one, two, and even three of these four fundamental principles violated in the practice of the imprisonment of our fellow beings. The practice of hurrying one, who does commit a crime, away from the sight and contact of his fellow beings, is indicative of a universal sentiment in modern society. Society demands at least this protection, and its request and privilege should never be denied in this respect. But the old idea of punishment for revenge has nearly died out of modern penalties of the law. There was a time when, coupled with the desire to shut one away from society, doubtless for its own protection, was a desire to take revenge upon the individual who had outraged society. Sometimes a desire for revenge precipitated an immediate punishment regardless of law and order. Sometimes it was studiously and systematically cruel in all its plans for punishment as well as in their execution. But in a large measure this has been eradicated from the spirit of our laws and institutions. We see some evidence of it in our modern process of lynching when anger and revenge seize upon people with such force as to cause them to lynch the lawbreaker in a most cruel manner. So also in respect to individuals who have committed great crimes, when the whole community seem so desirous of revenge that they have thrown their whole support into the prosecution of the offender. But these are exceptional cases. The spirit of punishment in modern times is that which looks calmly on the act of the law-breaker as an injustice to society for which he must pay the penalty. In other words, a man is imprisoned for life or hung, not because society desires to wreak upon him vengeance on account of the crime which he has committed, but because society demands protection, and that he must be punished on account of the demand to uphold the dignity and power of the law, for law without a penalty has little force to the evil doer.

Again, in regard to the prevention of crime. One of the chief objects of penal servitude is to set an example before other evil-disposed persons of what the consequences must be if they in turn violate the law. But in each of these cases it is to make the commitment of crime less frequent that men are imprisoned, rather than that they should suffer for their sins. But, finally, in the last case the reform of criminals within or without the prison walls has become one of the prime principles of penology. No present system or theory can be complete in these days that does not consider in some manner the methods of bringing back into legitimate society those who by their deeds have become outcasts from the body politic. In the study of sociology there are two sides of social life to be considered: First, there is what might be called legitimate society, which has sprung up from indefinite and simple beginnings, but has grown into a strong organism, which might be called the proper status of social life; and then there is the other side of humanity which may be termed the broken down, decrepit or fragmentary part of the great social body, which may be called disorganized society. It is as much the duty of the reformer to study the organized and legitimate society as it is to study the disorganized or the fragmentary. In modern times there have been a great many who call themselves social scientists, who devote a great deal of time to the criminal and the pauper, and properly so, for, indeed, it is from these broken down parts of humanity that we realize more especially the nature of human society, and discern more clearly the means of preventing crime; but the ideal or legitimate society must not be lost sight of. We must keep before our eyes the proper laws, proper government and proper protection of organized society while we investigate the habits, conditions and qualities of its outcasts. Hence in all modern reforms there are two subjects to consider: A reform measure which shall by direct application tend to develop and strengthen that which is already considered good and, on the other hand, a reform measure which shall reclaim and reform that which is considered bad. In this respect the state prison and the state university are not so far apart as it would seem: one tending to build up and strengthen legitimate society, to protect the state in all its interests, to make law more prominent, reform more stable, human society more moral and intellectual, crime less frequent and industry more prevalent by well ordered education. These are the objects of the state university. While, on the other hand, in accordance with the last one of the penological principles stated, the prison has for its duty the same objects as the university, although applied to a class of individuals entirely different, who overstep the bounds of the law and by their own habits have abstracted themselves from legitimate society. Both institutions exist for the improvement of society and neither is instituted for the purpose of revenge.

While we have carried on the work of reform of prisoners to a considerable extent and while many seem to be carried away with it as the only great method of solving the evils of the day, we must not forget that the great institutions which tend to develop society on the basis of prevention of crime are not the only ones which are important to consider. And this arises from the very fact of reform, that if we allow either crime or pauperism to develop rapidly, unchecked, we shall soon find it such a burden on human society that the legitimate and well organized will become defective on account of the increase in the number of paupers and criminals who form a constant menace to civil institutions. While all sentiments for reform arise primarily from human sympathy with the weak and the erring, the state still rests the cause of its action in the full and complete protection of legitimate society. It matters not how individual sympathies act, the reformation of criminals finds its cause to be in the common weal of society. To make a prisoner more intellectual, to give him better moral qualities, to prepare him for better industrial independence, to send him out with a better life and means, if he wills, to support himself, to adopt means to help him from the prison world in which he has lived into a greater world outside: all this might arise out of benevolence, but it has for its ultimate end the simple protection and improvement of society as a whole. Consequently reform has become the sole great object in detaining criminals within prison walls. All other objects must be considered as means to this one great end.

In the discussion of penological principles one of the foremost methods of reform to be noticed is that of the classification of all criminals. Perhaps Belgium was the foremost state of Europe to adopt a thoroughly practical classification of prisoners. Formerly it was considered sufficient to have a large prison pen, a foul den into which old and young, light offenders and heavy villains were thrust, taking them out only occasionally for service or keeping them without service at all. Here the old criminals, hardened through many years of repeated crimes, would rehearse their stories to the young who were soon educated in all of the tricks of the trade. Here in these horrid dens the propensities for crime were increased rather than diminished, and plots and plans were made for future depredations upon society.

Within a comparatively recent period most nations have endeavored to properly classify prisoners. First a general classification, separating the old from the young, the hardened criminals from the novices. The modern tendency is to institute reform schools and work houses for juveniles, reformatories for youth, and regular prisons for hardened criminals. But in the highest ideal of prison science each one of these is to be a reformatory of a different class. Kansas has determined upon this classification. The Reform School at Topeka, the Reformatory at Hutchinson and the State Penitentiary at Lansing represent this three-fold classification. The reformatory at Hutchinson has not been completed. Its methods are to be patterned after the reformatory at Elmira, N. Y., the model institution of its class in America. The chief difficulty in the establishment of such an institution in Kansas is its great expense. It is a great undertaking for a young state like Kansas to compete with an old wealthy state like New York. Yet the Kansas reformatory may take all the essential features of the Elmira reformatory and by obtaining rather more service from its inmates may be made less expensive. It will be trying to Kansas taxpayers to provide such an industial school for the criminals of the state as that at Elmira, while it is only by dint of close saving that they are able to give as good an education to their own sons and daughters who have never offended against the state. Yet it must be remembered that this is done for the benefit of the whole state, for the purpose of lessening crime and expense. The reformatory at Hutchinson should be completed as soon as possible as there is a great need for it that the prisoners at Lansing may be properly classified and a certain group of those most susceptible of reform should be sent there.

Within the prison walls classification of individual prisoners according to crimes, temperament and habits has been of great assistance in their management. In the United States there are two main systems in vogue, that known as the Pennsylvania System and that as the New York System. The former may be defined as the solitary cellular system, and the latter as the single cell system, with prisoners working and dining together. The Pennsylvania system had its origin in the celebrated Cherry Hill prison, built in 1821 to 1829, containing over 600 separate cells for continuous solitary confinement. This solitary confinement in large airy rooms is expensive but is considered as the best treatment of prisoners. Here the prisoner is kept at work, or instructed in trades or books. Work becomes a necessity to him.

The only punishment is a dark cell with deprivation of work for a period.

The New York system is as has been practiced at Auburn, by which the prisoners are confined in solitary cells during the night, but have companionship during the day while at work, and at the dinner table. Each system has warm advocates. The solitary cell system has had most practice in Europe but the American plan has made up the lack of proper classification by the excessive work of prisoners.

Many persons hold that classification of prisoners in groups is a failure, and that the solitary cellular system is the only commendable method. Edward Livingston has thus set forth the advantages of this system:

"Every association of convicts that can be formed will, in a greater or less degree, corrupt, but will never reform those of which it is composed, and we are brought to the irresistible conclusion that classification once admitted to be useful, it is so in an inverse proportion to the numbers of which each class is composed. But it is not perfect until we come to the plan at which it loses its name and nature in the complete separation of individuals. We come then to the conclusion that each convict is to be separated from his fellows."*

The extent of isolation which each prisoner undergoes must be determined somewhat by the nature of his case and somewhat by the conditions and convenience of the prison. It is hardly possible for many modern prisons to have complete separation on account of the expense incurred, for this would mean that within the cell itself the prisoner must perform all labor, and that the cell shall be commodious enough to carry on this labor by himself, or else that he be given labor elsewhere alone. Such a system requires an increased amount of attendance.

At the Kansas penitentiary the system of solitary cell confinement at night and when off duty, and the silent associations of prisoners in groups during the day while at work and at meals, is now in vogue. Without doubt this association during the day carries with it evil influences which are in a measure lessened by the requirements of the law for ten hours of labor for all able-bodied prisoners.

Whatever system of classification is adopted the reform idea must be faithfully considered. There should be an ample opportunity for study and for work, that both physical and intellectual powers may receive development. It has been proved by long continued observation that the typical criminal is weak in body and in mind. He may have intellectual cunning developed to a considerable degree, and

* Tallack, Penological and Preventive Principles, p. 118.

may be capable of great physical efforts for spasmodic periods, but he is not a well developed being either physically or mentally.† Hence his reform must frequently begin with physical discipline and this followed by mental training, or the two must be carried on together. In the Kansas penitentiary the law requires prisoners to work ten hours at labor. Consequently they have left, for study and general improvement, their evenings and Sundays. There is a school on Sunday for all who wish to attend. This is a very meagre showing for any systematic training with a view to permanent reform. It would seem that eight hours of labor per day is sufficient for able-bodied persons if any intellectual improvement is expected of them. In many instances it would be more profitable to spend even less time in routine labor and give better opportunity for mental discipline and general physical culture. Mental discipline brings a reform of intelligence, of knowledge and of judgment which are supremely necessary in the care of persons criminally disposed and in the prevention of crime. In this respect a careful classification of the inmates of every prison should be had, whatever be the system adopted, and each individual should have a treatment that best suits his case. Men are not reformed in groups and companies but by special influences brought to bear upon the individual. The Elmira reformatory has been a living application of this theory. This institution has been taken as a model not only for America but for the whole world, and at present represents the most successful institution for the reform of young criminals yet established. It makes no distinction between the prisoners within and the people without any further than is necessary on account of the difference in conditions.

When prisoners enter the Elmira reformatory they are given grade *two* with the possibility of their falling to grade *three* or rising to grade *one*. Each grade is clothed differently from the others, and in that respect a discrimination in clothing is shown between the different groups or prisoners within the prison rather than between those within and the people without. All attempts are here made possible to make men dwell upon the better things of life, to turn their whole attention to the development of what manhood is still within them, and thus transform the criminal into independent and self-asserting manhood.

But classification should not stop here. According to our principle each individual should be treated according to the character of his crime and the condition of his criminality, indeed, according to his own character. Sweeping laws which pass upon a great mass of

† Criminology, McDonald, pp. 36-96.

criminals, that are made inflexible and indiscriminative, are the most valueless that can ever be instituted for the guidance of the warden of a prison. In his judgment should rest the determination of many things concerning prison discipline. A warden should be a person especially trained for his position by long practice and theoretical study. So far as possible he should be removed from political regime, and be continued in office during good behavior and competent administration. There should not be too many laws and rules instituted by boards of supervisors, which tend to hamper him. In Kansas the Board of Directors of the state prison make the rules for the government of the warden. Ordinarily this check upon administrative government may be wise, but to a well prepared and competent warden such laws are liable to prove irksome in the extreme. Even the statutes passed by the state ought to be sufficiently flexible to give large discretionary powers to the warden. Too many boards are a supreme nuisance to rational government. There is no greater mistake made than in the creation of a prison law which shall treat a thousand prisoners as one man, whether in regard to their food, or to the hours they shall work, or to the method of confinement, or the length of sentence, or to grade marks, or to the method which may be taken to reform them. Consequently the singling out of each individual as a character study with a desire to give him the full benefit of all helpful measures to reform him, and to place him in a way to make himself independent after he leaves the prison is, indeed, one of the prime factors in prison discipline. The method of classifying together individuals of the same character and degree of criminality, with a view to make them mutually helpful by conversation and association rather than to deteriorate their character has been tried in some instances but as a rule it has proved a failure. Nevertheless it does seem that something might be done in this way. At least, possibly those who have a life sentence should be classified together in the same group. If prisoners must work together during the day time each group could be placed by itself. If in any kind of association there is contamination either by words or looks or signs, a few prisoners of the same degree of criminality could be classified together, which without doubt will make fewer chances for those who are very evil in nature to degrade others. How far this may be carried with success can only be determined by those who will make of it a practical example with an intense desire and determination to succeed. At any rate, it may be affirmed that the classification of prisoners in groups can be carried on with great skill and a great deal of benefit, if the buildings are arranged for this purpose: different dining rooms, different apartments and reading rooms, different associations in every way. The departmental system would have this advantage, that sets of rules could be made for the government of each separate department and would thus more nearly meet the conditions and needs of each separate group of prisoners. But such a classification is urged only in cases where the solitary system is practically impossible. In close connection with this classification might be considered the question of hereditary treatment. Every prisoner who enters any prison whatever should be carefully studied as to his past history and present life, in order to ascertain his own nature and the elements of manhood within him which are possible of development. A careful record of every prisoner, his past life, the crimes he has committed, his education, his conditions and associations should be carefully considered. This record will enable those who have charge of prisoners to study their character, and not only enable them to manage them better as a disciplinary means, but also furnish a means for such reform as the prisoners are capable of. It may do more even than this, in the study of the influence of heredity in crime. There are those who hold that not much can be made out of the fact that criminal fathers are more apt to have criminal children than others. But no one who has made a careful inquiry into hereditary taints can question that there is a great tendency in hereditary crime. The subject has not been studied sufficiently far to give data enough to warrant us in drawing mathematical conclusions. But cases have been cited where criminals have married and intermarried and large numbers of children have become criminals through many generations. An interesting fact is to be noted here, however, that a large number of the so-called hereditary crimes arise out of existing conditions rather than from blood taint; thus a child whose parents are thieves, and the companions of whose parents are thieves, grows up with his early life biased in this direction; all about him are men engaged in these corrupt practices and the early life is impressed with the supposition that this is a normal state of affairs and he naturally grows up to follow the calling of his parents and neighbors, just as an individual who is brought up to know nothing but farming, and considers this the legitimate calling of his father and neighbors, would seem likely to take to it as a livelihood rather than to something else with which he is less familiar.

The investigations of such men as Charles Booth in London* would seem to indicate that crime arises chiefly out of conditions, examples, and habits, rather than from the assumption that men are born to crime through any inherent psychological tendency. In this

* Life and Labor of the People of London, by Charles Booth, 3 vols.

it is not intended to show that heredity does not have a large influence in the development of crime. Statistics have been prepared to thoroughly substantiate the fact that heredity plays a great part in the development of the criminal.

"Of the inmates of Elmira reformatory 499, or 13.7 per cent. have been of insane or epileptic heredity. Of 233 prisoners at Auburn, New York, 23.03 per cent. were clearly of neurotic (insane, epileptic, etc.) origin; in reality many more. Virgilio found that 195 out of 266 criminals were affected by diseases that are usually hereditary. Rossi found five insane parents to seventy-one criminals, six insane brothers and sisters and fourteen cases of insanity among more distant relatives. Kock found morbid inheritance in 46 per cent. of criminals. Marro, who has examined the matter very carefully, found the proportion 77 per cent., and by taking into consideration the large range of abnormal characters in the parents, the proportion of criminals with bad heredity rose to 90 per cent. He found that an unusually large proportion of the parents had died from cerebro-spinal diseases and from phthisis. Sichard examining nearly 4,000 criminals in the prison of which he is director, found an insane, epileptic, suicidal and alcoholic heredity in 36.8, incendiaries 32.2 per cent. thieves, 28.7 sexual offenders, 23.6 per cent. sharpers. Penta found among the parents of 184 criminals only 4 or 5 per cent. who were quite healthy."*

Such being the awful tendency of crime to breed crime, questions arising respecting the causes of crime ought to be a careful study by all persons interested in criminology or penology.

The question has often arisen, How will you find out correctly about the past history of individuals? Some conclude that, because prisoners are dishonest, there is no method by which you can find out about their past life or early conditions. A careful study of this question by men who are expert in handling criminals, has convinced the public that this may be done. Possibly as much of the record of the prisoner as is convenient to be obtained, should be procured by the court and sent to the warden with the sentence. If it could not, the warden then could ascertain through a commission the past history of each prisoner as he comes to him and a full record of his life, condition, habits, etc. If this was not complete, it could be verified from time to time or be changed from time to time, as facts developed later on. Perhaps no one has succeeded any better in this line than has Mr. Brockway, general superintendent of the Elmira reformatory. Mr. Brockway presents the subject in the following letter:

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* Havelock Ellis, The Criminal, page 93.

F. W. BLACKMAR, ESQ., Lawrence, Kansas:

DEAR SIR:—Yours of the 21st. There is a mistaken impression abroad about the possibility of ascertaining from prisoners the truth on any subject. They are liars, in common with the remainder of the race not in prison. Perhaps more apparently so, but nevertheless they are not in this respect more untruthful than witnesses called to the stand in courts, witnesses who have never been and, probably, never will be in prison. My observation is, in the five investigations of my prison administration, had during long years of it, that the statements of prisoners before the several commissions were as truthful as are the statements of witnesses heard at trials outside.

The real difficulty in ascertaining the truth in the examination of prisoners is not very much more difficult than to ascertain the truth of any other common class of witnesses. It goes without saying that the examination of witnesses needs to be made by a competent, pains-taking examiner, before whom it is usually easily determined whether the witness is lying, prevaricating or making substantially a truthful statement. Moreover, it is possible by clues ascertained in the course of the examination from statements made by the prisoner,—names, dates, etc., to verify or disprove the accuracy of the statement he makes on his examination. There are some cases, not very many, where no clue can be had or dates or names ascertained. These, however, constitute such a small percentage of the prisoners examined, that it constitutes a class scarcely worth considering in this connection.

The particular purpose of inquiring into the early and antecedent history of the prisoners committed to this Reformatory during the last fifteen years has been to ascertain the character of the defects of the man himself, with a view to map out and conduct a course of treatment calculated to cure such defects or build up counteracting impulses and habitudes, as well as to determine the cause of the defects observed. It has been abundantly demonstrated by our experience here that the record made on the date of the prisoner's admission, which is an abstract of the examination held by the General Superintendent, is substantially accurate,—accurate in all the essentials required to determine the real character of the man. I am sure, if it was deemed important to go back one or two generations for hereditary influences, we might ascertain enough from the prisoner on his examination to enable further inquiry outside which, together with the statements of the prisoner, would form very reliable data.

I am, dear sir,

Very respectfully yours,

Z. R. BROCKWAY, *Gen. Supt.*

The following table shows something of Mr. Brockway's method of classification as the result of his investigations:*

BIOGRAPHICAL STATISTICS OF INMATES.

1. Relating to their Parentage (Hereditary.)

Insanity or epilepsy in ancestry.............. 499 or 13.7 per cent.

DRUNKENESS (*in Ancestry*).

Clearly traced..............................1,408 or 38.7 per cent.

Doubtful.................................... 403 or 11.1

Temperate...................................1,825 or 50.2

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* See Annual Report of the Board of Managers of the Elmira Reformatory, 1889.

EDUCATION (*in Ancestry*).

Without any education	495 or 13.6	per cent.
Simply read and write	1,885 or 38.1	
Ordinary common school or more	1,592 or 43.8	
High School or more	164 or 4.5	

PECUNIARY CIRCUMSTANCES (*in Ancestry*).

Pauperized	173 or 4.8	per cent.
No accumulation	2,801 or 77.0	
Forehanded	662 or 18.2	

OCCUPATION (*in Ancestry*).

Servants and clerks	376 or 10.4	per cent.
Common laborers	1,197 or 32.6	
At mechanical work	1,343 or 36.9	
With traffic	633 or 17.7	

THE PROFESSIONS (*so-called*).

Law	16	
Medicine	36	
Theology	10	
Teaching	25	
	87 or 2.4	per cent.

2. Relating to Inmates Themselves (Environment).

THE HOME LIFE.

(*a*) Character of Home Life.

Positively bad	1,883 or 51.8	per cent.
Fair (only)	1,453 or 39.9	
Good	300 or 8.3	

(*b*) Duration of Home Life.

Left home previous to 10 years of age	187 or 5.2	per cent.
Left home between 10 and 14 years of age	226 or 6.2	
Left home soon after 14 years of age	1,121 or 30.8	
At home up to time of crime	2,192 or 57.8	

NOTE.—As to the 1534 homeless:

Occupied furnished rooms in cities	390 or 25.4	per cent.
Lived in cheap boarding houses (itinerant)	280 or 18.2	
Lived with employer	331 or 21.6	
Rovers and tramps	533 or 34.8	

EDUCATIONAL.

Without any education (illiterates)	710	or 19.5	per cent.
Simply read and write (with difficulty)	1,814	or 49.9	
Ordinary common school	979	or 26.9	
High school or more	133	or 3.7	

INDUSTRIAL.*

Servants and clerks	1,041	or 28.6	per cent.
Common laborers	1,853	or 51.0	
At mechanical work	649	or 17.8	
Idlers	93	or 2.6	

CHARACTER OF ASSOCIATIONS.

Posititvely bad	2,072	or 56.9	per cent.
Not good	1,439	or 39.6	
Doubtful	64	or 1.8	
Good	61	or 1.7	

NOMINAL RELIGIOUS FAITH OR TRAINING.

Protestant	1,531	or 42.1	per cent.
Roman Catholic	1,667	or 45.8	
Hebrew	207	or 5.7	
None	231	or 6.4	

The study of physical, mental and moral characteristics will lead us to other determinations and will show in physical health that the prisoners are as a rule not much, if any, below the average of people at large. It will also show that the majority of them not accustomed to regular work or employment are not capable of doing as much labor or enduring as much constant physical fatigue as would the same body of men who are not criminals taken from the common ranks of the people. So as to mental characteristics, we can urge that the criminal intellect has not been keen enough to take proper rank with the average mind. It is a fact, however, that many criminals are very shrewd and intellectually keen. Doubtless something could be said about the quality of such intellect and its special characteristics. It is the intellect of a coarse nature and not cultured, refined, or properly trained in the aggregate. The well developed mind, balanced in every particular, is rare among criminals. It will be seen, however, that a defect in the moral nature is in most instances a secret cause of the crime. Moral insensibility seems to be the common characteristic of a large proportion of prisoners. It

*It should be stated that the above who claimed some occupation are, as a rule, not regularly employed, nor steady reliable workmen.

is indeed too true with many of them that their conscience consists merely in the humiliation of being caught. Dwell as they may upon past deeds, the great fault of their own, as far as they view it, is in the fact that they were caught in the act and apprehended and punished. This moral insensibility is found in all grades and degrees, from that of a complete lack of moral symptoms to those of a highly sensitive moral nature.

Of the 4,000 criminals who have been through the reformatory at Elmira, 36.2 per cent showed on admission positively no susceptibility to moral impressions; only 23.4 per cent were ordinarily susceptible.*

The following tables, taken from the report of the general superintendent of the Elmira reformatory for 1889, may be found interesting. It must be observed that the majority of these prisoners are young and all of them under the age of 30.

CONDITION AS OBSERVED ON ADMISSION.

PHYSICAL.

(*a*) As to health:		
Debilitated or diseased	200 or	5.5 per cent.
Somewhat impaired	501 or	8.3
Good health	3,135 or	86.2
(*b*) As to quality:		
Low or coarse	916 or	25.2 per cent.
Medium	1,354 or	37.2
Good	1,366 or	37.6

MENTAL.

(*a*) Natural capacity:		
Deficient	73 or	2.0 per cent.
Fair (only)	789 or	21.7
Good	2,300 or	63.2
Excellent	474 or	13.1
(*b*) Culture:		
None	1,572 or	43.2 per cent.
Very slight	1,040 or	28.6
Ordinary	916 or	25.2
Much	108 or	3.0

MORAL.

(*a*) Susceptibility to moral impressions now (estimated):		
Positively none	1,318 or	36.2 per cent.
Possibly some	1,310 or	36.1
Ordinarily susceptible	851 or	23.4
Specially susceptible	157 or	4.3

* The Criminal, p. 129.

(*b*) Moral sense, even such as shown under the examination, either filial affection, sense of shame, or sense of personal loss:

Absolutely none	1,794 or 49.3	per cent.
Possibly some	1,112 or 30.6	
Ordinarily sensitive	553 or 15.2	
Specially sensitive	177 or 4.9	

Without doubt this is a better showing by far than can be had in any ordinary prison. Auburn contains a different class of criminals than is found at Elmira. So, also, for the older prisons of Europe, there are more *recidivistes*, or habitual criminals in these prisons. In the West there appears to be fewer of the habitual class and more of the accidental class in proportion than are found in older countries of denser population. Yet much of a helpful nature could be had by a more careful study of individual characteristics of criminals than is at present carried on. This means more time, more help and more expense, but in the long run it would amply pay.

An excellent phase of the Kansas system is the shortening of terms on account of good behavior within the prison walls. It is provided by statute that three days per month for the first year shall be deducted from the term of sentence of such prisoners as have no marks against them for disobeying the rules of the prison. If the record has been good at the close of the first year, six days per month shall be deducted during the second and eight days per month during the third if good conduct continues. These privileges apply to years or parts of a year.*

Another timely measure permits prisoners to participate in their own earnings. Five per cent. of each day's labor at the rate of seventy-five cents per day, are entered to the credit of each prisoner.† If, on account of good behavior, a sentence is commuted at the end of the first year, the prisoner may have the privilege of sending these earnings to his family. There certainly is no reason why the prisoner within the walls should not support a family, if he has one, rather than allow it to be thrown upon the public. At least part of his earnings should be sent home and part saved for him to the end of his term. A certain per cent. of the earnings may be used by the prisoner in providing himself with a few comforts. (The floor in the cell shown in fig. 5 has a carpet provided in this way.) This, among other rules, suggests that the condition and conduct of the prisoner, as well as the crime, should determine the length of the sentence. If crime can be reckoned as moral insanity, as many specialists hold, then a sentence for a fixed time is similar to sending a sick man to a hospital for treatment,

* Kansas Statutes, 6421, 1889.

† Ibid., 6439.

stating that he must remain exactly two years and three months to be cured, when in fact it may take longer or he may be cured before the end of a year. Certain it is that no criminal should be returned to the ranks of society until a reform has been thoroughly commenced. And when it can be ascertained that he will not commit crime again, it is idle to confine him longer. New York and Ohio have taken advanced steps in this direction and have instituted what is known as the indeterminate sentence for all criminals, whether in reformatories or penitentiaries.*

When the solitary cellular system is in vogue, the prisoners are limited to certain occupations within the cell, but when the associated system is practiced, all kinds of industry involving machinery may be carried on. This has given rise to what is known as the contract system, a method of employing prisoners, which should not be confounded with the unfortunate and nearly antiquated lease system. The statutes of Kansas† permit the contracting of prisoners to responsible parties, but still the state maintains its disciplinary control over the prisoners. The directors are obligated to advertise for bids in the leading papers in each congressional district. Contracts shall not exceed a term of ten years, and awards are made to the highest responsible bidder. Forty-five cents per day for able-bodied men is the minimum point below which bids are not accepted. There is a great controversy respecting the defects of the contract system, but it is not as bad as it at first appears when laborers are employed otherwise with great difficulty. Doubtless the better way is absolute management of all industries, as in case of the coal mines, by the prison superintendent.

The management of the mines is intrusted to a skillful engineer, Mr. Oscar F. Lamm. The writer has investigated the conditions under which men work, and has been to the face of the mines where they were at work, and can testify that the stories circulated about hard usage in the mines are wholly unfounded, except by persons who consider all labor, particularly mining, hard usage. The air below is pure—men are sent down every morning to test the air before prisoners are allowed to go down—and the mining is comparatively easy. There is very little difficulty in it, and the prisoners are not so bad off in these mines as are the miners in private mines elsewhere in Kansas. It may be a dreary life to lead for a person who has not been accustomed to work underneath the ground, but the average miner would pronounce the life in the mines endured by the prisoners as one of comparative ease and very few hardships. In all the experience of

* See Proceedings of the National Conference of Charities, 1891, p. 220.

† Revised Statutes, 6442, 1889.

the mines, only one individual has been seriously hurt, and that when he disobeyed orders directly.

There have been many objections to the contract system urged by persons who are outside of the prison and its management. Whatever objections there may be to the contract system in itself, those usually observed are of no force. It is said that the goods made by prisoners come into close competition with goods made by union men outside of the prison and therefore the union men urge the repeal of the law granting the privilege of contracting prisoners for work. There can be no reason in this from the following principles: First, because every citizen of Kansas is interested in the right management of the prison as a means of protecting him and his family. In order to have this protection it is necessary that laborers be given employment for the sake of proper management. As there are less than a thousand of these prisoners all told, many of them are employed about the buildings and grounds and many employed in furnishing coal and other goods to state institutions, the competition does not figure at all in the great labor market. Again, while the prison mines have been putting forth abundance of coal in supplying state institutions and the market elsewhere, other coal mines in and around Leavenworth have been unable to fill the orders in supplying the demand upon them. Superintendents have tried again and again during the past two years to obtain sufficient miners to take out enough coal to supply the market, but they have failed. So far as the mines are concerned, the hue and cry about competitive labor amounts to nothing. Again, the contract system is carried on in this way: The prisoners are always under the charge of the warden and prison authorities. Contracts are let to the highest bidder for a certain number of laborers. This labor must be done on the prison grounds and under the general oversight of the prison authorities. If a prisoner is not doing well at a certain occupation, he is transferred to some other occupation. He has much the same treatment everywhere. Care is taken to adapt the prisoner to the labor that best suits his condition. When these goods are finished they pass out on the market in competition with other goods of the state and neighboring states. This, as has been stated, cannot be avoided unless the solitary system is adopted and with it an exclusion of machinery. The minimum price for contract laborers is forty-five cents per day, and as a matter of business, as those contracts are let to the highest bidder and as labor is plentiful outside of the prison, there can be very little difference in the effect of this contracting for prison labor and the injury of union labor outside as respects the cheapness with which goods can be thrown upon the market. However, it seems to me that it would be better to have all prisoners and all manufacturing under the direction of the prison, and that raw material should be purchased to supply the machinery placed there for the purpose of manufacturing the goods and then the goods should be furnished to state institutions where they need them and the surplus be thrown upon the market at the usual price. This would keep all the prisoners employed and would also give them instructions by way of learning and drill in completing the finished product, which is an education in itself. Then wherein it is necessary and possible, part of the time should be employed in obtaining a fair theoretical as well as industrial education. In this way the management of the prisoners in their graded condition would be more directly under the control of the warden and, instead of being treated as a gang at work in the shop and elsewhere, an individual consideration of every prisoner would be reached in discipline, manual labor and intelligent training.

It is not the purpose of penal institutions to humble or degrade humanity. There is no object in it and moreover it has a tendency to breed crime. Men who are sufficiently evil and reckless to commit flagrant crimes are not benefitted by a punishment that degrades them or tends to rob them of the appearance of manhood. For this reason the striped suits worn by prisoners should be abandoned and suits which will classify persons within the walls, be adopted. If it be said that it is more difficult to apprehend those who escape if the traditional striped clothes are abandoned, let it be said this is of no importance; if the Bertillon or French system of registry be adopted, as represented in the following tables, there will be little chance of escape.

BERTILLON OR FRENCH SYSTEM OF PRISON MEASUREMENT AND REGISTRY.

Height,	1 m.	Remarks.	Head, length,		Remarks.	Left foot,		Remarks.	Color of left eye.	Circle,	Age years.
Stoop,			Head, width,			" mid. ft.				Periph. Z.	
Outs. A,	1 m.		Right Ear. length,			" lit. ft.					Born in
Trunk,			Right Ear. width,			" fore A.				Pecul'r'ts.	

Remarks incident to measurements,

SPACE FOR PHOTOGRAPH.

DESCRIPTIVE.

Forehead.	Incline,	Nose.	Profile.	Ridge,			Right Ear.		Beard, Hair,
	Height,			Base,					Complexion,
	Width,		Dimensions.						Weight,
	Peculiarities,		Length.		Projection.	Breadth.			Build,
			Peculiarities,				Chin,		

Measured at..........189......, by..........

Remeasured..........

When and where,..........

Institution..Reg. No..........................

Name ....

Alias ....

County.........................., Crime.........................., Sentence..................

Occupation.., Descent..........................

Known or admitted former imprisonment...

MARKS, SCARS AND MOLES.

Numerical Order.		Numerical Order.	

NOTE:—Please follow strictly Book of Instruction, not only as to measurements and general description, but also particularly as to Marks, Scars, etc. See pages 65 to 81. Use abbreviations as given in instructions.

One of the great difficulties in connection with prison reform is that of restoring to important places in legitimate society the ex-convicts who have been serving long terms of imprisonment. First and foremost is the consciousness of the prisoner that he has been a convict, that he has worn the striped clothes and been separated from society for a period of years on the supposition that he was not worthy to live in said society and therefore had forfeited his right to live in it. If he be strong enough to overcome the effects of such a feeling he must indeed have received a permanent reform or be strong in character. In addition to this is the fact that people know he has been a jail-bird and they will not want to employ him or trust him.

This has a tendency to make him feel that he is still an outcast from society and that there are greater walls than those of the prison separating him from the trust and confidence of society. If he is employed by those who do not understand that he is from prison he carries with him continually the consciousness of deception, and this in itself has rather a bad tendency in developing a spirit which (if it does not already exist) will tend to make him feel that he is an enemy to the society which seems against him. It will be a strong character, even though it be determined to do right at all times and even though the prison reform has been salutary, if it resists the influence of such conditions. True there are prisoners of entirely different character, who consider all attempt at reform within the prison walls as so much nonsense, or at least nothing more than opportunities for winning the favor of their superiors while under sentence, and when they pass from the prison walls they still feel, if they feel at all, that society is against them and they are against society, and they are ready at the slightest opportunity to engage in their old pursuits without even attempting to enter a legitimate calling and live respectable and honored citizens.

To relieve all this there have been attempts to form prison associations which would receive the prisoner at his discharge, place him in the hands of individuals who understand his life and character and who would sympathize with him in the attempt to continue his well begun reformation, and he, understanding them, would have confidence not only in himself but in the people around him. In this way he makes the connection which has been broken off between himself and legitimate associations, and has a possibility of outliving the past. Such an association in Kansas might accomplish a vast deal of good. It ought to be formed by philanthropists and business men who would take an especial interest in this work. Each prisoner when he has finished his sentence should be assisted quietly and earnestly in securing the proper place. It would save very many, who have left the prison with good intentions, from returning to old practices.

Perhaps the furlough system, as carried on by the Elmira reformatory, is the most unique that has ever been tried for the purpose of making the connection of the discharged prisoners with the industrial and social life without. Prisoners are discharged on furlough of three years, during which time they are placed under good influences and have all the opportunities for continuing the reform outside of the prison walls. These prisoners report monthly to the prison authorities and of their own accord. If, at the end of three years, they have made satisfactory progress and have occupied positions of trust without betraying confidence, they are given their final discharge on the supposition that they are, from that time on, able to care for themselves in a manly way. Of the discharged prisoners by the furlough system over 75 per cent. have completed their three years with credit to themselves, which speaks well for the permanent reforming character of the Elmira system. There is need of such a school in Kansas. When the Hutchinson reformatory was projected, commissioners were sent to study the Elmira system and other systems and it was determined to carry out or follow as nearly as possible the former, believing it would be of benefit to Kansas. Certainly a reform prison is needed at preseut for the younger criminals, where they can be separated from the old and hardened and be placed under the best influence possible. One chief detriment to the effective working of such a reform school in the West is that it is an expensive institution, and that the people of to-day are not willing to pay sufficient taxes for the support of an institution in which so much care is given to those who have committed crimes against the state. There is a feeling here still that it is better to give support to our educational institutions and to all efforts along the line of educating that part of society which is already good and making it better, rather than spending so much money on that which is broken down. But it must be remembered, as was stated in the foregoing principles, that the care for the broken down parts of humanity is only in the interest of general humanity and should be considered upon that basis. However, I think also that a reformatory could be carried on at Hutchinson on a less expensive basis than that one at New York, and with proper management it could be made to go a long way towards supporting itself and still give proper reformatory practice for all who should come within its scope. At least the Hutchinson institution should not be abandoned under any consideration whatever. It would relieve the present overcrowded condition of our penitentiary and provide in a large measure for a class which are not sufficiently provided for.*

Discharged prisoners from Lansing find but little difficulty in obtaining work in the mines if their previous training has prepared them for it. So, also, those who have trades well learned need not be out of employment and the prison authorities render assistance to prisoners in a general way in obtaining work after being discharged.

Much more might be said about criminology and penology in Kansas, of a more scientific nature than what is contained in this somewhat general discussion; it is the intention of the writer to refer again to this subject in connection with the study of sociology at the University of Kansas.

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*The Kansas Legislature at its recent session made an appropriation to complete the Hutchinson Reformatory.

A Brief Bibliography of Municipal Government in the United States.

BY FRANK H. HODDER.

In political science, things near at hand and always with us are slighted, while remote and obscure questions are made the subject of most careful investigation. Taxation is a notable illustration of this fact. There is no act of government which so directly and intimately concerns the whole people, and yet it would be difficult to name one which has received so little careful study. In English there is not a single systematic and comprehensive work on the subject. Similarly with municipal government. With the present distribution of population this department of government controls more than one-fourth of our whole people in all their most important political relations. There is still no systematic treatise on the subject, but public interest has been aroused, and a large number of lectures, articles in periodicals and scientific journals has been printed in recent years. It is a hopeful sign that municipal government is beginning to receive careful attention in colleges. For the purpose of assisting college study of the subject, a list of such literature as could be found was printed some time ago. As it has been found useful in several institutions, it has seemed worth while to extend it and bring it down to date. The study of municipal government at home is very properly preceded by a summary of local government generally and by a glance at municipal government abroad. The order of the references is as follows:

I. Introductory.
  1. Local Government Generally.
  2. European Cities.
    a. London.
    b. Paris.
    c. Berlin.
    d. Other Foreign Cities.

II. American Cities.
  1. Legal Status.
  2. Statistics.
  3. Finance.
  4. General Discussions.

5. Municipal Industries.
6. Various Topics.
7. Particular Cities.
    a. New York.
    b. Other American Cities.

I. INTRODUCTORY.

1. LOCAL GOVERNMENT GENERALLY.

Short accounts of the systems of local government of the principal countries of continental Europe are given in the Cobden Club Essays: Local Government and Taxation, London, 1875, edited by J. W. Probyn. See also F. Béchard's *De L'administration de la France*, 2 vols. Paris, 1851, with appendix on municipal organization in Europe.

The best short description of English local government is M. D. Chalmers's Local Government, "English Citizen" Series, London, 1883. See also Local Administration, "Imperial Parliament" Series, London, 1887, by Wm. Rathbone, Albert Pell and F. C. Montague. For still shorter account read chapter 15 of May's Constitutional History and article on "Local Government in England" by F. J. Goodnow in the Political Science Quarterly, December, 1887, vol. 2, pp. 338-65, and an article by the same writer on "The Local Government Bill" in the Political Science Quarterly, June, 1888, vol. 3, pp. 311-333. Supplement Chalmers with Cobden Club Essays: Local Government and Taxation in the United Kingdom, London, 1882, edited by J. W. Probyn. The most exhaustive work on English local offices is Rudolph Gneist's *Self Government: Communalverfassung u. Verwaltungsgerichte in England*, untranslated, 3d ed., 1876. For full bibliography see Gomme's Literature of Local Institutions, London, 1886.

The best short outline of local government in the United States is an article by S. A. Galpin on "Minor Political Divisions of the United States," in Gen. F. A. Walker's Statistical Atlas of the United States. The papers on the local institutions of several of the States in the Johns Hopkins University Studies in Historical and Political Science are especially valuable. Chas. M. Andrews has articles on Connecticut towns in the Johns Hopkins Studies, vol. 7, and in the Annals of the American Academy of Political Science, October, 1890, vol. 1, pp. 165-91. Especially important is Prof. Geo. E. Howard's Local Constitutional History of the United States, vol. 1.: "The Development of the Township, Hundred and Shire," printed as an extra volume in this series. John Fiske's lecture on "The Town Meeting," delivered at the Royal Institution, was printed in Harper's Magazine, vol. 70, pp. 265-272, and in his American Political Ideas, N. Y.,

1885. A different view of the present importance of local institutions is taken by Prof. S. N. Patten in an article on the "Decay of State and Local Government," in the first number of the Annals of the American Academy of Political Science. For comparison of American and foreign methods, read R. P. Porter's article "Local Government: at Home and Abroad," Princeton Review, July, 1879, N.S. vol. 4, p. 172, and reprinted separately. See two articles on "Local Government in Prussia," by F. J. Goodnow in the Political Science Quarterly, December, 1889, vol. 4, pp. 648-66, and March, 1890, vol. 5, pp. 124-58. For further reference on local self-government see W. F. Foster's Monthly Reference Lists, vol. 2, pp. 23-29, and his pamphlet of References on Political and Economic Topics, p. 24.

For Canada, see J. G. Bourinot's "Local Government in Canada: an historical study," in Transactions of the Royal Society of Canada for 1886, vol. 4., sec. 2, pp. 42-70; printed separately by the publishers, and reprinted, with a letter on the municipal system of Ontario, in the 5th series of the Johns Hopkins Studies. A paper on "The Ontario Township," by J. M. McEvoy, printed in 1889, forms No. 1 of the Toronto University Studies in Political Science.

2. EUROPEAN CITIES.

For the purpose of comparison, some study should be made of municipal government abroad. Dr. Albert Shaw gives a general view of "Municipal Government in Great Britain," in Notes Supplementary to the Johns Hopkins Studies, No. 1, January, 1889, and in the Political Quarterly, June, 1886, vol. 4, pp. 197-229. Of larger works on English municipal history, mention may be made of J. R. S. Vine's "English Municipal Institutions; their Growth and Development from 1835 to 1879," London, 1879. Dr. Chas. Gross has printed a very complete "Classified List of Books relating to British Municipal History," Cambridge, 1891, as No. 43 of Bibliographical Contributions of Harvard University. Foreign experience is of very little assistance in the solution of the general problem of municipal government in the United States, but it may be useful in indicating improved methods of administration in particular departments of a city government. Several cities that illustrate different forms of municipal government may be taken as examples.

a. London.

Specially excepted from the operation of the Municipal Corporations Act of 1835. For outline of government read Chalmers, chap. 10. For full description see J. F. B. Firth's Municipal London, 1876, and his Reform of London Government and of City Guilds, "Imperial

Parliament" Series, London, 1888. For history of the corporation consult W. J. Loftie's History of London, 2d ed., 1884, and the same author's small work, London, published in 1887 in Freeman's series on "English Historic Towns." Both books are based on new material, part of it recently discovered by Bishop Stubbs. For additional references, see Gomme, pp. 122-134.

There have been a great many articles on the municipal government of London in recent periodical literature. Among them may be cited those by W. Newall, Contemporary Review, 1873, vol. 12, p. 73, and 1875, vol. 25, p. 437; W. M. Torrens, Nineteenth Century, 1880, vol. 8., p. 766; Alderman Cotton, Benj. Scott, City Chamberlain, and Sir Arthur Hobhouse in Contemporary Review, 1882, vol. 41, pp. 72, 308, and 404 respectively; the Westminster Review, for January, 1887; Dr. Albert Shaw on "How London is Governed," in the Century, November, 1890, vol. 41, pp. 132-147, and on "Municipal Problems of New York and London," in the Review of Reviews, April, 1892, vol. 5, p. 282; James Monroe on "The London Police," in the North American Review, November, 1890, vol. 151, pp. 615-629; Sir John Lubbock on "The Government of London," in the Fortnightly Review, February, 1892, vol. 51, p. 159; and an article on the "Municipal Administration of London," in the Edinburgh Review for April, 1892. For a good review of attempts since 1860 to regulate the London gas supply, see an article in the British Quarterly for January, 1879.

A Royal Commission on the City Livery Companies reported May 28, 1884. See the discussion by Sir R. A. Cross, one of the dissenting members of the Commission, in the Nineteenth Century for 1884, vol. 16, p. 47, and by Sir Arthur Hobhouse in Contemporary Review for 1885, vol. 47, p. 1. The most important work on the London guilds is William Herbert's "History of the Twelve Great Companies of London," London, 1837. The latest contribution to the subject is Price's "Description of the Guildhall," London, 1887.

b. Paris.

A sketch of its government by Yves Guyot, a member of the municipal council, may be found in the Contemporary Review, March, 1883, vol. 43, p. 439. Dr. Shaw gives an excellent short account in an article entitled "The Typical Modern City" in the Century, July, 1891, vol. 42, pp. 449-66. He cites as the principal authority on the subject Maxime Du Camp's *Paris, ses organes, ses fonctions, et sa vie dans la seconde moitie du dix-neuvieme siecle.* An extended description is also given in a work entitled *Administration de la Ville de Paris,* written by Henri De Pontich under the direction of Maurice Block, Paris, Guillaumin, 1884. The *Rapports et Documents* and *Process-Verbaux* of the municipal council are printed yearly in three large quarto volumes, and the municipal bureau of statistics issues an annual report.

c. Berlin.

An excellent short account of the government of Berlin is given by Dr. Rudolph Gneist, a member of the municipal council since 1848, in the Contemporary Review, December, 1884, vol. 46, p. 769. See also the report on the "Administration of the City of Berlin" in Foreign Relations for 1881, p. 487, made by Assistant-Secretary of Legation Coleman at the request of Hon. Andrew D. White, then Minister to Germany. Also the articles by Prof. R. T. Ely in the Nation for March 23 and 30, 1882, vol. 34, pp. 145 and 267. In the Nation for September 25, 1892, vol. 55, p. 221, Mr. Leo S. Rowe combats some of Dr. Shaw's generalizations respecting municipal government in Europe, taking Berlin as his text. The Magistracy of Berlin publish reports at irregular intervals. The first, *Bericht ueber die Vervaltung der Stadt Berlin, in den Jahren 1829 bis inclu. 1840*, Berlin, 1842, and the second, *in den Jahren 1841 bis incl. 1850*, Berlin, 1853, are of considerable importance. A third, published in 1863, covers the period from 1851 to 1860, and a fourth, printed in 1882, covers the period from 1861 to 1876. The Director of the Statistical Bureau of the city publishes annually *Das Statistische Jahrbuch der Stadt Berlin.*

The present municipal system of Prussia dates from the reorganization of the municipalities by Stein and Hardenburg, November 19, 1808. See Seeley's Life of Stein, part 5, chap. 3, and Meier's *Reform der Vervaltung-Organization unter Stein und Hardenberg*, Leipsig, 1881. The present "Municipal Corporation Act," *Stædte-ordnung*, was passed May 30, 1853. See Kotze, *Die Preussischen Stædte Verfassungen*, Berlin, 1879, and Backoffner, *Die Stædteordnungen der Preussischen Monarchie*, Berlin, 1880, and especially Eugen Leidig's *Preussisches Stadtrecht*, Berlin, 1891. See also the articles on local government in Prussia cited above.

d. Other Foreign Citiès.

Statistics of all important German cities are given in Dr. M. Neefe's *Statistisches Jahrbuch Deutscher Stædte*, Erster Jahrgang, Breslau, 1890. Financial statistics of the great European cities are given in Joseph Körösi's *Bulletin Annual de Finance des Grandes Villes*, Dixième Année, Budapest, 1890.

A short account of the municipal government of Vienna is given in a report by Mr. Kasson in Foreign Relations for 1879, p. 64 and an extended account in Dr. Felder's *Die Gemeinde-Vervaltung der Reichs-haupt und Residenzstadt Wien*, Vienna, 1872. For the government of Budapest see Dr. Shaw's article in the Century, June, 1892, vol. 44, pp. 163-179. Prof. F. G. Peabody gives a sketch of Dresden in an article entitled "A Case of Good City Government," in the Forum, April, 1892, vol. 13, p. 53.

The following relate to various British Cities: Dr. Shaw's "Glasgow, a Municipal Study," in the Century, March, 1890, vol. 39, pp. 721-736; the same writer's "Municipal Lodging Houses," in No. 1 of the Charities Review, November, 1891; Julian Ralph's "The Best Governed City in the World" (Birmingham) in Harper's Magazine, 1890, vol. 81, pp 99-111; Thos. H. Sherman's report on "Liverpool, its Pavements, Tramways, Sewers and Artisans' Dwellings," in Consular Reports, June, 1890, vol. 33, pp. 284-303; and Consul Smyth's report on "Tramways and Water Works in England," in the Consular Report for December, 1891.

II. AMERICAN CITIES.

1. LEGAL STATUS.

For comparison of the provisions of the state constitutions relating to municipal corporations, see F. J. Stimson's American Statute Law, Boston, 1886, vol. 1, articles 34, 37 and 50. Note the classification of municipalities in Ohio. On the relation of municipalities to the states, consult the chapter on "The Grades of Municipal Government" in Judge T. M. Cooley's Constitutional Limitations, 6th ed., Boston, 1890, and a short chapter at the close of the same author's Principles of Constitutional Law. Judge J. F. Dillon's Treatise on the Law of Municipal Corporations, 4th ed., 2 vols., Boston, 1890, is the standard authority on the subject. Note the introductory historical sketch. A new text-book on the Law of Municipal Corporations, by Chas. F. Beach, Jr., has been recently issued by Houghton, Mifflin & Co. Reference may also be made to Judge Dillon's Law of Municipal Bonds, Chicago, 1877, and to A Treatise on Municipal Police Ordinances, Chicago, 1887, by N. T. Horr and A. A. Bemis, of the Cleveland bar. The authors of the last work say in their preface that "The necessity for it arises from the fact that, except in those cities and towns where the municipal council has the assistance of regularly employed legal advisers, the limits of lawful legislation are apt to be exceeded."

Numerous references to articles in law journals are given on pp. 386-388 of Jones's Index to Legal Periodical Literature, Boston, 1888.

An article by J. R. Berryman on "Constitutional Restrictions upon Legislation about Municipal Corporations," in the American Law Review, May-June, 1888, vol. 22, p. 403, may be cited.

2. STATISTICS.

The Eleventh Census will give very full statistics of cities, but though some of the results have been announced in bulletins, none of the final reports have yet been issued. These results have been summarized by Hon. Carroll D. Wright in the Popular Science Monthly for 1892, vol. 40. On "Urban Population" see p. 459; on "Social Statistics of Cities" p. 607, and on "Rapid Transit," p. 785.

The following Reports of the Tenth Census treat of this subject: vol. 1, Population; vol. 7, Valuation, Taxation and Indebtedness; vol. 18, Social Statistics of Cities: New England and Middle States (reviewed in the Nation, vol. 44, p. 256); and vol. 19, Social Statistics of Cities: Southern and Western States.

Scribner's Statistical Atlas of the United States, N. Y., 1883, exhibits the figures of the census graphically (p. xlv, statistics of population). Plate 21 illustrates the growth of American cities since 1790. There were then only eight cities of eight thousand inhabitants, and the population of New York was 33,131. Plate 30 gives ratios of different nationalities to total population in the largest fifty cities. Plate 76 gives net per capita debt in the largest one hundred cities.

On movement of population see an article by B. G. Magie, Jr., in Scribner's Monthly, January, 1878, vol. 15, p. 418; Prof. Richmond Smith's "Statistics and Economics," p. 264 in vol. 3 of the Publications of the American Economic Association; a study on the "Rise of American Cities" by Dr. A. B. Hart in the Quarterly Journal of Economics, January, 1890, vol. 4, pp. 129-157; an article by Lewis H. Haupt on "The Growth of Great Cities" in the Cosmopolitan for November, 1892, and another by John C. Rose, on "The Decrease of Rural Population" in the Popular Science Monthly for March, 1893, vol. 42, pp. 621-38. Cf. work by E. Levasseur, entitled *Les Populations Urbaines en France, comparees a celles de l'Etranger*, Paris, 1887.

The Annual Statistician, published by L. P. McCarty, San Francisco, gives the following statistics for leading cities: Number of votes registered and polled; number of voting precincts; strength of police; losses by fire and number of fire-engines and firemen; value and capacity of gas and water works; number and character of street lights; vital statistics; number of murders, suicides, and executions; length of street railroads and cost of motive power; telegraph and telephone mileage; number of saloons and cost of licenses; attendance and cost of schools, annual tax-rate, expenditure and the public debt.

3. FINANCE.

Volume 7 of the Reports of the Tenth Census, compiled by Robert P. Porter, gives statistics of local taxation and indebtedness, and a summary of the provisions of the several state constitutions limiting the rate of taxation, the amount of municipal debts, and the purposes for which they may be contracted. See p. 674 for an analysis of the purposes for which the debt outstanding in 1880 was contracted. The Eleventh Census will give similar data. Mr. Porter published an article on municipal debts in the N. Y. Banker's Magazine for September, 1876, and another in Lalor's Cyclopædia of Political Science, vol. 1, p. 730. Cf. also his article in the Princeton Review, N. S., vol. 4, p. 172. For a further study of this subject, read Prof. H. C. Adams's Public Debts, N. Y., 1887, Part 3, chap. 3. See also G. W. Green's article on "Municipal Bonds," Lalor's Cyclopædia, vol. 2, p. 920; Prof. S. N. Patten's "*Finanzwesen der Staaten und Stædte der Nordamerikanischen Union*, Jena., 1878; C. Hale's "Debts of Cities," Atlantic, vol. 38, p. 661, for the law of Massachusetts; D. L. Harris's "Municipal Economy," Journal of Social Science, vol. 9, p. 149, for the experience of Springfield, Mass., the articles in Bradstreet's for February 10 and March 3, 1883, for a comparison with local debts in England, and H. B. Gardner's "Statistics of Municipal Finance" in the Publications of the American Statistical Association, June, 1889, vol. 1, pp. 254-67. On the debt of New York City see the paper by Wm. M. Ivins cited below. A Statement of Facts Concerning the Financial Affairs of the City of Elizabeth, N. J., which has the largest per capita debt in the United States, was published by some of the citizens of that place in January, 1886.

Municipal taxation is treated at length in Prof. R. T. Ely's Taxation in American States and Cities, New York, 1888. The Reports of the Commissioners Appointed to Revise the Laws for the Assessment and Collection of Taxes in New York, 1871 and 1872, contain much valuable material. The members of the Commission were David A. Wells, Edwin Dodge, and George W. Cuyler. The first report was reprinted in New York by Harpers, and both were reprinted in England by the Cobden Club. Cf. also Wells's "Theory and Practice of Local Taxation in America," in the Atlantic Monthly for January, 1874; "Rational Principles of Taxation," a paper read in New York, May 20, 1874, Journal of Social Science, vol. 6, p. 120; and his "Reform of Local Taxation" in the North American Review for April, 1876. On the evils of double taxation see a paper on "Local Taxation" by William Minot, Jr., read in Saratoga, September 5,

1877, and printed in the Journal of Social Science, vol. 9, p. 67. See Report in 1876 of New Hampshire Tax Commission, composed of Geo. Y. Sawyer, H. R. Roberts, and Jonas Livingstone; and Report of the Michigan Commission, House Journal, February 23, 1882. A similar Commission, appointed by the City of Baltimore, reported in January, 1886. The Report contains, in addition to the recommendations of the Commission, a paper by Prof. R. T. Ely, entitled "Suggestions for an Improved System of Taxation in Baltimore." A further article on "Municipal Finance" may be found in Scribner's Magazine, January, 1888, vol. 3, pp. 33-40, and a thesis entitled "Special Assessments: A Study in Municipal Finance," by Victor Rosewater, is announced for vol. 2 of the "Studies in History, Economic and Public Law," issued by Columbia College.

4. GENERAL DISCUSSIONS.

Adams, Charles Francis. "Municipal Government: Lessons from the Experience of Quincy, Mass." Forum, November, 1892, vol. 14, pp. 282-92.

Berryman, J. R. "Constitutional Restrictions upon Legislation about Municipal Corporations." American Law Review, May-June, 1888, vol. 22, p. 403.

Bowles, Samuel. "Relation of State to Municipal Governments, and the Reform of the Latter." Journal of Social Science, vol. 9, p. 140.

A paper read in Saratoga, September 7, 1877.

Bradford, Gamaliel. "Municipal Government." Scribner's Magazine, October, 1887, vol. 2, pp. 485-493.

Browne, G. M. "Municipal Reform." New Englander, February, 1886, vol. 45, p. 132.

Bryce, James. "The American Commonwealth." Lon. and N. Y., 1888.

This well known work contains the following chapters on municipal government: chapters 50 and 51, "The Government of Cities;" chap. 52, "An American View of Municipal Government in the United States," by Pres. Seth Low; chapters 59-64 explain the working of party machinery; chap. 88, "The Tweed Ring in New York City," by F. J. Goodnow, and chap. 89, "The Philadelphia Gas Ring."

Cambridge Civil Service Reform Association. "Prize Essays on Municipal Reform." 1884.

Contents:—"The Selection of Municipal Officers: their Terms and Tenures," by T. H. Pease, of Chicago, Ill.; "The Appointment of Municipal Officers," by John Prentiss, of Keene, N. H.; and "The Selection and Tenure of Office of Municipal Officers," by Prof. H. T. Terry, of the University of Tokio, Japan.

Chamberlain, Joseph. "Municipal Institutions in America and England." Forum, November, 1892, vol. 14, pp. 267-81.

Mr. Chamberlain was Mayor of Birmingham 1873-6. He compares its government with that of Boston.

Crandon, F. D. "Misgovernment of Great Cities." Popular Science Monthly, vol. 30, pp. 296 and 520.

Eaton, Dorman B. "Municipal Government." Journal of Social Science, vol. 5, p. 1.

A paper read in Boston, May 13, 1873.

Eliot, C. W. "One Remedy for Municipal Misgovernment." Forum, October, 1891, vol. 12, pp. 153-168.

Fassett, J. S. "Why Cities are Badly Governed." North American Review, May, 1890, vol. 150, pp. 631-7.

Senator Fassett summarizes the results of the investigation in 1890 of a committee of the New York Senate on cities.

Field, David Dudley. "Our Political Methods," Forum, November, 1886, vol. 2, pp. 213-22.

Fisher, Wm. R. "Municipal Government." Publications of the Philadelphia Social Science Association.

This Association has united with the American Academy of Political and Social Science and its publications are now furnished by the Academy.

Fiske, Amos K. "Remedies for Municipal Misgovernment." Forum, April, 1887, vol. 3, pp. 170-77.

Fiske, John. "Civil Government in the United States." N.Y., 1890.

Chapter 5.

Ford, Worthington C. "American Citizen's Manual." N. Y., 1882.

Part I, pp. 66-83, on municipal corporations.

Forum. "The Science of Municipal Corruption." March, 1893, vol. 15, pp. 43-51.

Author's name not given.

Godkin, E. L. "Criminal Politics." North American Review, June, 1890, vol. 150, pp. 706-23.

Godkin, E. L. "A Key to Municipal Reform." North American Review, October, 1890, vol. 151, pp. 422-31.

Grace, William R. "Government of Cities in the State of New York." Harpers, 1883, vol. 67, p. 609.

Hale, E. E. "The Congestion of Cities." Forum, January, 1888, vol. 4, pp. 527-35.

Harrison, Carter H. "Municipal Government."

An address delivered before the Nineteenth Century Club of New York City, November 23, 1886.

Ivins, William M. "Municipal Finance." Harpers, October, 1884, vol. 69, pp. 779-87.

Ivins, William M. "Municipal Government." Political Science Quarterly, June, 1887.

The author claims that changes in municipal organization have been incident to the extension of the general functions of government, and gives an analysis of the system of government in New York City.

Ivins, William M. "Machine Politics and Money in Elections." Harper's "Handy Series," N. Y., 1887.

This little book describes the working of election laws in New York, gives the amount of assessments paid by candidates for office, and advocates the adoption of the essential features of the English system.

Janes, Lewis G. "The Problem of City Government." 40 pp. N.Y., D. Appleton & Co., 1892.

This is a lecture before the Brooklyn Ethical Association, printed in a series entitled "Man and the State."

Johns Hopkins Studies in History and Political Science.

Vol. 3. "The City of Washington," by J. A. Porter.

Vol. 4. "The Town and City Government of New Haven," by Chas. H. Levermore.

Vol. 5. "The City Government of Philadelphia," by E. P. Allinson and Boies Penrose.

"City Government of Boston," by James M. Bugbee.

"City Government of St. Louis," by Marshall S. Snow.

Vol. 7. "The Municipal Government of San Francisco," by Bernard Moses.

"Municipal History of New Orleans," by W. H. Howe.

Extra vol. 1. "The Republic of New Haven: a History of Municipal Evolution," by Chas. H. Levermore.

Extra vol. 2. "Philadelphia, 1681–1887. A Study of Municipal Development," by E. P. Allinson and Boies Penrose.

Extra vol. 4. "Local Constitutional History of the United States." Vol. I, "The Development of the Township, the Hundred and the Shire." Vol. II will treat of the "Development of City and Local Magistracies."

Kasson, John A. "Municipal Reform." North American Review, September, 1883, vol. 137, pp. 218-30.

Lewis, W. D. "Political Organization of a Modern Municipality." Annals of the American Academy of Political and Social Science, January, 1892, vol. 2, pp. 26-38. Reprinted separately.

The author is instructor in political economy in Haverford College. The main thought of his paper is that the way to improve city politics is to separate them from national politics.

Low, Seth. "Municipal Home Rule."

A speech delivered in Brooklyn, October 6, 1882.

Low, Seth. "Municipal Government."

An address delivered February 19, 1885, before the Municipal Reform League of Rochester, N. Y., and printed by the League.

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Low, Seth. "The Problem of Municipal Government."

An article in the Civil Service Reformer for April, 1889, and reprinted as No. 4 of Notes Supplementary to Johns Hopkins University Studies.

Low, Seth. "The Government of Cities in the United States." Century, September, 1891, vol. 42, pp. 730-6.

Mathews, Robert. "Municipal Administration."

An address before the Fortnightly Club of Rochester, N. Y, January 20, 1885.

Mayors of Boston, Baltimore, Buffalo and St. Louis. "How to Improve Municipal Government." North American Review, November, 1891, vol. 153, pp. 580-95.

Morison, Frank. "Municipal Government: a Corporate, not a Political Problem." Forum, August, 1892, vol. 13, pp. 789-94.

New York. "Report of the Commission to devise a Plan for the Government of Cities in the State of New York." Assembly Doc., No. 68, vol. 6, 1877.

This is a very able report. The commission was appointed by Governor Tilden, with Wm. M. Evarts as chairman. The amendment to the constitution proposed by the commission was discussed by E. L. Godkin in the "Nation," vol. 26, p. 108.

New York. "Testimony taken before the Senate Committee on Cities." Transmitted to the Legislature April 15, 1891. 5 vols.

Vol. 5 contains much information respecting cities in New York and the general laws for the incorporation of cities in other states.

Parker, Francis J. "A Study of Municipal Government in Massachusetts." Boston, 1881.

This pamphlet resulted from two reports of a commission appointed in 1881 to revise the city charter of Newton, Mass. The discussion was continued by Mr. Parker and Professor W. F. Allen in the "Nation," September, 1881, vol. 33, pp. 169 and 196.

Parton, James, "Overgrown City Government." Forum, February, 1887, vol. 2, pp. 539-48.

Parton, James. "Municipal Government." Chautauquan, January, 1888, vol. 8, p. 203.

Pennsylvania. "Report of a Commission to devise a Plan for the Government of Cities in the State of Pennsylvania." Harrisburg, 1878.

Prichard, F. P. "The Study of the Science of Municipal Government." Annals of the American Academy of Political and Social Science, January, 1892, vol. 2, pp. 18-25. Printed separately.

The author advocates the formation of local societies for the purpose of studying the science of government.

Ralph, Julian. "Western Modes of City Management." Harper's Magazine, April, 1892, vol. 84, p. 709.

Reemelin, Charles. "City Government."

A paper read at the meeting of the American Association for the Advancement of Science, held at Ann Arbor, Mich., in August, 1885.

Shapley, Rufus E. "Solid for Mulhooly."

This admirable satire was called out by the rule of the gas ring in Philadelphia. It was printed anonymously in 1881 and reprinted in vol. 1 of Spofford & Shapley's "Library of Wit and Humor," Phila., 1884. It gives an excellent picture of machine methods in large cities.

Sterne, Simon. "Cities, Administration of American" in Lalor's Cyclopedia of Political Science," vol. 1, pp. 460-68.

Sterne, Simon. "The Administration of American Cities." International Review, vol. 4, p. 361.

Sterne, Simon. "Suffrage in Cities." No. 7 in Putnam's "Economic Monographs." o. p.

Sterne, Simon. "Constitutional History of the United States." N. Y., 1882.

Pages 257 and 274 give a brief criticism of municipal government. Mr. Sterne was a member of the New York commission.

Storey, Moorfield. "The Government of Cities." Proceedings of the National Civil Service Reform League for 1891.

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White, Andrew D. "The Government of American Cities." Forum, December, 1890, vol. 7, pp. 357-72.

Wilder, Amos P. "The Municipal Problem: A Plea for Liberty."

5. MUNICIPAL INDUSTRIES.

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Allen, Walter S. "The State and the Lighting Corporations." Annals of the American Academy of Political and Social Science, March, 1892, vol. 2, pp. 131-9.

Baker, C. W. "Monopolies and the People." New York, 1889.
Chapter 5.

Baker, M. M. "The Manual of American Water Works." Engineering News Co., N. Y.

This trade annual gives for each city date when water works were built; the source and mode of supply; cost, debt, and rate of interest; annual expense and revenue from consumers and the public; the number of miles of pipe and kind of pipe for mains and services; the number of taps, meters, and hydrants; the ordinary and fire pressure and daily consumption. The first works in the United States for public supply were built at Bethlehem, Pa., in 1754. New York was first supplied in 1799, and Philadelphia in 1801. Water in both cities was pumped by steam engines and distributed through bored wooden logs.

Bemis, E. W. "Municipal Ownership of Gas Works in the United States." Publications of the American Economic Association, vol. 6, 1891.

Bemis, E. W. "Recent Results of Municipal Gas-Making." Review of Reviews, Jan., 1893, vol. 7, pp. 61-8.

Boston. "Report of Special Committee on Use of Streets by Private Corporations." City Document 144, September 8, 1890.

Consular Report. "Gas in Foreign Countries." Washington, 1891.
Other consular reports cited under "Foreign Cities."

Farrer, T. H. "The State in its Relation to Trade." London, 1883. "English Citizen Series."

Chapter 10 gives a brief discussion of the action of the state in the matter of certain undertakings which are total or partial monopolies.

Finley, Robert J. "Electric Street Lighting in American Cities. The question of municipal vs. private supply." Review of Reviews, February, 1893, vol. 7, p. 68.

Foote, Allen R. "Municipal Ownership of Industries" and "Municipal Ownership of Quasi-Public Works." Washington, D. C., 1891.

Two pamphlets against public ownership.

Francisco, M. J. "Municipal Lighting." Rutland, Vermont, 1890.
Arguments against public ownership.

Goodwin, W. W. "Directory of the Gas Light Companies." N. Y., A. M. Callendar & Co.

This trade annual gives the number of gas companies, number of public lamps, price of gas, method or manufacture, etc., in the cities of the United States.

James, E. J. "The Relation of the Modern Municipality to the Gas Supply." Publications of the American Economic Association, vol. 1.

Keeler, Bronson C. "Municipal Control of Gas Works." Forum, November, 1889.

Mikkelsen, M. A. "Electric Street Lighting in Chicago." Annals of the American Academy of Political and Social Science, March, 1892, vol. 2, pp. 139-44.

Powers, Samuel Leland and Schindler, Solomon. "The Use of Public Ways by Private Corporations. A Discussion." Arena, May, 1892, vol. 5, pp. 681-93.

Sinclair, A. H. "Municipal Monopolies and their Management." No. 2, Toronto University Studies in Political Science. Toronto, 1891.

This is an excellent essay on the relation of cities to water works, gas and electric lighting, and street railways. It may be obtained on application to the Education Department of Ontario.

Sinclair, A. H. "The Toronto Street Railway." Quarterly Journal of Economics, October, 1891, vol. 6, pp. 98-105.

University of Wisconsin. "Joint Debate on Municipal Ownership and Operation of Lighting Works and Street Railways."

This is a debate by students of the University of Wisconsin, printed in the college paper, "The Ægis," for March 3, 1893. Arguments for and against public ownership are well stated.

6. VARIOUS TOPICS.

Adams, H. B. "Notes on the Literature of Charities." Johns Hopkins University Studies in History and Political Science, vol. 5.

References on the charities of Baltimore, Philadelphia, New York and Boston.

Billings, John S. "Public Health and Municipal Government." Supplement to the Annals of the American Academy of Political and Social Science, February, 1891.

Address before the Academy, January 14, 1891.

Clarke, Thomas Curtis. "Rapid Transit in Cities." Scribner's Magazine, May and June, 1892, vol. 11, pp. 567-78 and 743-58.

Gould, E. R. L. "Park Areas and Open Spaces in American and European Cities." Publications of the American Statistical Association, 1888, vol. 1, pp. 49-61.

Holls, F. S. "Compulsory Voting as a means of Correcting Political Abuses." Annals of the American Academy of Political Science, April, 1891, vol. 1, pp. 586-614.

Philbrick, John D. "City School Systems." Circular of Information, No. 1, 1885, issued by the National Bureau of Education.

Purroy, H. D. "English and American Fire Services." Forum, November, 1886, vol. 5, pp. 299-307.

Shaw, Albert. "Municipal Lodging Houses." Charities Review, No. 1.

Smith, Irwin F. "Influence of Sewerage and Water Supply on the Death-Rate in Cities."

A paper read at a Sanitary Convention in Ypsilanti, Mich., July 1, 1885, and reprinted from a Supplement to the Annual Report of the Michigan State Board of Health for the year 1885. Numerous references in the notes.

Sterne, Simon. "The Greathead Underground Electric Railway." Forum, August, 1891, vol. 11, p. 683.

Thompson, Clifford. "Waste by Fire." Forum, September, 1886, vol. 2, pp. 27-39.

Warner, Amos G. "The New Municipal Lodging-House in Washington." Charities Review, March, 1893.

7. PARTICULAR CITIES.

The municipal reports of American cities form the original material for a study of their government. Many of the papers already cited, especially the Johns Hopkins Studies, relate to particular cities, but have been given above because of their more or less general application. New York is taken as a type of our large cities and a few notes are added upon other cities.

a. New York.

For a brief account of the system of Government, see the article on "New York," by E. L. Godkin in the Encyclopædia Britannica, 9th ed., vol. 17. Dr. J. F. Jameson's "Origin and Development of the Municipal Government of New York City," Magazine of American History, May and September, 1882, gives a sketch of municipal government down to 1821. A portion of each volume of the Manual of the Corporation (28 v., 1841-71), after that for 1846, is devoted to a history of the city. The volume for 1868 contains a reprint of old charters. The fact that James Parton in October, 1869, North American Review, vol. 103, p. 413, attributed the growing evils in the government of the city to the abolition of household suffrage, is interesting in connection with the recommendation of the Commission of 1877. See also in the North American Review, "The Judiciary of New York," July, 1867, vol. 105, p. 148, and Charles Nordhoff's "Misgovernment of New York," October, 1871, vol. 113, p. 321. An account of the Tweed ring may also be found in the North American Review, in a series of articles by C. F. Wingate, entitled "An Episode in Municipal Government," beginning in the number for October, 1874, and ending in the number for October, 1876. On the same subject cf. A. H. Green's "Three Years' Struggle with Municipal Misrule in New York City, a Report made by the Comptroller to the Board of Aldermen," February 18, 1875, and S. J. Tilden's "Municipal Corruption," Law Magazine and Review, N. S. vol. 2, p. 525, London, 1873. See also Geo. H. Andrews's Twelve Letters on the Future of New York, N. Y., 1877. The entire second volume of the Statutes of New York for 1882 is devoted to the present charter of the City of New York, or the "Consolidated Act," as it is called. The Investigation of the Department of Public Works in 1884 was printed in Senate Doc. No. 57, 1884; and the investigation by the committee, of which Theodore Roosevelt was chairman, was reported in Assembly Docs. Nos. 125, 153, and 172, 1884. The Report of the Investigation of the New York Consolidated Gas Company forms Senate Doc. No. 47, 1886. The committee found that in 1883 the gas trust declared dividends of from 23 to 33 per cent. A pamphlet by Wm. M. Ivins on "The Municipal Debt and Sinking Fund of the City of New York" contained an argument on hearing before the Governor, June 2, 1885, and an historical review of the funded debt and of the operation of the sinking-fund since its foundation. Of recent articles on cost and methods of elections cf. W. M. Ivins's articles cited above; Theodore Roosevelt's "Machine Politics in New York City" in the Century, November, 1886, vol. 33, p. 74; E. S. Nadal's "The New York Aldermen" in the Forum, September, 1886, vol. 2, pp. 49-59; Howard Crosby's "Letter to the People of New York" in the Forum, December, 1886, vol. 2, pp. 420-28; J. B. Bishop's "Money in City Elections," an address read before the Commonwealth Club in New York, March 21, 1887, reported in the Evening Post and printed separately; the same writer's "The Law and the Ballot," Scribner's Magazine, February, 1888, vol. 3, p. 194; and the Nation, vol. 44, pp. 180 and 204; A. C. Bernheim's "Party Organizations and their Nomination to Public Office in New York City" in the Political Science Quarterly, March, 1888, vol. 3, pp. 97-122, and the same writer on "The Ballot in New York" in the Political Science Quarterly, March, 1889, vol. 4, pp. 130-52; and Dr. Shaw's "Municipal Problems of New York and London" in the Review of Reviews, April, 1892, vol. 5, p. 282.

b. Other American Cities.

Boston.—Report of the Commission on the City Charter and Two Minority Reports (Docs. 120, 146, and 147, 1884). The first Report contains an outline of the municipal governments of New York, Brooklyn, Philadelphia, Baltimore, St. Louis, and Chicago.

Philadelphia.—Johns Hopkins Studies cited above; E. V. Smalley's article on the "Committee of 100" in the Century, July, 1883, vol. 4, p. 395; Publications of the Philadelphia Social Science Association for 1876 and 1877, on the subject of building associations; Henry C. Lea had a "Letter to the People of Philadelphia" in the Forum, January, 1887, vol. 2, pp. 532-8. The reform charter or the "Bullitt Bill," which went into effect April, 1887, is said to be a model municipal constitution.

Chicago.—Reports of the Citizen's Association, beginning in 1874. Ada C. Sweet, on "Chicago City Government" in Belford's Monthly for November, 1892.

Charleston.—The Yearbooks contain in the appendices much valuable historical matter. That for 1880 gives a sketch of the development of the city government; that for 1883 a description of the centennial celebration, with an historical review.

Providence.—Town and City Government in Providence, a Study in Municipal History, by Geo. C. Wilson, Providence, Tibbitts & Preston, 1889.

Explanation of Plates.

Plate I. Skull of *Pteranodon* sp., one-fifth natural size.

Plate II. Left front paddle of *Clidastes velox* Marsh, two-thirds natural size. *C*, coracoid; *S*, scapula; *H*, humerus; *I*, first digit; *V*, fifth digit.

Plate III. Left hind paddle of *Clidastes velox* Marsh, two-thirds natural size. *Il*, ilium; *P*, pubis; *Is*, ischium; *F*, femur; *T*, tibia; *Fb*, fibula; *I*, first metatarsal.

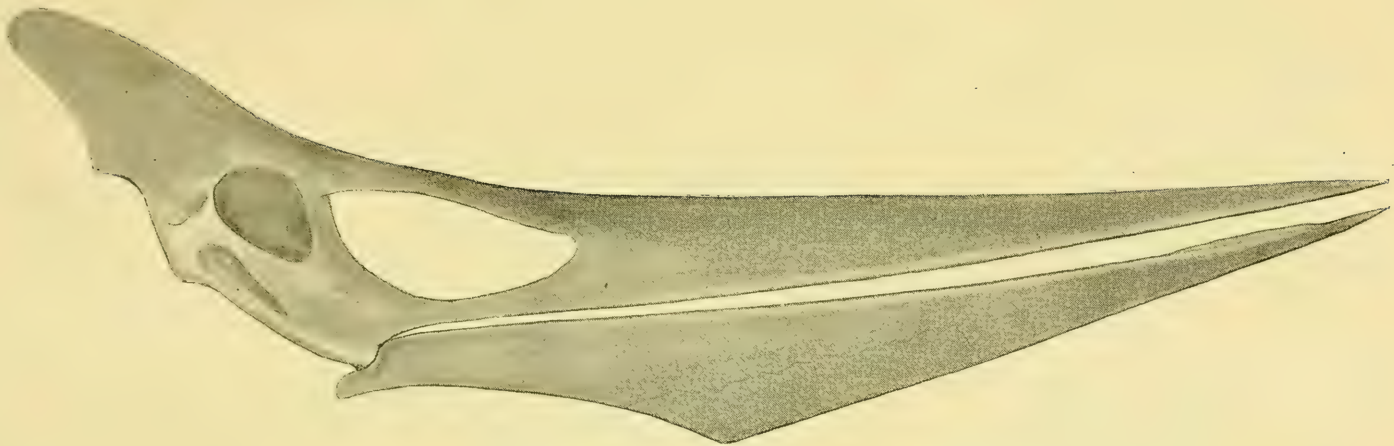
Plate IV. Right front paddle of *Clidastes Westii* Williston, one-third natural size. *S*, scapula; *C*, coracoid; *H*, humerus; *R*, radius; *U*, ulna; *I*, *IV*, first, fourth digits.

Plate V. Right hind paddle of *Clidastes Westii* Williston, one-half natural size.

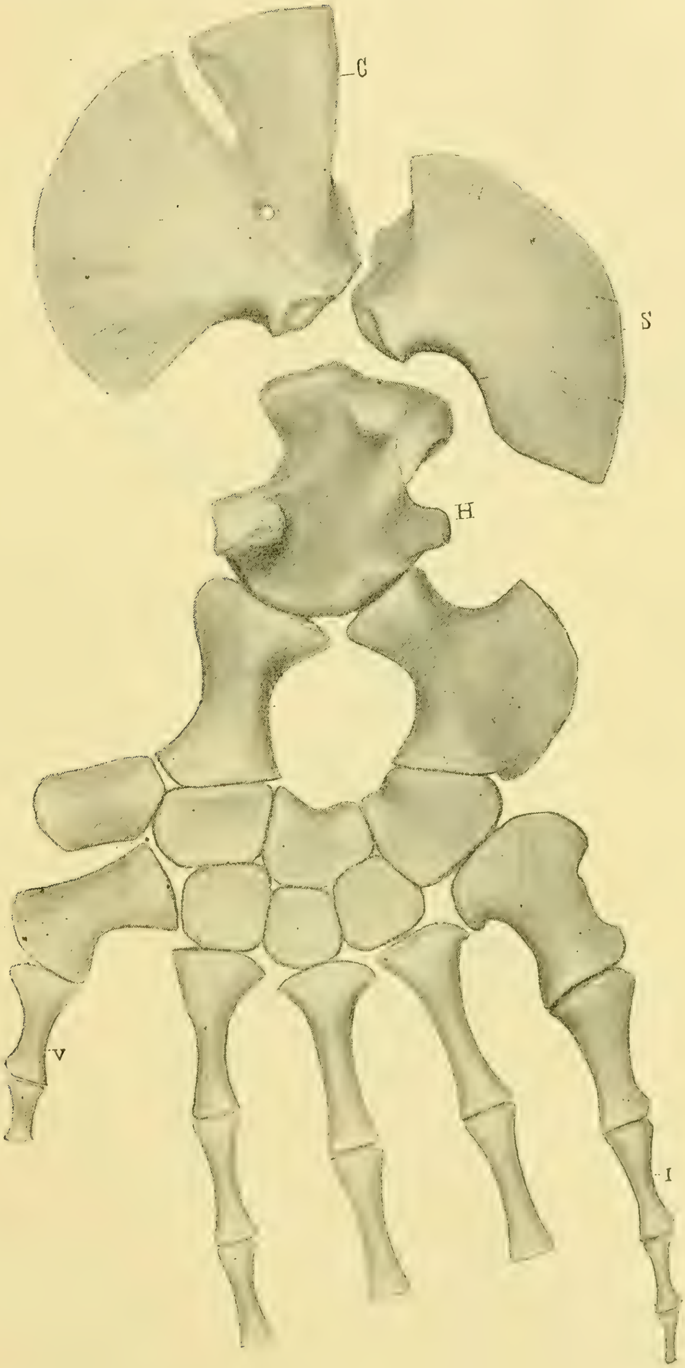
Plate VI. Eighteenth dorsal vertebra of *Clidastes Westii* Williston, natural size. Fig. 1, centrum from behind; fig. 2, from below.

Plate VII. Fig. 1, *Microdon megalogaster* Snow; fig. 2, *Brachyopa cynops* Snow; fig. 3, *Syrphus ruficauda* Snow; fig. 4, *Callicera montensis* Snow; fig. 5, *Tropidomyia bimaculata* Williston; fig. 6, *Rhingiopsis rostrata* Roeder; fig. 7, *Ancanthina hieroglyphica* Wiedemann.

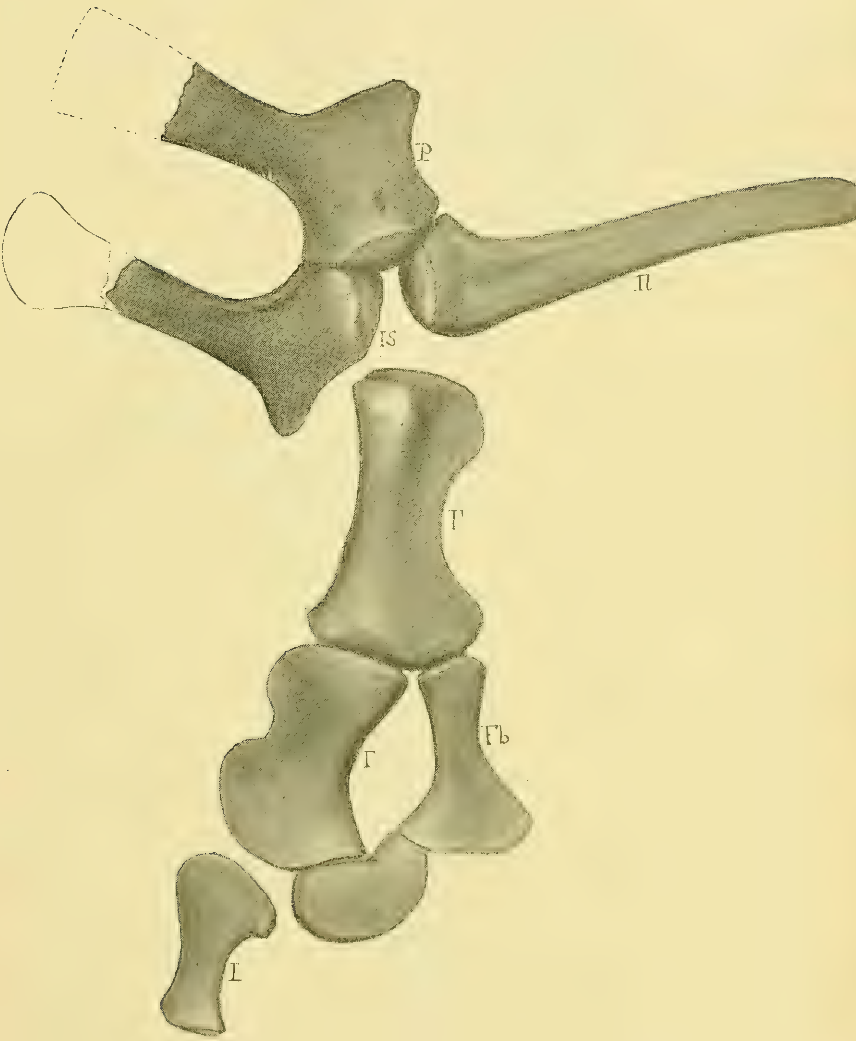
Plate VIII. *Melitera dentata.* Adult, silken cocoon and outer layer of dirt-masses held together by silken threads; larva (shaded); larva in outline showing position and number of tubercled hairs; hind wing of adult showing venation.



S. W. Williston. ad nat. del.



S. W. Williston, ad nat. del.



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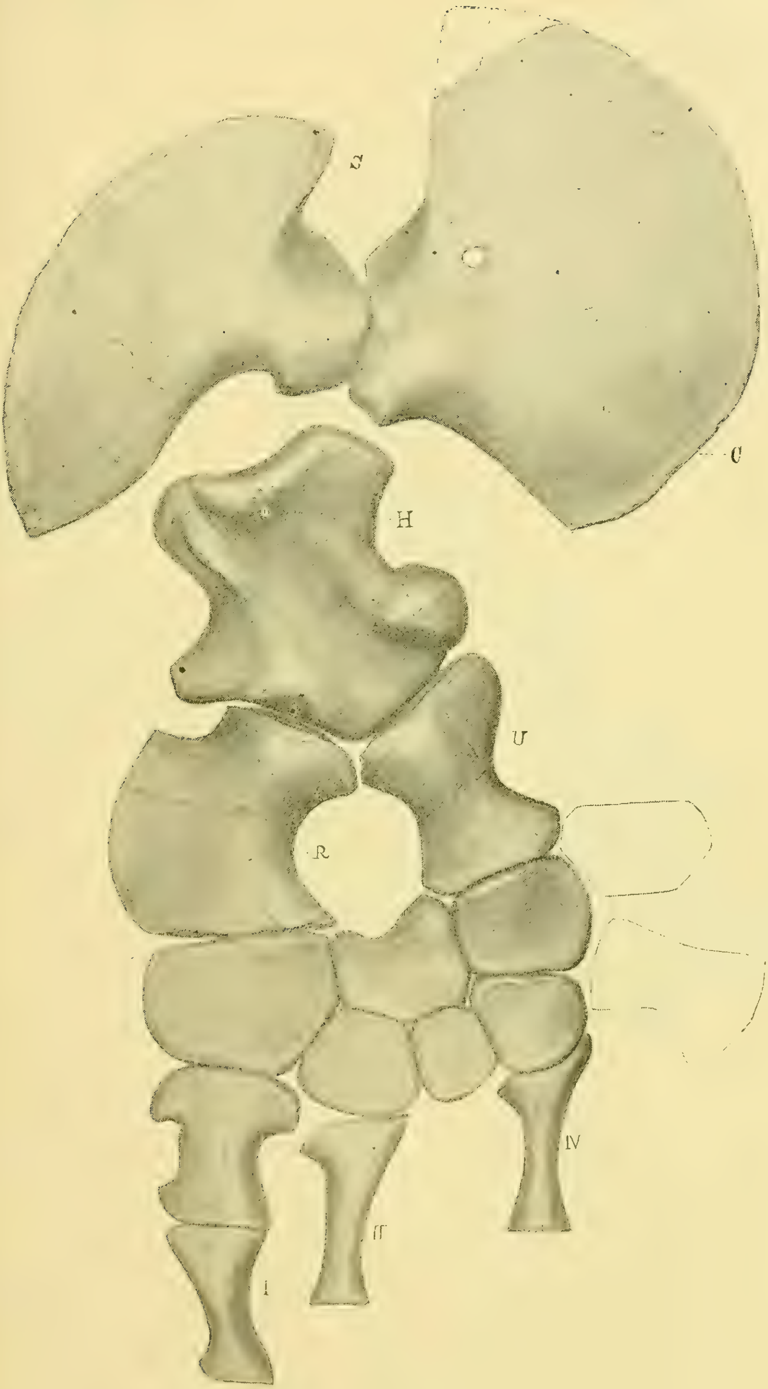

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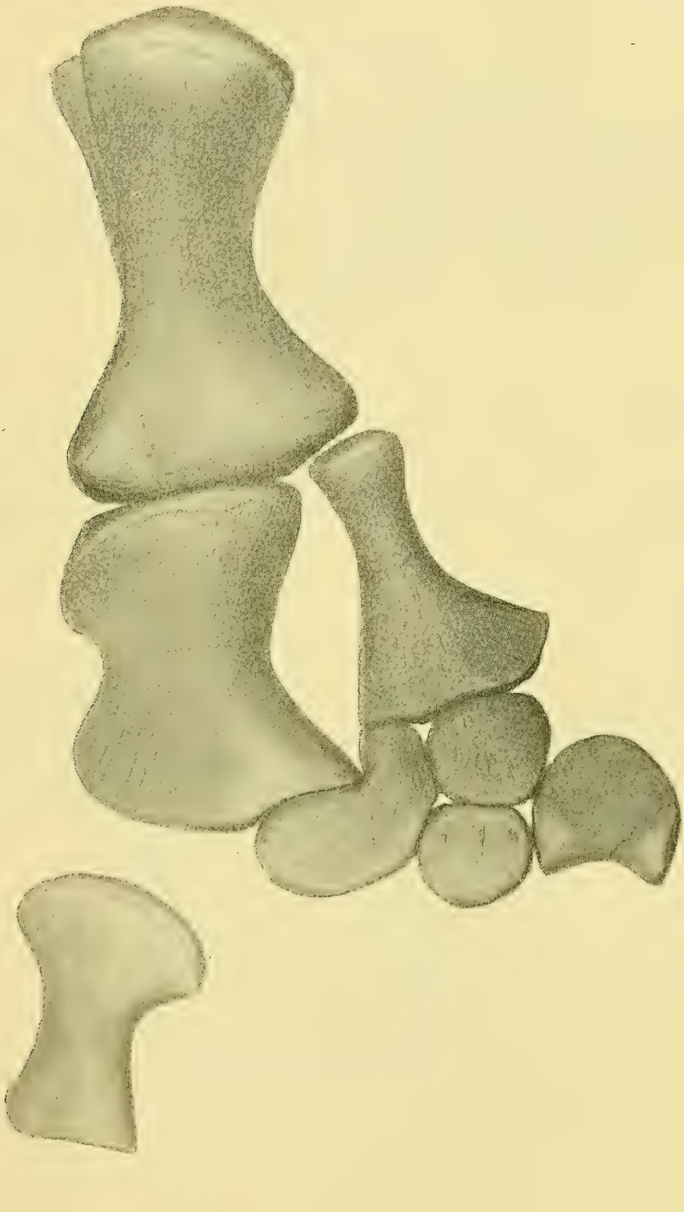
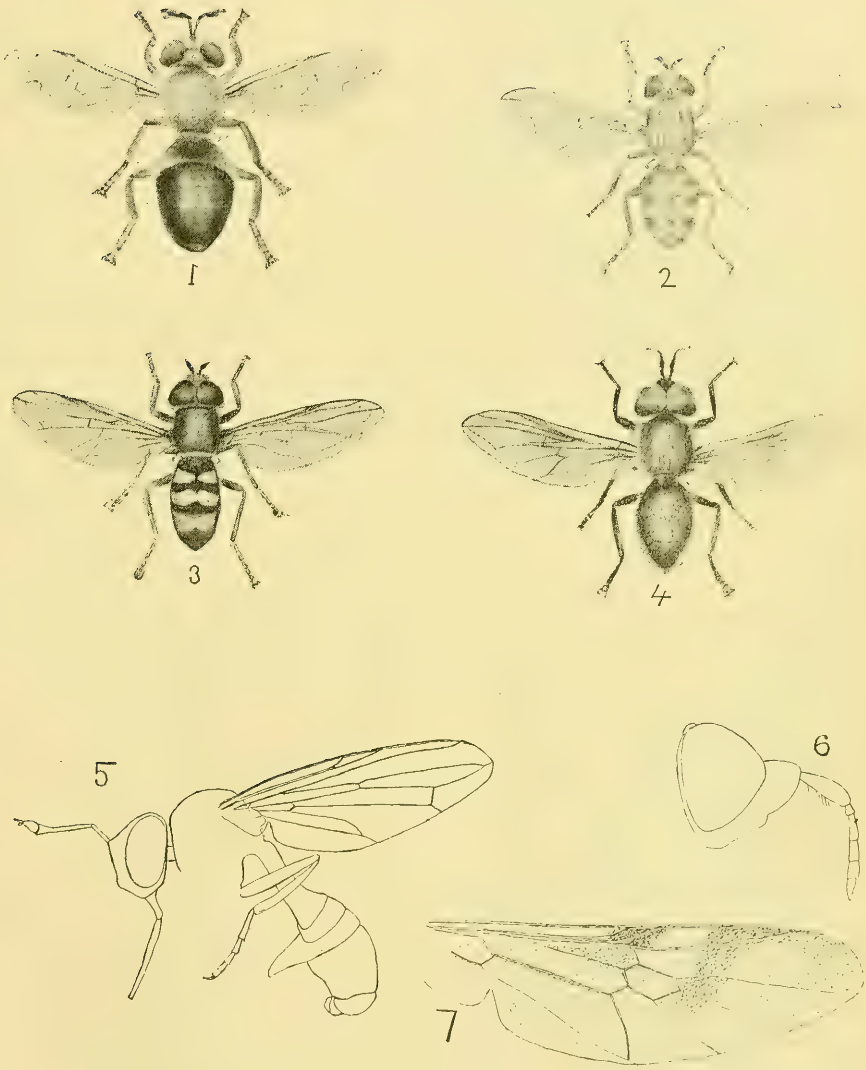


S. W. Williston, ad nat. del.

FIG. 1.

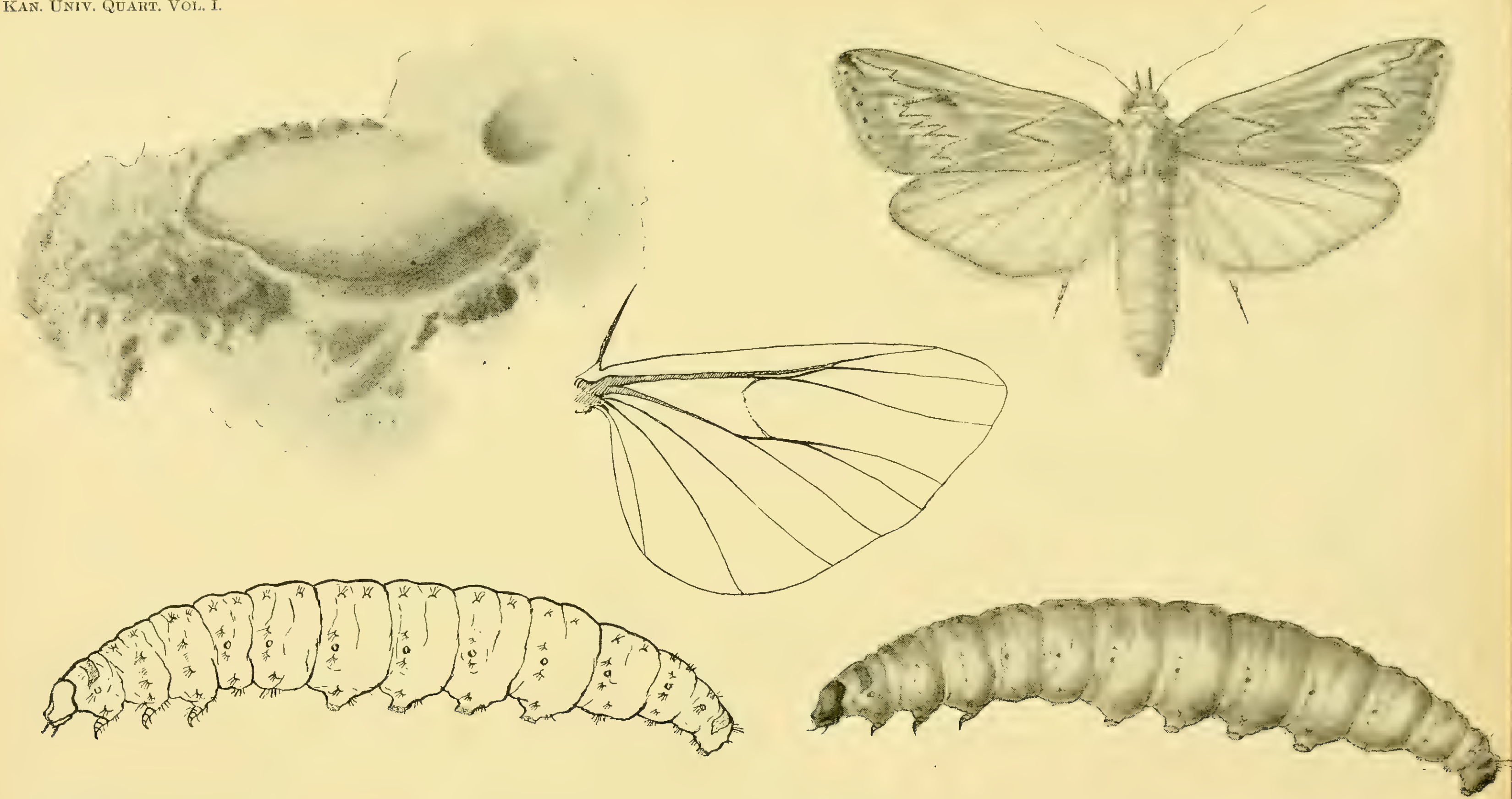
FIG. 2.

S. W. Williston, ad nat. del.



Mary Wellman and S. W. Williston, ad nat. del.

PLATE VIII.



Mary Wellman, ad nat. del.

PLATE IX.

Fig. 1. *Apiocera*, sp. *c*. *a*, paraglossa, from below; *b*, ligula, from below; *c*, palpifer; *d*, palpus; *e*, galea; *f*, labella; *g*, head.

Fig. 2. *Apiocera* sp. *a*, head; *b*, labellum, from inner side.

Fig. 3. *Apiocera haruspex*, O, S., head; *a*, leg.

Fig. 4. *Rhaphiomidas Acton* Coq., head.

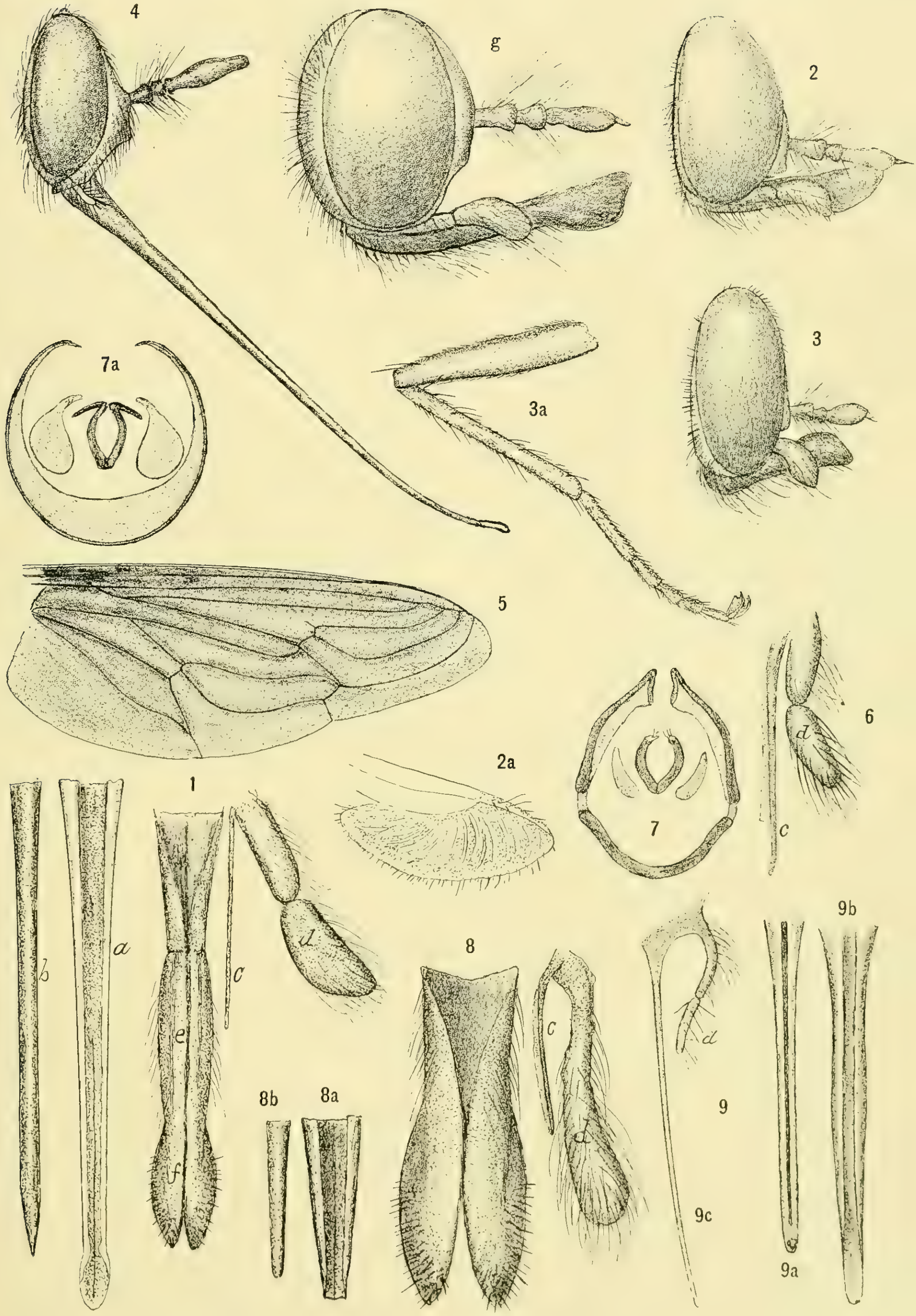
Fig. 5. *Mydas clavatus* Drury, wing.

Fig. 6. *Cyrtopogon*, sp. *c*, palpifer; *d*, palpus.

Fig. 7. *Proctacanthus Milberti* Macq., distal section of proboscis; *a*, proximal section, beyond end of paraglossa. The middle enclosed figure is the ligula; the lateral ones, the palpifers.

Fig. 8. *Psilocephala*, sp., galea, from above; *a*, paraglossa, from below; *b*, ligula, from below; *c*, palpifer; *d*, palpus.

Fig. 9. *Hirmoneura*, sp., Africa: *a*, ligula, from above; *b*, paraglossa, from below; *c*, palpifer. *d*, palpus.



S. W. Williston, ad. nat. del.

PLATE X.

Fig. 1. *Mallophora Freycineti*, *a*, paraglossa, from below; *b*, ligula from the side; *c*, palpifer; *d*, palpus; *e*, galea.

Fig. 2. *Hirmoneura*, sp., labella, from below, flattened out.

Fig. 3. *Apiocera*, sp. *b*. *a*, paraglossa, from below; *b*, ligula; *c*, palpifer; *d*, palpus; *e*, galea; *f*, labella; *g*, wing.

Fig. 4. *Apiocera*, sp. *a*, Australia. *a*, paraglossa, from below; *b*, ligula, from above; *c*, palpifer; *d*, palpus; *e*, galea; *f*, labella: *g*. wing.

Fig. 5. *Apiocera haruspex*, O. S. *b*, ligula, from above; *c*, palpifer; *d*, palpus; *e*, galea; *an*, antenna; *g*, wing; *h*, male genitalia.

Fig. 6. *Laphria*, sp. *a*, paraglossa, from below; *b*, ligula, from above; *c*, palpifer; *d*, palpus; *e*, galea, from the side.

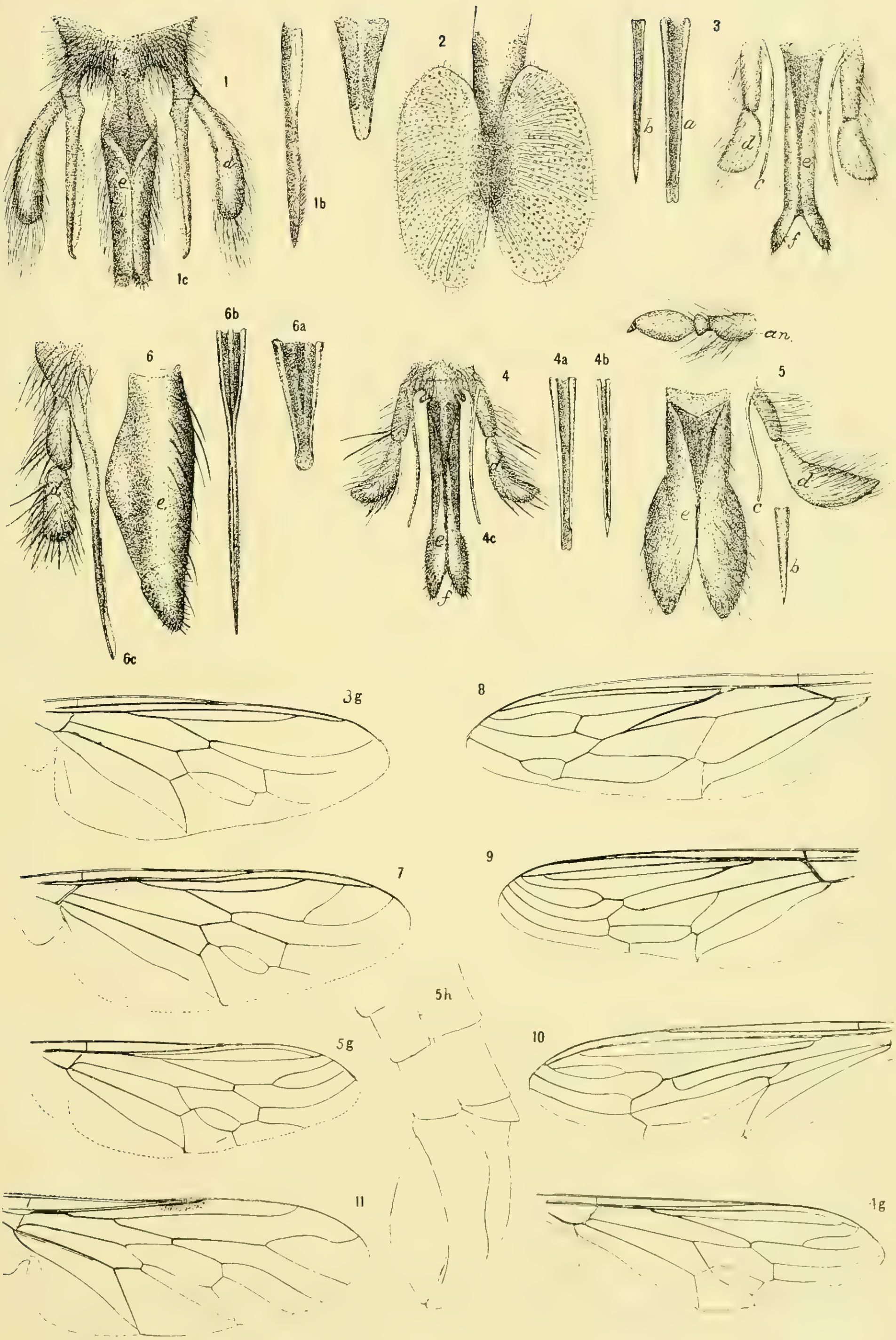
Fig. 7. *Apiocera*, sp. *c*, wing.

Fig. 8. *Hirmoneura*, sp. wing.

Fig. 9. *Rhaphiomidas Acton* Coq. wing.

Fig. 10. *Triclonus bispinifer* Westw. wing.

Fig. 11. *Psilocephala* sp. wing.



S. W. Williston, ad. nat. del.

PLATE XI.

Fig. 1. Cross section of leaf of *Spartina stricta*, parasitized by *Uromyces Spartinæ*. Magnified 110 diameters.

Fig. 2. Cross sections of leaf of *Eriophorum Virginicum*, parasitized by *Puccinia angustata*. Magnified 133 diameters.

Fig. 1.

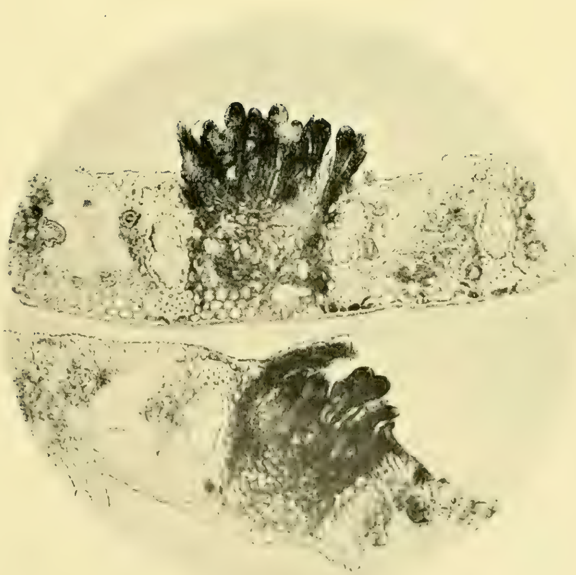


Fig. 2.

PLATE XII.

Fig. 1. Cross section of leaf of *Spartina cynosuroides*, parasitized by *Puccinia Phragmitis*. Magnified 98 diameters.

Fig. 2. Cross section of leaf of *Avena sativa*, parasitized by *Puccinia coronata*. Magnified 130 diameters.

Fig. 1.

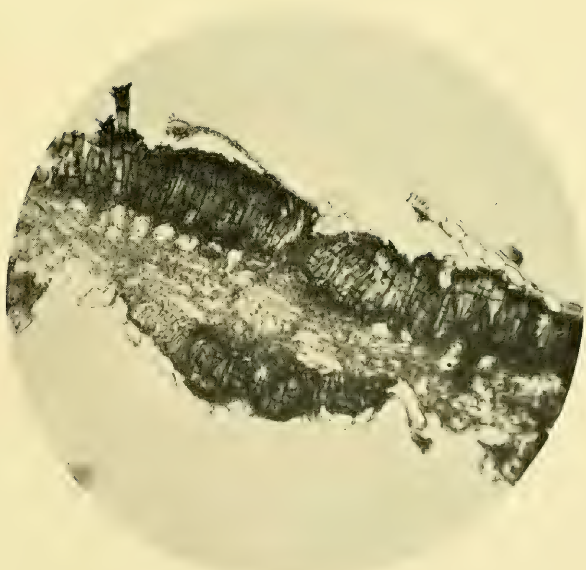


Fig. 2.

PLATE XIII.

Fig. 1. Cross section of leaf of *Setaria Germanica*, parasitized by *Piricularia grisea*. Magnified 111 diameters. *Setaria Germanica* is referred to in the text, by oversight, as *Panicum sanguinale*.

Fig. 2. Cross section of leaf sheath of *Zea-Mays*, parasitized by *Ustilago Zeæ-Mays*. Magnified 16 diameters.

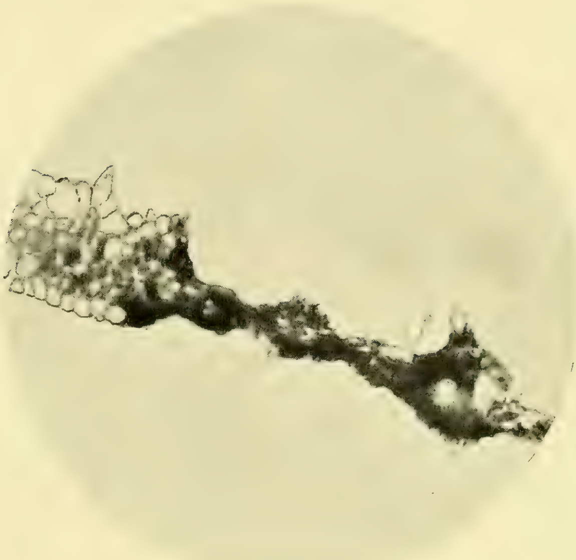


Fig. 1.

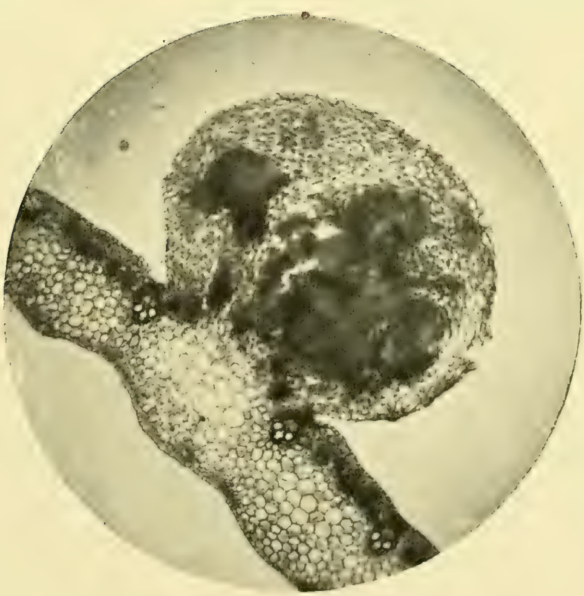


Fig. 2.

E. S. Tucker. Phot.

KANSAS STATE PENITENTIARY—MAIN ENTRANCE.

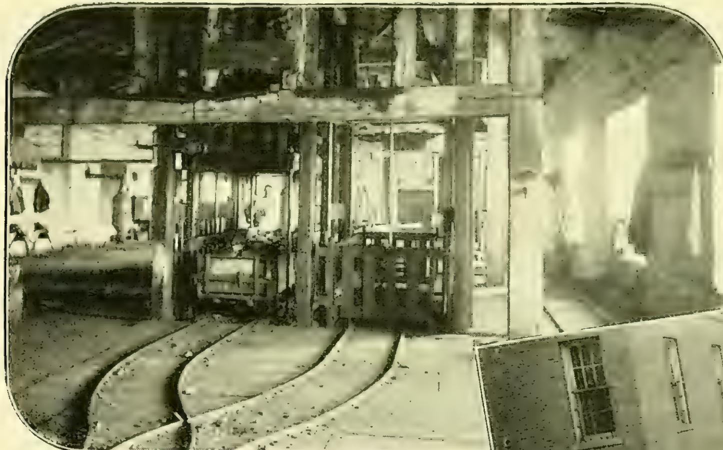
E. S. Tucker, Phot.

HORSE COLLAR FACTORY.

E. S. Tucker, Phot.

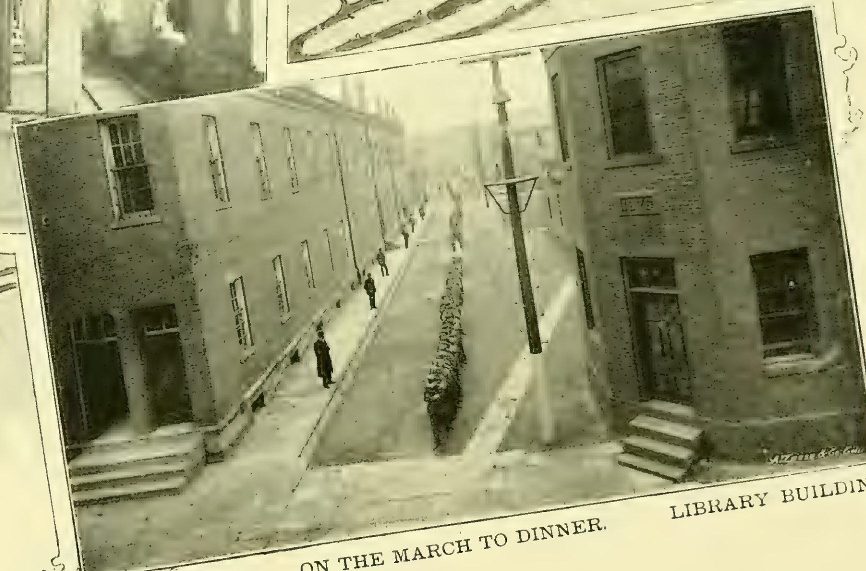
INTERIOR OF CELL HOUSE.

Fig. 4.



ENTRANCE TO COAL SHAFT.

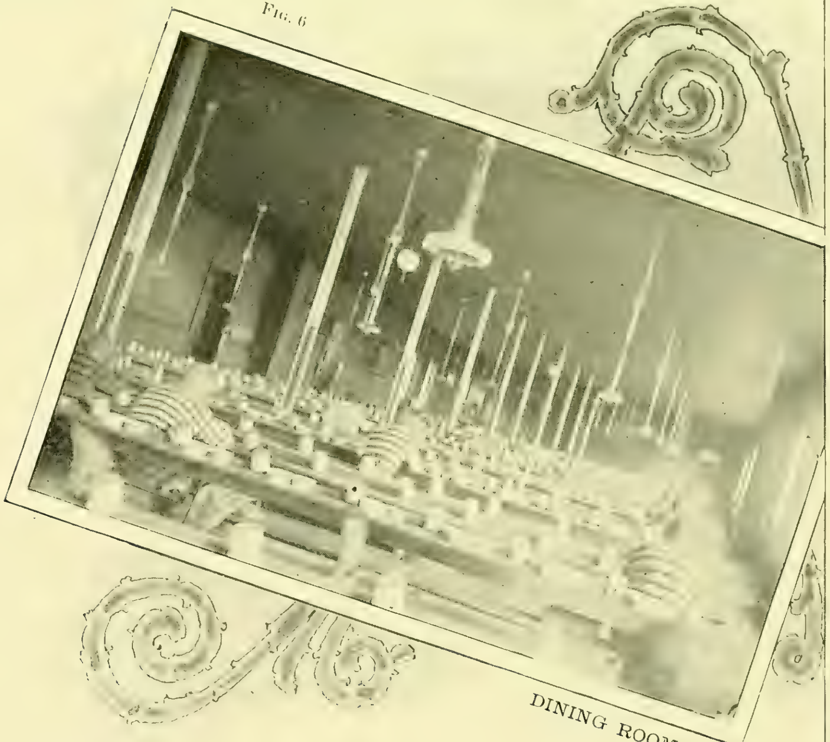
Fig. 5.



DINING HALL. ON THE MARCH TO DINNER. LIBRARY BUILDING.

E. S. Tucker, Phot.

Fig. 6



DINING ROOM.

Fig. 7.

INTERIOR OF CELL.

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