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KANSAS UNIVERSITY QUARTERLY.

VOL. VI. JANUARY, 1897. NO. 1.

Diptera Brasiliana.

BY S. W. WILLISTON.

PART IV.

Paramyia, gen. nov.

Front broad, plane, bristly on the sides, the bristles extending nearly to the antennæ; two reclinate ocellar bristles present. Antennæ short, the third joint broader than long, with a dorsal, finely pubescent arista. Face short, receding in profile, gently concave, the oral margin slightly protuberant; a vibrissal bristle present on each side. Cheeks narrow, with a row of short bristles on the inferior margin. Proboscis as long as the body; slender, with a hinge near the middle. Palpi elongate, projecting beyond the antennæ; broad, flattened, with a few bristles near their tip. Eyes round, bare. Mesonotum with prescutellar bristles, but no anterior centrodorsal ones. Scutellum large, with four strong bristles, the median ones remote from each other. Abdomen oval, composed of five visible segments, of which the fifth is the longest. Legs not elongate; provided with short hair; all the tibiæ without preapical bristle. First longitudinal vein of the wings very short, the auxiliary vein wholly rudimentary; the costa continues to the tip of the third longitudinal vein; anterior cross-vein situated near the base of the wing and before the tip of the first vein; posterior cross-vein wanting; second basal and the anal cells very small and indistinct, but complete; sixth vein imperceptible; second and third veins nearly parallel, the former gently concave anteriorly; third and fourth veins gently divergent.

This genus differs from *Phytomyza* in the extraordinarily developed proboscis and palpi.

Paramyia nigra, n. sp.

Female. Black. Front opaque, with a long, shining triangle, reaching nearly to the front border. Face more yellowish; in some reflections silvery on the sides. Proximal portion of the proboscis piceous; distal portion yellowish. Thorax shining; mesonotum with rather abundant, short, black hair. Abdomen less shining than the mesonotum. The knees narrowly, the front and middle tibiæ and tip of the hind tibiæ, and all the tarsi yellow. Wings tinged with brownish. Length 2½ mm.

One specimen, Grenada, H. H. Smith.

Beckeriella, gen. nov.

Front very broad and short; a single, small, fronto-orbital bristle present on each side. No bristle on the second joint of the antennæ; arista pectinate. Face about one-third the width of the head; flattened and receding on the upper half, the lower half or third projecting; with one or two small bristles on each side; clypeus prominent. Mesonotum without bristles save one on each side in front of the scutellum; hair very short, the acrostichal ones in two rows. Scutellum much swollen, with a long projecting spine on each angle, into which is inserted a bristle. Abdomen broad and arched; roughened; first segment very short, the fifth and sixth (female) together about equal to two-thirds the length of the fourth. Claws curved; pulvilli present. Third and fourth longitudinal veins of the wings convex anteriorly, the fifth ventricose posteriorly; the costal vein reaches to the fourth vein. Eyes bare. Oral opening small.

This genus has not a little resemblance to the following, and also to *Lytogaster*, from both of which it will be easily distinguished by the structure of the head, as well as by other characters. The male probably has only three visible abdominal segments.

It gives me pleasure to dedicate this genus to Mr. Theo. Becker, who is doing work of much value to American students in dipterology.

Beckeriella bispinosa.

Ephydra bispinosa Thomson, Eugenies Resa, 593. Rio de Janeiro.

Female. Front brown pollinose, opaque. Face moderately shining black. Antennae reddish yellow. Cheeks very narrow. Mesonotum shining, somewhat metallic black, with indistinct stripes of fine white pubescence. Halteres black. Pleuræ shining black; finely whitish or yellowish pubescent. Abdomen moderately shining, somewhat metallic black, with delicate white pubescence, leaving the narrow hind margin of the third and fourth segments shining, with a transverse, oval, white-pollinose spot before the hind margin. Legs black; all the tibiæ and tarsi reddish yellow, the terminal joints of the latter darker colored. Wings variegated, brownish and subhyaline, with dark brown clouds on the cross-veins; tip of the first vein and the nearly contiguous costa light yellow; a similar yellow spot is also seen on the costa a little beyond the humeral cross-vein. Length 3 mm.

One specimen, Rio de Janeiro.

Gastrops, gen. nov.

Front broad; plane between the orbital grooves, smooth and a little depressed; on either side with two fronto-orbital bristles, inserted close together. Second joint of the antennæ without anterior bristle; third joint about twice as long as wide; arista with pectinations above. Oral opening of moderate size; clypeus projecting. Face with a large, protuberant gibbosity, below which the profile is nearly vertical; on either side with a row of hairs close to the eyes, of which the upper ones are bristle-like. Eyes nearly round, bare. Cheeks in width equal to nearly one-half the vertical diameter of the eyes. Mesonotum convex; a single bristle present on each side in front of the scutellum. Scutellum convex, with a small tubercle on each posterior angle, from which arises a bristle. Abdomen broad, strongly convex; scrobiculate; first segment in both sexes, and the fifth in the male very short, giving the appearance in this sex of a triarticulate abdomen. All the tibiæ with a row of bristle-like hairs on the outer side. Claws curved; pulvilli present. The costa attains the tip of the fourth longitudinal vein; third vein gently convex anteriorly; fifth vein nearly straight; third section of the costa about two-thirds the length of the second.

Notwithstanding the absence of the spine on the second antennal joint, this genus and the preceding will both find their most natural position in the vicinity of *Hecamede*.

Gastrops niger, n. sp.

Male, female. Body shining, somewhat metallic, black. Antennæ red, the third joint at the tip and on the upper part black. Face on the lower part with a fine, light yellow pubescence. Mesonotum with indistinct indications of two longitudinal stripes and with short black hairs. Abdomen somewhat greenish, shining. All the tibiæ and tarsi, except the terminal joints of the latter, red or yellow. Wings tinged with brownish. Length 2½-3 mm.

Twenty specimens, Grenada and Rio de Janeiro, H. H. Smith.

Allotrichoma abdominale Williston, Dipt. St. Vincent, 398.

This species was placed in the genus *Hecamede*, notwithstanding the imperfect description given by Loew of the genus, by reason of its similarity to the European H. *lateralis* Loew, as shown by the description. Becker has since separated this species as the type of his genus *Allotrichoma*. This species agrees in nearly all respects with the figure and description given by Becker, and I am still in doubt of the identity. As the additional species described by Becker show a very close resemblance, it is very probable that the present is not the same as *laterale*. The peculiar bristles on the hind tibiæ of the male are present in this species, but I do not observe the hypopygial appendages figured by Becker. I have since examined typical specimens of *A. abdominale* from Brazil.

Ilythea flavipes Williston, Dipt. St. Vincent. 403.

My doubts concerning the location of this species are dissipated by the figures and descriptions given by Becker of the type and only other known species, *I. spilota* of Europe. The species is a true *Ilythea*, differing from *spilota* most especially in the short second longitudinal vein of the wing. This species I have also from Rio de Janeiro.

Psilopa aciculata Loew, Monogr. i, 142; Williston, Dipt. St. Vincent, 394, pl. xii f. 142.

Specimens of this species from Rio de Janeiro agree with others from St. Vincent and Grenada.

Psilopa nigrimana Williston, Dipt. St. Vincent, 363.

Several specimens from Brazil agree with the type specimens.

Psilopa metallica Schiner, Novara, Diptera.

Face narrow, not projecting in profile, shining metallic green, with a single bristle on each side below; on either side a row of slight inequalities. Antennæ yellow; arista with about eight rays. Front shining green, very finely aciculate. Scutellum more purplish, with four strong bristles. Pleuræ shining green and black. Abdomen deep metallic green or brassy, the fourth segment about as long as the two preceding together. Legs black; the knees and all the tarsi yellow. Wings yellowish, the immediate root blackish; second and third sections of the costa of nearly equal length. Length 2 mm.

There are some discrepancies from Schiner's description, as will be seen, but I hardly doubt the identity.

Brachydeutra argentata Walker, Dipt Saund. (*Notiphila.*)

Brachydeutra dimidiata Loew, Monogr. etc. i, 163.

This species seems to have a wide distribution; I have it from Brazil, Bolivia, Paraguay, Grenada and Kansas.

Scatella stagnalis Fallen, etc.

Scatella obscura Williston, Dipt. St. Vincent, 403.

I believe that the species described by me is identical with this European species, also recorded from Greenland. I have it also from Brazil.

Paralimna obscura, Williston, Dipt. St. Vincent, 390.

Specimens from Brazil agree with the types.

Paralimna multipunctata Williston, Dipt. St. Vincent, 390.

Numerous specimens from Brazil. In some there is a distinct cloud on the cross veins. Notwithstanding the absence of a stump of a vein, I am not sure that this species is not identical with *P. appendiculata* and probably also *P. secunda*.

Notiphila bellula Williston, Dipt. St. Vincent, 390

Numerous specimens from Brazil.

Notiphila pulchrifrons, n. sp.

Female. Front with a slender, silvery white stripe or triangle in the middle, with the immediate region of the ocelli brown; on either side a broader stripe convergent toward the middle, opaque black; outside the black stripe the narrow orbits are brown. Antennæ black; arista with about ten rays. Face much longer than broad, only moderately receding in profile, nearly straight and with a rounded carina on the upper part; light opaque yellowish grey in color. Mesonotum opaque dark brown, with two, narrow, more yellowish stripes, and, exteriorly, two elongated spots, or an interrupted stripe. The narrow lateral and anterior margins of the mesonotum white. Pleuræ silvery grey, with an elongated brown spot immediately below the noto-pleural suture. Abdomen dark brown, opaque, with a narrow medium stripe and the posterior angle of all the segments silvery or bluish grey. Legs black, the four posterior tibiæ and tarsi reddish. Wings lightly tinged with brownish. Length 4 mm.

Four specimens, Brazil, H. H. Smith. In some specimens the grey of the abdomen forms complete cross-bands.

Notiphila striata, n. sp.

Female. Front yellowish grey, the small ocellar triangle brown. Face straight and receding in profile, with a depression below each antenna; uniformly opaque yellowish grey in color. Mesonotum yellowish grey, opaque, with five narrow, brown stripes;

the middle stripe is geminate or forked posteriorly; the next outer stripe on each side ends a little beyond the middle, while the outermost ones are abbreviated both in front and behind. Pleuræ yellowish grey, with brown spots. Abdomen with four series of more or less confluent, coffee-brown spots on a bluish grey ground, narrowly separated by a stripe; posteriorly there are minute brown spots in addition. Legs black, the tip of the femora, the tibiæ and tarsi yellow, the front and middle tibiæ with brown rings. Wings tinged with brownish. Antennæ reddish yellow, the third joint blackish above. Length 4 mm.

Two specimens, Brazil.

Ochthera regalis, n. sp.

Male. Front much narrowed below, the sides concave; the large triangle in the middle sub-shining black, the orbits opaque, for the most part black. First two joints of the antennæ blackish, the third light yellow. Face much narrowed in the middle, where the width is scarcely greater than the length of the antennæ; in profile scarcely projecting beyond the eyes; longitudinally convex, with a low, flat tubercle in the middle, below which the color is metallic golden. Mesonotum in the middle with a broad purple stripe, continuous to the tip of the scutellum, and widened at the front margin: on either side of the stripe a narrow, white-pollinose stripe, reaching to the angles of the scutellum and turned outward in front to the humeri; exterior to the white stripe are two oval spots of a brown color, partly separated by a triangular white spot at the suture; lateral margins of the scutellum shining black. Pleuræ black, with an oblique, white-pollinose stripe. Abdomen shining, somewhat metallic, green-black. Legs black; the front tibiæ and tarsi, save the terminal joints, yellow; the four posterior tibiæ, the proximal portion of the dilated hind metatarsi and the terminal joints of the tarsi brown or brownish yellow. Front femora much dilated, their outer side whitish. Wings nearly hyaline. Length 5 mm.

Female. Face not wider in the middle than the length of the third antennal joint, without indication of the flattened tubercle; a brassy stripe in the middle, separated from the narrow whitish orbits by a fine line.

Two specimens, Rio de Janeiro. The oral opening is very small, and the cheeks are exceedingly narrow.

Ochthera humilis, n. sp.

Male, female. Front short, only a little inclined; the large ocellar triangle shining black, the orbits opaque black. Antennæ dark brown. Face at its narrowest place more than one-fourth of the width of the head, distinctly prominent in profile, the lower portion convex and receding; wholly opaque yellowish grey, except a small oval, metallic spot in the middle. Mesonotum greyish; somewhat metallic bronze in some reflections, with four, narrow, bronze stripes. Scutellum shining black on the flat portion; grayish yellow on the margins. Pleuræ black, with the usual oblique greyish stripe. Abdomen shining metallic, greenish black; in the male at least very distinctly pruinose; in the middle anteriorly with brownish spots. Legs black; all the femora greyish outwardly; all the tarsi reddish; front femora moderately thickened; hind metatarsi elongated and thickened, more so in the male. Wings nearly hyaline. Length 5 mm.

Two specimens, Rio de Janeiro.

Parydra humilis, n. sp.

Female. Front moderately shining, somewhat metallic, nearly uniform in color with some brownish dust. Antennæ black throughout; arista distinctly pubescent on the basal part. Face gently convex, nearly vertical on the lower part; rather thickly greyish and brownish pollinose; on either side with a moderately strong bristle and one or two shorter below it. Cheeks in width equal to more than half the diameter of the eyes. Mesonotum and scutellum shining, metallic black, with thin brownish dust; the acrostical hairs are bristle-like. Abdomen black, only a little shining. Pleuræ opaque greyish; on the upper part of the mesopleuræ sub-metallic. Legs yellow, the two distal joints of the tarsi black. Wings tinged with brownish, with an indistinct cloud on the cross-veins; the second section of the costa nearly three times the length of the third; second vein not appendiculated; third and fourth veins nearly parallel, or very slightly convergent. Length 4 millim.

Two specimens, Rio de Janeiro (Smith). The male specimen has the antennæ somewhat reddish, and the abdomen is more shining metallic in color. From *P. bicuspidata*, Karsch the only other described South American species, the present differs in the straightness of the third vein.

Lipochæta Coquillett.

The limits of the families Ephydridæ, Drosophilidæ, Oscinidæ, Agromyzidæ and Geomyzidæ are not at all what one might wish for classificatory purposes. Becker would exclude the genus *Aulacigaster* from the Ephydridæ. Schiner places it among the Drosophilidae, but does not greatly object to its location with either the

Ephydridæ or Geomyzidæ. Mik refers it to the Ephydridæ and Loew to the Agromyzidæ; all of which views render it clear that the definition of these families is not very exact. Through the kindness of Mrs. Slosson I have recently had the opportunity to examine the type species of *Lipochaeta* Coq. Its habitus is very foreign to the Ephydridæ and its union with it will require the abandonment of the families Oscinidæ and Agromyzidæ. No Ephydrid that I know of lacks bristles, while both of these latter families have numerous forms without them. The face is too short, the antennæ too different in structure to belong with the Ephydridæ. Moreover the pollinose body and white wings, while, not absent among Ephydridæ, are not at all common. All these characters, however, are found in species related to *Leucopis*, *Cryptochætum*, *Rhicnoessa*, etc. If it is a representative of a new sub-family, at least half a dozen other genera, like *Cryptochætum*, *Canace*, *Aulacigaster*, *Diastata*, *Leiomyza*, etc. will require the same treatment. I prefer to place it among the Ochthiphilinæ in the vicinity of *Rhicnoessa*. Its relation with *Lipara* can not be overlooked.

I may add to the description that the anal cell is incomplete, the costa is continued to the tip of the fourth vein, and the last abdominal segment (? female) is conical and elongated; the first vein does not reach the middle of the wing, the third and fourth veins are gently convergent; the second vein is long; and the ocelli are not remote from the vertical margin, as figured.

Physogenua vittata Macquart, Dipt. Exot. Suppl. iii, 60. pl, vii, f. 2; Becker, Berl. Ent. Zeitschr. xl, 255, pl. i, ff, 4, 5. *Lauxania variegata* Loew, Dipt. Amer. Sept. Centur. i, 83; Schiner, Novara Dipt. 277. *Sciomyza obscuripennis* Bigot, Ramon de la Sagra, 326 (Roeder, Stett. Ent. Zeit. 1885, 349).

Numerous specimens, Brazil.

Physogenua ferruginea Schiner, Novara Exped. 277. *Sapromyza urinc* Giglio-Tos, Bollet di Mus. Anat. Comp. di Torino, viii, 158; Ditt. del Messico, iii, (*Physogenua*).

Numerous specimens from Chapada, Brazil, agreeing quite with the descriptions.

"**Genus incertum**," Becker, Berl. Ent. Zeitschr. xl, pl. i, f. 12.

Numerous specimens from Brazil agree well with the characters given for this genus by Becker, and it seems probable that the species is identical with the one he had.

"**Genus incertum" nigra** Williston, Dipt. St. Vincent, 379, pl. xiii, f. 133, (*Physogenua*.)

Specimens of this species, referred by me to *Physogenua*, to which the relationship is the nearest, are not uncommon in Brazil, apparently. The figure of the head given by me is incorrect, in that the clypeus is not distinguished from the lower part of the face.

Sapromyza rubescens Macquart. Dipt. Exot. ii, 3,345; Schiner, Novara Dipt. 279; F. Lynch A., An. Soc. Cient. Arg. xxxiv, 288. *Sapromyza latelimbata* Macquart, Dipt Exot. Suppl. v, 120, pl. vi, f. 18 (Lynch).

Male, female. Head yellow. Front less than one-third of the width of the head, a very little wider below, with the usual strong bristles; the proclinate ocellar bristles small. Antennæ light reddish yellow, the third joint oval, rather more than twice as long as broad; arista black, moderately plumose. Palpi yellow. Thorax yellow, the mesonotum light reddish yellow; scutellum plane. Abdomen brownish yellow or yellowish brown. Legs yellow; all the tarsi (except the middle metatarsi), and the distal portion of the hind tibiæ brownish. Wings lutescent hyaline, the costa to beyond the fourth vein, and moderately broad clouds on the cross-veins, dark brown; the brown of the marginal cell for the first half does not quite reach the second vein; first vein very short, its termination about opposite the first section of the third vein; ultimate section of the fourth vein only a little longer than the penultimate section. Length 5 millim.

Eight specimens, Chapada and Rio de Janeiro, Brazil.

Sapromyza geminata Fabricus, Syst. Antl, 331, (*Dictya*); Wiedemann, Auss. zw. Ins. ii, 450; Schiner, Reise der Novara, Dipt., 279; F. Lynch A, An. Soc. Cient. Arg. xxxiv, 269, 299. *Sapromyza plagosa* Giglio-Tos, Bollet. di Mus. Zool. ed Anat. Comp. di Torino, viii, 158; Ditt del Messico, iv.

Wiedemann speaks of only two spots in the apical clouding of the wings; in the specimens before me there are three and sometimes four.

Sapromyza contigua (Fabr.) Wiedemann, Auss. zw. Ins. ii, 450; Schiner, Novara Dipt. 279; F. Lynch A, An Soc. Cient. Arg. xxxiv, 290.

Two specimens Chapada, agreeing well with the description. A third specimen from the same place differs in having the abdomen black. A fourth specimen, from Rio de Janeiro is perhaps specifically different. It agrees in everything save that the fourth vein is clouded nearly to the cloud of the cross-vein and the margin of the scutellum has two black spots.

Sapromyza macula Loew, Centur. x, 82; Williston Dipt. St Vincent, 380.

Numerous specimens from Brazil.

Sapromyza xanthiceps, n. sp.

Female. Face shining yellow, with two narrow stripes, convergent anteriorly, and on either side contiguous with the eyes; on the outer side of the two lower bristles a large round spot, all deep brown. The front at the vertex is as broad as its length; proclinate ocellar bristles small. Face, cheeks, proboscis and palpi light yellow. Face on the sides lightly silvery pollinose. Cheeks and occiput with black hairs. Antennæ light reddish yellow, the third joint about three times as long as wide; arista black, moderately long plumose. Thorax yellow, the mesonotum and scutellum light reddish yellow. Scutellum plane. Abdomen yellow or brownish yellow, the second and following segments each with a narrow posterior black band. Legs yellow; the distal end of all the tibiæ and the tarsi (except the middle metatarsi) brown. Wings luteous hyaline; the costal, marginal, the anterior part of the submarginal from in front of the cross-vein, and its distal part wholly, the distal part of the first posterior, extending into the second posterior cell, broad clouds on the cross-veins and a narrower cloud on the fifth vein dark brown; first longitudinal vein very short, terminating about opposite the middle of the first section of the third vein; penultimate section of the fourth vein about two-thirds of the length of the ultimate section. Length 6-6½ mm.

Two specimens, Piedra Blanco, Brazil.

Sapromyza picrula, n. sp.

Male, female. Head opaque light yellow. Front with the sides parallel, a little more than a third of the width of the head; a rounded brown spot on either side at the insertion of the lower bristle, apparently the lower one of an obsolete stripe. Proclinate ocellar bristles strong. First two joints of the antennæ blackish; third joint light reddish yellow, more than three times as long as wide; arista black, moderate long plumose. Face at the middle of each lateral depression with a brown spot, connected by a slender line with a median spot above the oral margin, forming a U or V shaped figure. Proboscis and palpi black. Mesonotum light ochraceous yellow, with two, narrow, median stripes or slender spots, and, on each side with a number of spots, all light brownish or reddish. A single bristle on each side in front of the a prescutellar row. Scutellum plane, with a large black spot on each lateral margin. Abdomen yellow, with three series of large black spots, the middle ones forming a stripe; in some specimens the abdomen appears to have an irregular black band on the anterior part of each segment. Legs deep brown; the base of the front and middle tibiæ, the middle tibiæ, save the distal end, and the first one or two joints of the four posterior tarsi light yellow. Wings smoky hyaline; the distal portion from the tip of the first vein obliquely across to the back of the fourth vein brown; posterior cross-vein less deeply clouded; termination of the first vein before the anterior cross-vein; ultimate section of the fourth vein about twice the length of the penultimate section. Length 5 mm.

Six specimens, Chapada. A number of other specimens from the same locality differ as follows: Color light yellow; front with two dark brown stripes, not enlarged into a spot below. Face with a small V-shaped brown spot below. Mesonotum with six, narrow, light brownish stripes, the four in the middle more approximated; just outside them, and between them and the lateral stripe, an incomplete stripe back of the suture. Spots on the scutellum smaller. Legs yellow, front femora on the outer and distal part, hind femora to the immediate tip, and the distal joints of all the tarsi brown or brownish, color of the wings much less intense, being brown only on the outer part of the costa.

Sapromyza exul Williston, Dipt. St, Vincent.

A single specimen from Rio de Janeiro.

Sapromyza bipunctata Say, Compl. Wr. 367-Mexico.

A specimen from Rio de Janerio may be of this species. The head is yellow, including the antennæ. The arista is bare. The abdomen is of a uniform brownish color, perhaps the effect of dessication. The wings have a broad brown costal border, extending around the tip to beyond the fourth vein; a small projection from it extends across the middle of last section of the third vein. There is a narrow, dark brown cloud on each cross-vein.

Sapromyza lupulinoides, n. sp.

Male. Front yellowish; on the lowermost part a narrow transverse band light yellow, above which there is a black band of a little greater width, the upper margin of which is not sharply defined; a small black spot on either side of the root of the antennæ. Antennæ yellow; third joint about three times as long as wide; arista short plumose, or rather, long pubescent. Face light greyish yellow, with a blackish spot in the middle below. Thorax black, but whitish pollinose, giving a slaty color; scutellum dark brown, the immediate base grey. Abdomen uniformly reddish yellow or light ferruginous in color. Legs black, the front tarsi at the base yellowish. the four posterior tibiæ and tarsi yellow, save that the tip of the tibiæ is blackish. Wings uniformly yellowish. Length 4 millim.

One specimen. This species is closely allied to *S. lupulina* of Europe and North America, but will be at once distinguished by the short plumose arista.

Stegana.

Specimens of two or three species of this genus, from Brazil, evidently indicate close colorational resemblances as characteristic of the genus. Among them I believe I recognize in an imperfect specimen, *S. tarsalis* Will., which may be identical with *S. flavipes* Wied. Another species has the front much depressed and broad, the face and cheeks yellow and the palpi slender, but otherwise agrees with *S. hora* Will.

Drosophila opaca Will. Dipt. St. Vincent, 411.

Specimens from Brazil agree well with the types.

In a recent number of the Wiener Ent. Zeitung, Professor Mik, in calling attention to the preoccupation of the name *Sackeniella* mihi, states that Osten Sacken had shown its identity with *Curupira* Müller. I was quite familiar with Osten Sacken's paper when I proposed the name, and I think if Professor Mik will again examine the article, he will see that Osten Sacken did not consider the genera identical. That *S. rufescens* was included in the forms described by Müller as *C. torrentium* is probably true, as Osten Sacken shows, but that *C. torrentium* and *S. rufescens* are identical, can not be possible. "If my supposition be correct, *S. rufescens* would be the first species described in the mature state among the group of larvæ studied by Dr. F. Müller. The question of the other forms must remain open until we likewise obtain mature specimens of them."

Notwithstanding Müller's deserved repute as a naturalist, no dipterologist can accept the conclusions that *C. torrentium* had dimorphic females—one mellisugous and holoptic, the other sanguisugous and dichoptic. Certainly no such extraordinary conclusion can be accepted until such females have actually been bred. Prof. Mik will see by turning to Dr. Osten Sacken's paper (p. 162) the generic definition he has given for *Snowia* and *Curupira*.

Restoration of Oreodon Culbertsonii Leidy.

BY ALBAN STEWART.

(With Plate I.)

Among the material of the Oreodontidæ of the Kansas Museum are two remarkable specimens of *Oreodon culbertsonii*, collected by Dr. Williston in the White River Miocene of eastern Wyoming. The two specimens are lying in one slab, close together, the one, an older individual, partly overlying the other. The skeleton of the older animal lies with nearly all its bones in place, the only ones displaced being five cervical and six anterior dorsal and the caudal vertebræ. The other specimen is apparently complete, though some of the bones are partly concealed yet in the matrix. The two animals together furnish nearly every bone of the skeleton, the only ones left in doubt being the last rib, the terminal caudal vertebræ and the fifth digit of the front foot.

A restoration based upon this remarkably perfect material was nearly completed before I obtained access to the very thorough paper by Professor Scott on the same animal, in the Morph. Jahrbuch, lxvi, pp. 319-395, and, notwithstanding that the restoration given by him is in most respects excellent, I have thought it worth while to publish the present one, inasmuch as there are certain errors in Professor Scott's restoration, due to the insufficiency of the material upon which it was based. The present paper is, therefore, in a measure corrective of his paper, but for the most part supplementary.

The principal corrections here made are in the length of the tail, the shape of the pelvis, the position of the acromion process of the scapula and the presence of the metacromian, the form of the posterior superior angle of the scapula, and in the number of dorsal and lumbar vertebræ, as well as the length of the posterior ribs.

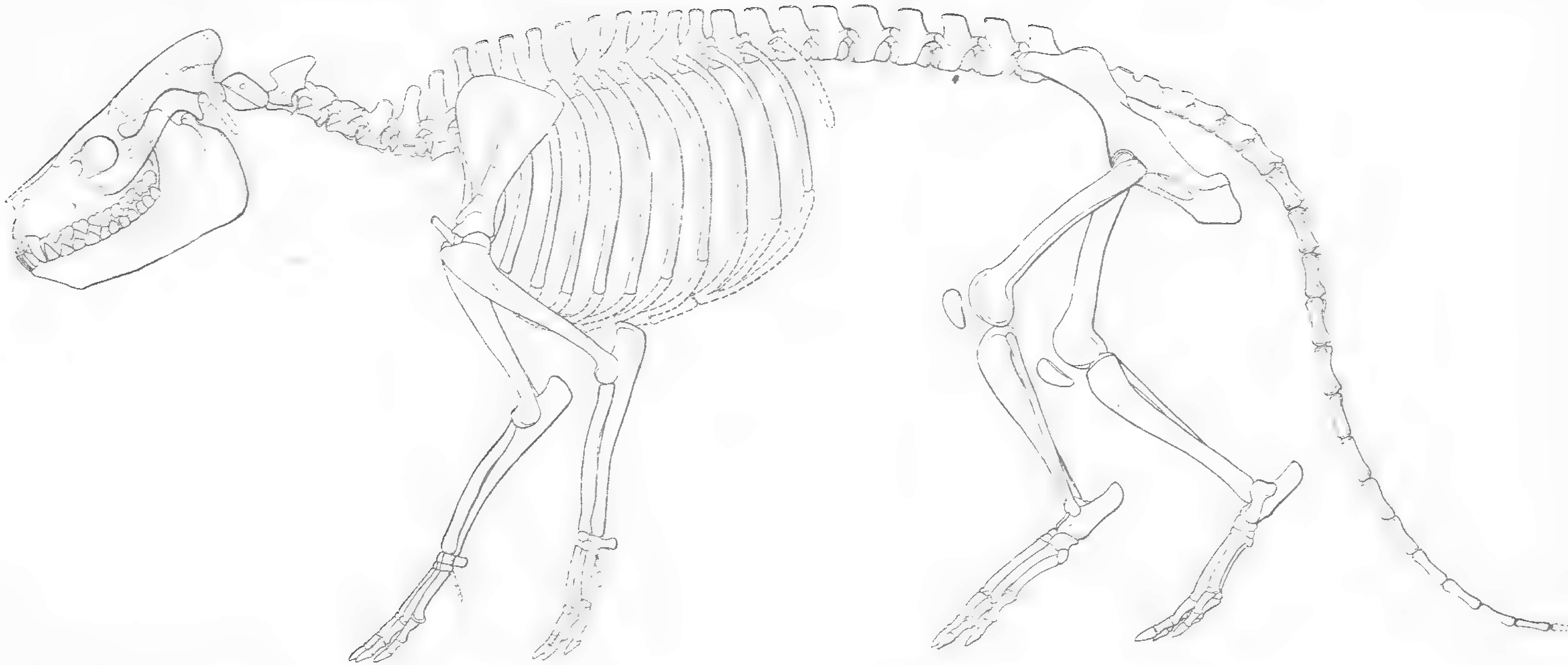
The caudal vertebræ are scattered and largely missing in the larger individual, but are nearly all in place in the younger skeleton, one or two at the tip being absent. There is not much difference in the size of the two individuals, and a careful comparison of the other bones shows very clearly the precise degree of enlargement required for the restoration. Scott suspected that the short tail figured by him might be incorrect, as appears from the following: "Obgleich kein mir bekanntes Exemplar von Oreodon einen vollstaendig erhaltenen Schwanz besitzt beweisen doch die vielen vorhandenen Wirbeln dass das Thier einen sehr langen Schwanz gehabt hat, eben so lang, wahrscheinlich, wie bei Anoplotherium." (Scott, l. c.)

The general form of the ilium is somewhat more slender than is indicated by Dr. Scott's figure, the superior border is slightly excavated, instead of arched, and the angles formed with the anterior and posterior borders are rounded and not acute. The ischium also presents a prominent tuberosity not shown in the figure, and which resembles that of the dog more than of the Artiodactyla.

The spine and acromial process, instead of being directed slightly backward, are curved gradually forward, and at the lower extremity project beyond the anterior border of the scapula. The superior portion of the metacromian process is wanting in the specimens, but there is sufficient remaining to indicate a considerable development in this species.

All the lumbar vertebræ and seven of the dorsals are in place. The sixth presacral is a true lumbar, showing no rib-facet, and it is provided with long, broad, transverse processes.

The ninth, tenth and eleventh ribs are in place, from which it is evident that the posterior ones are longer than were figured by Scott.



A. STEWART. from nature.

RESTORATION OF OREODON CULBERTSONII LEIDY.

Oreodon Beds, White River Miocene. One-fifth natural size

Gypsum in Kansas.

BY G. P. GRIMSLEY.

With Plates III, IV, V, VI.

HISTORICAL INTRODUCTION.

Gypsum (sulphate of lime), from two Greek words $\gamma\eta$=earth, and $\epsilon\psi\omega$=to concoct, is a mineral which has attracted attention from very early times. The transparent variety known as selenite was used by the ancients as a substitute for glass in windows. The best varieties were supposed to be in Upper Egypt and in Syria. It was also in favor for ornamental boxes, and for urns, in which lighted lamps were placed, and so threw a soft light through the apartments. The walls of the temple of Fortuna Seia were made of compact gypsum, and the interior, though without windows, is described as "sufficiently lighted by rays transmitted through the semi-pellucid walls." The writings of Theophrastus show that the Greeks were familiar with the use of plaster of Paris, made from calcining the gypsine stone in making casts. The term alabaster is commonly noted in the ancient writings, and sometimes refers to compact gypsum and sometimes to the stalactite carbonate of lime, so that it is often difficult to tell from the meagre descriptions which is intended.

The earliest account of the use of gypsum as a fertilizer in the ground form known as land plaster is in 1768, when a German clergyman, by name of Mayer, used it with success. After this time there were numerous experiments made to test its efficiency and the faith of the workers along this line gave the appearance of wonderful results. Thus one writes, that "the invariable results of several experiments incontestably prove that there is a most powerful and subtile principle in this tasteless stone, but by what peculiar agency or combination it is capable of forcing vegetation in such an instantaneous and astonishing manner is a mystery which time reserves for others to unfold."

Gypsum in nature occurs in five forms, all of which are found in the State of Kansas. 1. The earthy form, yellow or gray in color, and composed of loose dust-like particles, rather light in weight, and is formed from solution of gypsum in water. 2. The compact variety, including alabaster and massive gypsum, which is very soft and of specific gravity, 2.2 or near. 3. Fibrous gypsum or satin spar, usually found in thin layers, in form of fine needles or prisms. 4. Foliated gypsum, sometimes massive, but usually in small concretionary masses. 5. Spar gypsum or selenite, found in transparent crystals.

Gypsum is found in Thuringia, Saxony, Norway, at Mont Martre near Paris, Austria, Bohemia, Italy, Egypt, Arabia, Persia, and many other places in the old country. In the United States it is found along an east and west line in central New York, from Oneida county to Niagara; near Sandusky, Ohio; near Grand Rapids and Alabaster Point, Michigan; in Smyth and Washington counties, Virginia; in Alabama and Louisiana; in Iowa, Kansas, Arkansas, Texas, Oklahoma, Indian Territory, Colorado, Montana, Utah, South Dakota, Wyoming, Arizona, Idaho, New Mexico, California. The total amount produced in the United States in 1894 was 239,312 short tons. The State of Kansas* produced that year 64,889 tons, of which all but 647 short tons was calcined, thus standing second to Michigan among the states in quantity mined. The value of this product was $301,884, an excess of $112,264 over Michigan, placing this state first among the states of the Union in value of gypsum products. The value of the Kansas gypsum mined that year was greater than that of all the other states, excepting Michigan. There has been an increase in value of the gypsum products of Kansas of $207,649 in six years, which makes a record the state may well be proud of, and at the present time a very small percentage of the available supply has been taken, so that Kansas gypsum has a promising future.

LOCATION AND DIVISION OF AREA.

The gypsum deposits in Kansas occur in a belt trending northeast-southwest across the state. The belt of exposed rock varies in width from five miles at the north to fourteen in the central part and thirty-six miles near the southern line, with a length of 230 miles.

This area is naturally divided into three districts, which are named from the important centers of manufacture: the northern or Blue Rapids area in Marshall county, the central or Gypsum City area in Dickinson and Saline counties, the southern or Medicine Lodge area in Barber and Comanche counties. These areas ap-

*Statistics from 16th Annual U. S. Geological Survey, 1896.

pear to be separate, but careful mapping shows a number of isolated intermediate deposits which serve to connect at least two of the larger areas. Gypsum is reported from near Randolph and in the reservoir excavation at Manhattan in Riley county. It is worked for plaster at Longford in the southern part of Clay county, and it is found near Manchester in the northern part of Dickinson county. These smaller areas indicate a connection between the northern and central areas.

Gypsum deposits of economic importance are reported from near Peabody in Marion county, while they appear to be absent through Reno, Sedgwick and Kingman counties, where the extensive salt deposits occur. There is thus a break between the central and southern areas which is occupied by salt deposits.

GEOLOGY.

The northern area is located in the Permian beds, consisting of fossiliferous limestones and shales. The central area lies in the Permian, though higher than the northern, while the salt measures to the south occur near the top of the Permian. The southern Kansas gypsum is found in a series of red, sandy shales, called the Red Beds, which probably mark the transition from Permian to Cretaceous. The deposits, therefore, rise geologically from north to south, but they are confined to the Permian formation. The deposits to the south in Indian Territory and Texas are placed in the Permian, while those at the north in Iowa are referred to the Cretaceous.

TOPOGRAPHY.

The northern area shows the remnant of a plateau of 1250 feet elevation now indented by the Blue rivers and their tributaries, yielding a somewhat rugged topography. (This is shown in plate III from photograph at Manhattan with Blue river on right.) The central area lies seventy miles southwest of Blue Rapids, The area is drained by the Smoky Hill river, which flows in an extremely irregular or winding channel north of east, uniting with the Republican river at Junction City, thirty miles away, to form the Kansas. It flows in the middle of a broad valley 1100 feet above sea level and a mile or more in width. Its tributaries in the gypsum area are three or four small creeks—Gypsum, Holland and Turkey which flow almost directly north. The main water-shed lies twenty-two miles to the south of the river, and trends nearly east and west, with an elevation of 1500 to 1550 feet. This descends on the south side within eight miles to 1400 feet at the Cottonwood river. The divides between the north flowing creeks have a gradual slope of about twenty feet to the mile and their sides are deeply indented by erosion. They vary in height above the creek level from 100 to 150 feet. The effect is that of a dissected plateau with irregular surface. A number of small towns are situated along the railroads in the central part of the area, while larger cities are located on the river.

The southern area is situated 120 miles southwest of Gypsum City. The northern part is drained by the Medicine Lodge river, which rises in Kiowa county and flows southeast to Medicine Lodge, where it abruptly turns south and flows into Oklahoma; there it empties into the Salt Fork of the Arkansas river. The southern part is drained by the Nescatunga and its branches. The streams have cut deep channels or canyons in the soft strata which reach 200 feet in depth. The water shed between the two rivers is broad in Comanche county, with an elevation of 2200 feet; but it rapidly narrows to the southeast in Barber county, where its elevation is 2000 feet, descending to 1600 feet in the valley of the Medicine Lodge river within a distance of seven miles. The watershed trends parallel with this river and turns south near the central part of Barber county, still parallel with the river. This region, with its gypsum capped buttes of red clay and shale, possesses a very rugged topography and gives evidence of great erosion. These features are well shown in the photograph of Flower Pot Mound shown in Plate IV; and also in the photograph of the Gypsum Hills, near the town of Medicine Lodge, shown in Plate V.

BLUE RAPIDS AREA.

The first gypsum deposits worked within the state of Kansas were in the northern or Blue Rapids area. In November, 1869, the commissioners laid out the site for the town of Blue Rapids. They carefully investigated the natural resources of the region and recognized the value of the water power of the Blue, and also the value of the gypsum deposits which had been known for some time to exist on the Big Blue about two miles northwest of the town. On selling their various properties they made a reservation along the Blue of 100 rods, including the known outcrop of the beds and extending back from the river for a distance of 320 feet.

About the year 1871 Mr. J. V. Coon, of Elyria, Ohio, came to the new town, and, as the story goes, he burned some of the gypsum and carried it back to Cleveland, where it was pronounced to be of good quality and two car loads were ordered at a good price. He and a brother returned to Blue Rapids in 1872 and built a frame shed on the east bank of the river, below the town. In an iron kettle, which held about five barrels and which was heated by a stove, they commenced the manufacture of plaster of Paris. Prosperity seems to have attended their work, for in 1875 a stone mill was built by Coon & Son on the west side of the river and the water power of the river was now used for grinding. This mill is now standing, a monument to the commencement of a great Kansas industry. The town, for purpose of encouragement of the new departure, granted them the north half of their reservation, described as extending from a point at the middle of the outcrop and thence north. This mill was operated for nearly twelve years and then the firm unfortunately failed. The mill property and the gypsum grant of fifty robs of outcrop and twenty rods back in the hill, came into the hands of Mr. Sweetland, a business man of Blue Rapids. It was leased to several parties and the mill was run to the year 1889, when the flood caused considerable damage resulting in the abandonment of the mill.

Mr. Hayden, of New York, in 1887 bought the remaining portion of the old reservation and the adjoining Robinson farm. Fowler Brothers bought the farm back of the Sweetland twenty rods limit.

The earlier mining was done by stripping the cover of dirt and shales, and the rock was hauled in wagons to the mill. Later it was brought down the river in flat boats, drawn by a small steam tug.

In 1887 the Fowlers formed the Blue Rapids Plaster Company and built a one and one-half story frame mill of one kettle capacity on the west side of the river at edge of town. The present entry to their mine is fifteen feet above the water level, though the gypsnm bed rock is the bed rock of the river, which is four feet deep at this place. The entry runs east about 350 feet and the gypsum dips west toward the river. Five men are employed at the mine, and the rock is hauled out and up an incline to the railroad where a twenty-five ton car is loaded in two days and hauled to the mill. The gypsum occurs as a gray, mottled rock, with sugary texture, breaking with irregular fracture. The top consists of a layer of white selenite needles forming satin spar, with a thickness of one-fourth to one and three-fourth inches. Throughout the mine are numerous cutters, in which are found perfect, transparent crystals of gypsum, usually of small size.

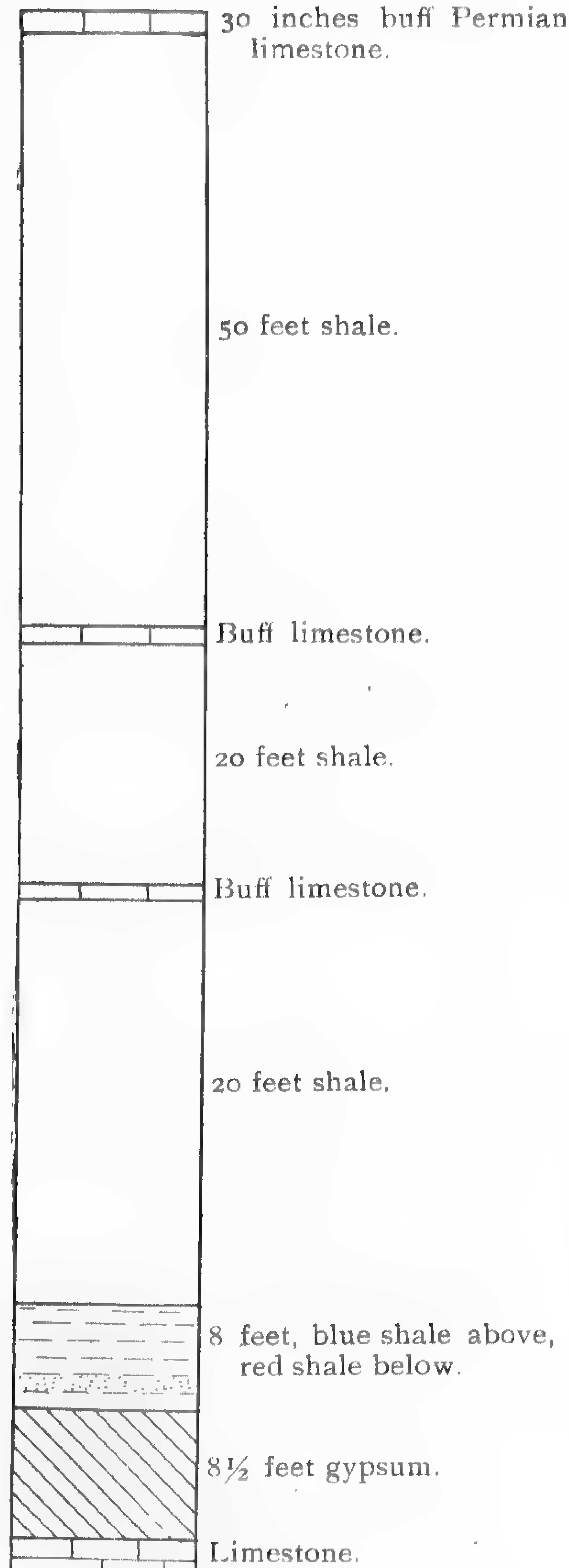


Figure 1. A geologic section at Great Western Gypsum mine, Blue Rapids, Kansas.

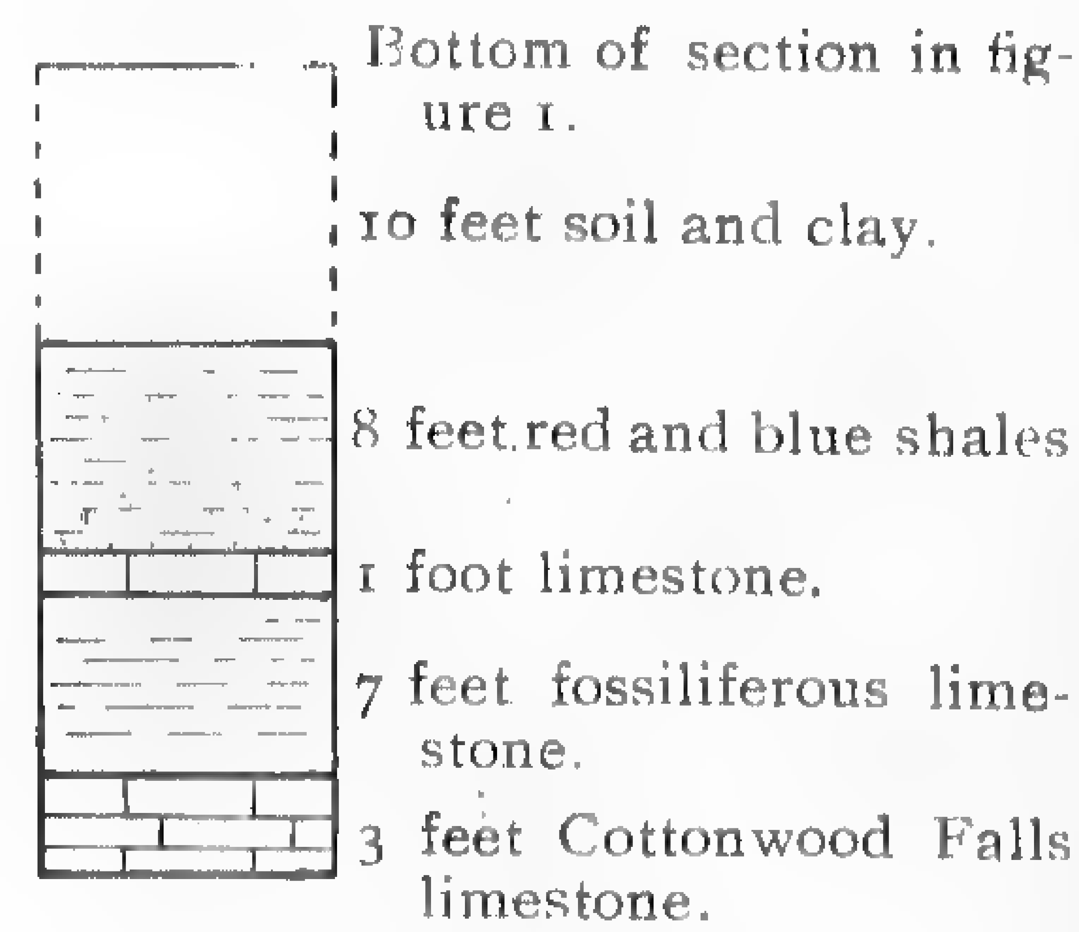


Figure 2. A geologic section one mile east of Great Western Gypsum mine, near Blue Rapids, Kansas.

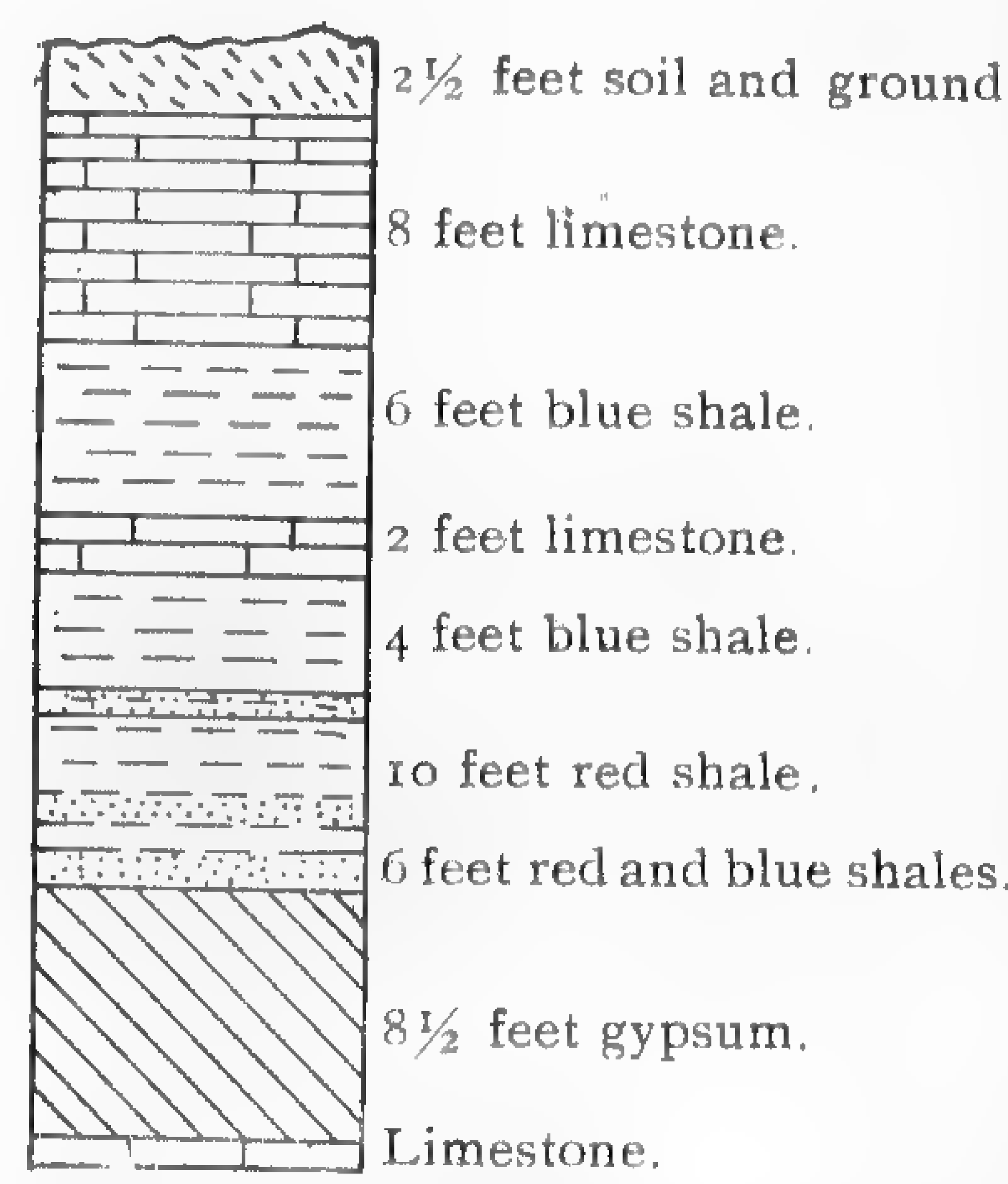


Figure 3. A geologic section at the Winter's gypsum mine, near Blue Rapids, Kansas

The Great Western mine is located on the side of a bluff, one mile north of the town and forty-five feet above the level of the water in the river. It is two and a quarter miles southeast of the Fowler mine. The entry runs east of north for about 400 feet. In the first 200 feet the gypsum was in round masses, thick at the middle and running out on the sides, with the trend across the entry and parallel with the slope of the hill. These appear to be old water courses. The thickness of the gypsum layer is the same as at Fowler Brothers' mine, eight and one-half feet, and both rest upon a limestone floor. The section of the hill, which is typical for the region, is given in figure 1. The section given in figure 2 was taken one mile east of the mine, and the top is ten feet lower than the bottom of the first section. The gypsum rock resembles very closely that already described, except there is an absence of the cutters and crystals.

On the banks of the Little Blue, two miles west of town, is located the Winter's mine. The entry runs east and is in the hill about 900 feet. The section, as shown in figure 3, is quite similar to the Great Western mine. The rock does not differ in appearance from other parts of this area.

These three places are the only ones in the northern area where the rock is used, but it outcrops at a number of other localities and is struck in the various wells to the north, south and west of Blue Rapids; but it appears to be absent in the wells to the east.

GYPSUM CITY AREA.

In the northern part of the area, six miles southwest of Solomon City, on Gypsum creek, is located the mine and mill of the Crown Plaster Company, The workable stratum of gypsum is five feet, and it is covered by forty feet of shales and gypsum layers which are much folded and broken. The entry is twenty feet above the water in the creek and is driven 115 feet east with two north entries eighty feet in length. The upper part of the stratum is similar to the northern gypsum, but the lower portion is very compact and is dotted with elliptical crystals of yellowish-brown selenite with the greater length in the direction of the vertical crystal axis (c), as represented in figure 4. The crystals are nearly one inch long and one-half inch wide, and give an appearance somewhat like the bird's eye limestone of the eastern United States.

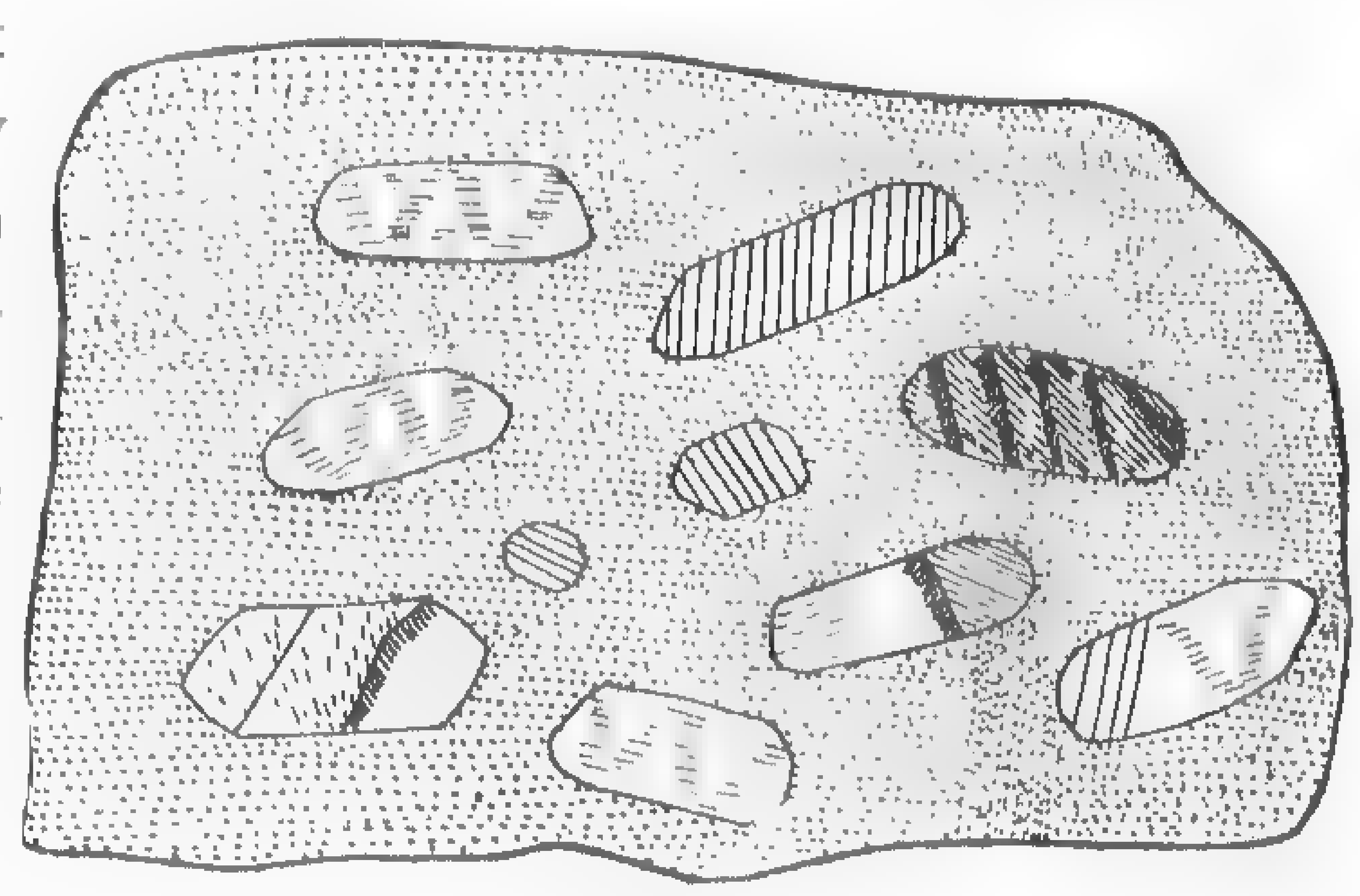


Figure 4. Solid, massive gypsum, containing rounded and irregularly placed crystals of gypsum.

At Hope, twenty miles southeast, is located the only other mine in the rock gypsum in the central area. This is owned by the Kansas Cement Plaster Company, and they now obtain the rock from a fourteen foot stratum at the bottom of an eighty foot shaft. This rock is white, and much of it is traversed by wavy, dark lines, which give a gneissoid appearance, and the plaster made from it is sold under the name of "Granite Cement Plaster." The lower part is compact and contains the rounded crystals of selenite, as in the mine at the north. Through this region there is another stratum five feet in thickness and 100 feet higher, but it is not worked at the present time.

SECONDARY DEPOSITS.

Most of the plaster mills in this central area use the earthy gypsum deposits, which occur at various places in the region. There are five of these known. The first of these was discovered in the spring of 1873, near Gypsum City, by Mr. John Tinkler, in running a fire guard around a field. Two years later he calcined some of the dirt, as it is locally called, in an ordinary thirty-eight gallon kettle and used the plaster in the cellar of his house, where it still remains in good condition. In 1889, he, with others, built a mill at the edge of town, but it is no longer used. The deposit covers an area of twelve acres with an average thick of eight feet. It consists of a loose, granular dirt, of light ash gray color when dry, and it is readily shoveled into cars. It is thus directly calcined with less labor and expense than is the case with the solid gypsum rock.

A number of years after the discovery of this deposit Mr. Gotlieb Heller discovered a similar deposit fourteen miles east near Dillon station. Another deposit is located three and one-half miles southwest of Dillon, and is five feet thick. In Marion county, about six miles south of the last deposit, the Acme Company own a mill and similar deposit which is six to ten feet thick. The Agatite Company have another mill and deposit at Longford, in Clay county, thirty-five miles northwest of the Dillon mill.

All of these deposits lie in low, swampy ground, and strong gypsum springs are usually found in them. In most there is a ledge of rock gypsum at the same level or ten to twenty feet below. The presence of recent shells and bones near the bottom of these deposits shows they are recent in age.

MEDICINE LODGE DEPOSITS.

The southern Kansas gypsum, with its continuation in Oklahoma and Texas, forms the largest area in the United States. Near

Medicine Lodge the rock caps the hills as a layer twenty-five feet thick protecting the underlying soft red beds, thus causing the very rugged topography already described. The red clays and shales below the gypsum contain an interlacing network of selenite and satin spar layers, which have been dissolved out of the solid stratum and carried downward by circulating water. In the western part of the area solution has carved out caves and underground channels, leaving, in many places, natural bridges of gypsum. The rock is snowy white, and the greater portion has a sugary texture, though the lower portion is compact. There are two mills making plaster from this rock. Best Brothers own a mill at the town of Medicine Lodge and manufacture the product known as Keene's cement, or Robinson cement. This mill has been in operation since 1889. The Standard Cement & Plaster Company have a mill west of Sun City and manufacture about eighteen tons of plaster per day. This great gypsum area is practically undeveloped at the present time.

ORIGIN AND AGE.

I have treated this subject quite at length in a recent paper for the Bulletin of the Geological Society of America, which will soon be issued from the press. The central and northern rock strata were deposited in an arm of the sea, cut off from the main ocean in the lower Permian or Neosho epoch. Farther out in the old gulf salt was deposited in large amount and forms today an important addition to the mineral wealth of the state. No salt is now found close to the gypsum, and if it did exist it has been removed by solution. The irregular upper surface of the gypsum shows that there has been solution in some places where large quantities of gypsum rock have been carried away.

The swamp deposits of earthy gypsum have probably been formed by deposit from springs, aided by wash from the hill-sides; and they are recent in age.

The southern gypsum was deposited in a shallow gulf cut off not far from close of Permian time. As in the northern gulf, a salt deposit occurs to the southwest in the Salt Plains district, but no trace is found near the gypsum.

TECHNOLOGY.

There are eleven mills in Kansas engaged in the manufacture of plaster from gypsum, seven use the gypsum rock and four use the gypsum dirt. Nearly the same process is used in all the mills of the northern and central areas, except that the mills using the dirt do not require the crushing machinery. The machinery is manufactured by Butterworth & Lowe, of Grand Rapids, Mich., and also by a Kansas company, the Ehrsam Machine Company, of Enterprise.

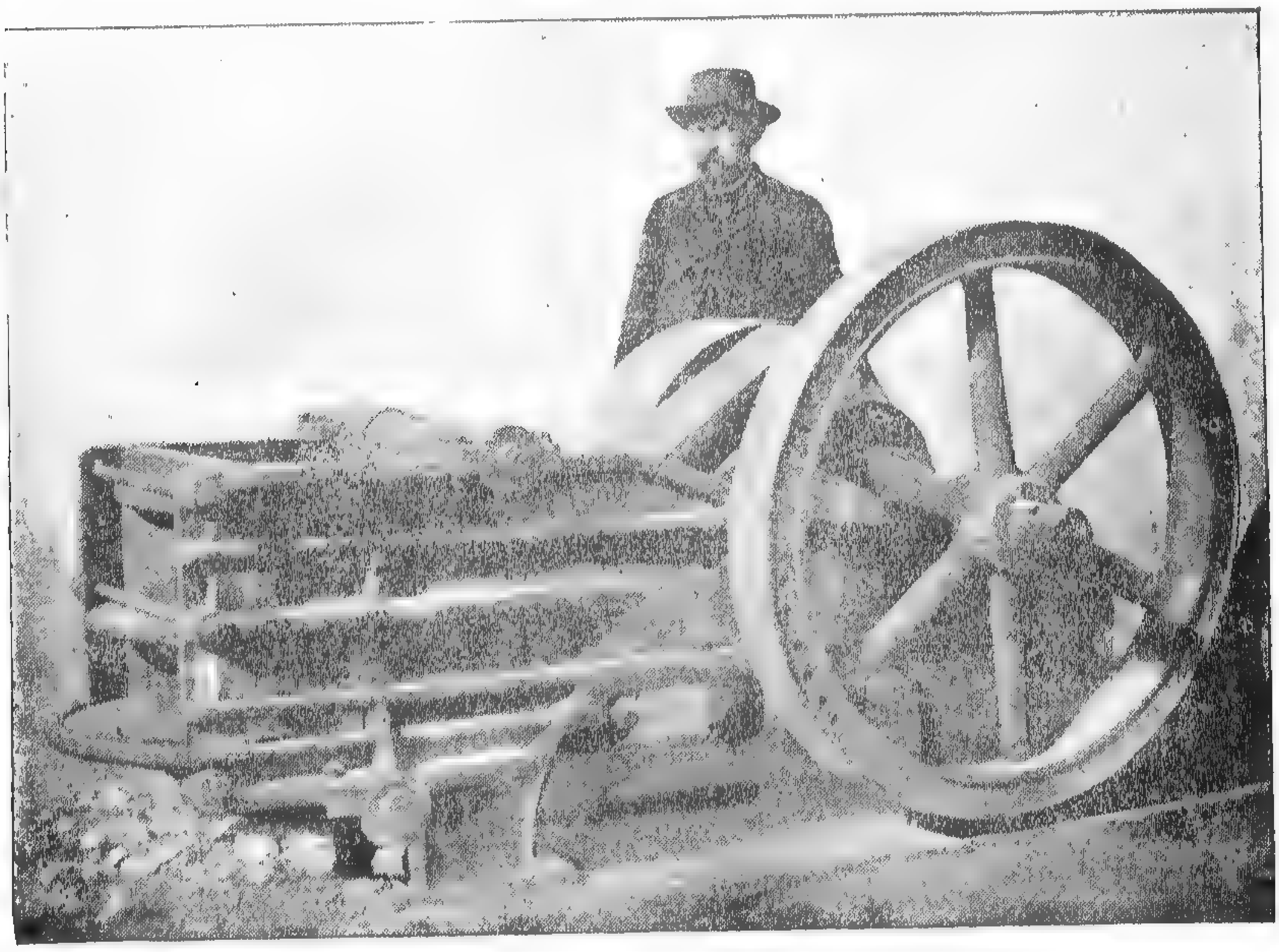


Figure 5. Gypsum Crusher.

On the ground floor is placed the crusher and nipper. The crusher has face plates or jaws of chilled iron, which have a backward and forward crushing motion, and it is operated by steam or water power. Blocks, averaging fifty pounds weight, are thrown into this machine and crushed into pieces about the size of a man's hand. These small masses drop from the crusher into the cracker, which is set in the floor just under the crusher. This machine, with its interior revolving shaft, acts somewhat like a coffee mill and further crushes the gypsum into fragments of the size of small gravel which fall into buckets of a chain elevator, whereby it is raised to a bin on the second floor. From this bin the gypsum particles pass through a spout into an ordinary buhr mill where it is ground into flour. From the buhrs it passes into another chain elevator and is carried to the top of the second story into the storage bin, located just over the kettle. It is then run slowly into the calcining kettle, taking about one hour to fill it to a depth of five feet. The average kettle is eight feet in diameter and six to eight feet deep, surrounded by a wall of stone nearly four feet thick.

Such a kettle holds seven and one-half tons of ground rock, which is calcined in three hours. It loses about one-fourth its weight through loss of water, which passes out the vapor stacks connected with the kettle, so that there remains about six tons of plaster. During the process of calcination the whole mass is stirred by a revolving stirrer, making about fifteen revolutions per minute.

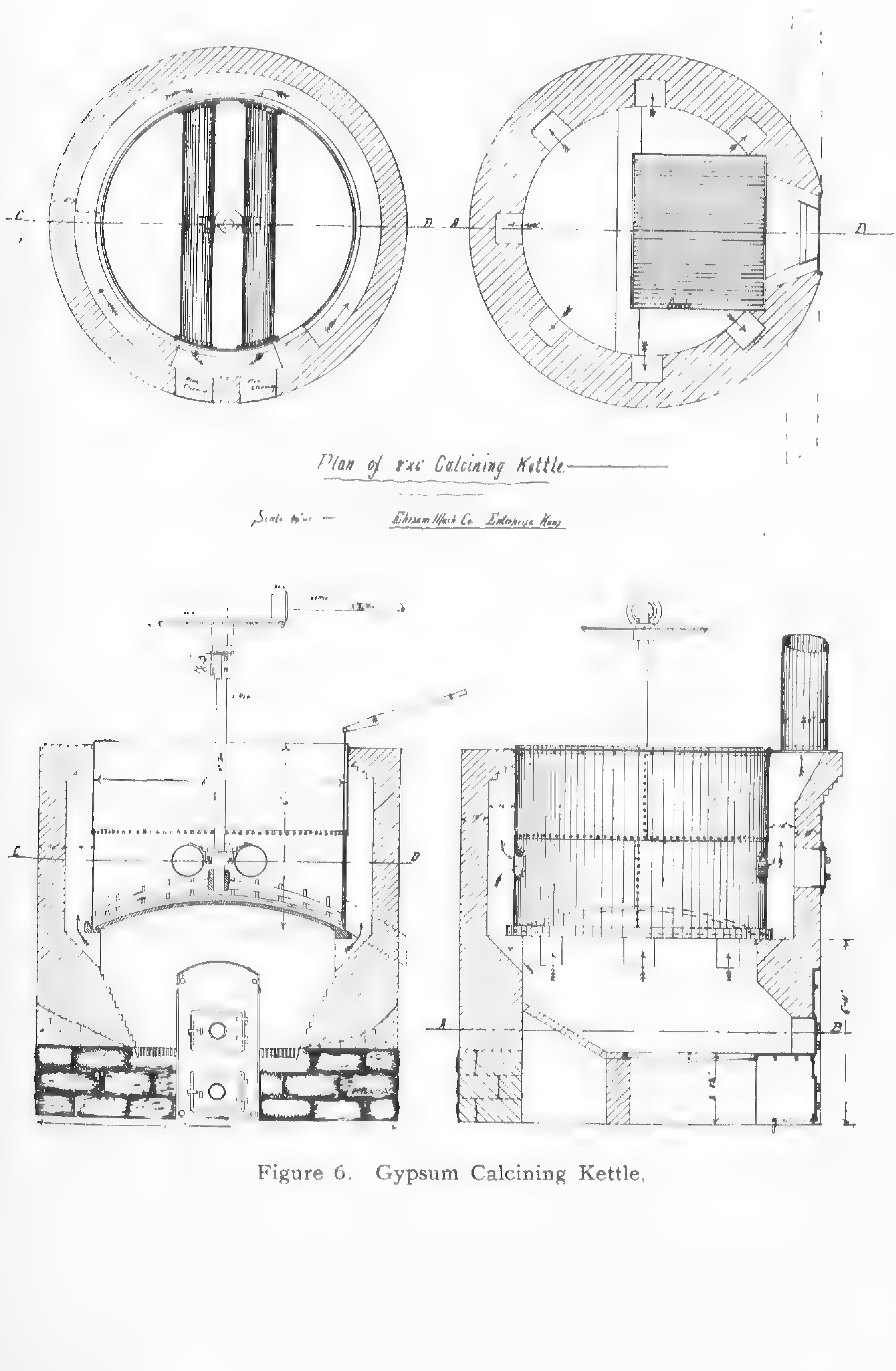


Figure 6. Gypsum Calcining Kettle,

The kettle is heated to about 240° F., before filling with the raw material, and this temperature is gradually increased to 340° F., as evaporation progresses. At the latter temperature the material stops the apparent boiling and *settles* down solid, leaving twelve to sixteen inches of vacant space at the top and the steam ceases to rise. After about one-half hour the material comes up again and then at a certain temperature, which is a trade secret, the whole mass is rapidly withdrawn through a gate near the kettle bottom and the plaster runs into a fire-proof bin on the ground. The kettle is then refilled, so that three kettles are usually burned in a day, and these require about 1400 pounds of coal.

During the process of calcination a *retarder* is mixed with the gypsum, the object of which is to form a plaster which will not set as quickly as the natural plaster of Paris. The latter sets in about ten minutes, while the retarder usually is added in sufficient amount to make it set in two hours, or in extreme cases in twenty-four hours. Various substances are used for this purpsse. Citric acid was formerly used with about two pounds to the ton of plaster, but the effect was apt to be very uneven. Magnesian limestone has been used with poor results. Sours and sweets form the worker's rule for retarders. Sorghum has been used with success; glue water was long in favor, but now they usually use patent retarders, known as Iola and Webster City retarders, and about fifteen pounds are used to the ton.

After the hot plaster passes from the kettle to the ground bin it remains about an hour to partially cool, and then it is raised to the second story and descends into a horizontal cylindrical reel, forty inches in diameter and ten feet long, slanting downward three-eighths of an inch to the foot. This is made of brass wire-cloth about forty by forty meshes to the inch. The tailings, usually about one per cent in amount, are carried back to the buhr mill and reground. The fine plaster is then run into 100 pound sacks or 250 pound barrels and is ready for shipment.

The advantages of wall plaster, made from gypsum, are outlined in the circulars of the various companies as follows: Being a perfect non-conductor of heat it is valuable for protection of iron joist, elevator shafts, and stairs; it sets and the walls dry out much quicker than lime work, so that carpenters can follow the plasterers almost immediately, as also the painters and paper hangers; any color can be mixed with the material in its preparation for mortar to produce any tint desired, and it does not affect coloring material as lime does; it requires less mortar than other materials; ceilings and walls, thoroughly soaked from leaking and unprotected roofs, have not been in the least injured; it attains a high polish and is now largely used for wainscoting as a substitute for marble; this plaster makes walls fire-proof, and they are not affected by change of temperature, they do not chip or crack and they become harder with age; it is dense and hard and so vermin proof.

USES.

The gypsum of Kansas in its ground, uncalcined state, is used as land plaster for fertilizer, which is thought to be directly beneficial in its lime; but its main value is indirect in retaining moisture and ammonia which is slowly given up to the growing plants. In many states large portions of the gypsum is thus used, but in this state only 560 tons, out of nearly 65,000 tons in 1894, was ground into land plaster. In this condition it is also valuable as a disinfectant around houses and stables, through its absorptive properties taking up the offensive odors.

Most of the mineral is calcined, and then in its finer grades it is used for dental plaster and as plaster of Paris for casts and moulds and white finish for walls. It has been used with marked success for fire-proof material. For this last purpose the calcined gypsum is mixed with finely ground cinders and poured between the iron joists with temporary plates above and below, giving a smooth under surface for the finishing coat of the ceiling of the lower stories and a smooth upper surface on which the tile floor may be laid. This material is claimed to be thirty-five per cent lighter, twenty-five per cent greater strength, and sixty per cent cheaper than tiling, which has long been used for this purpose.

The greater portion of the calcined material, however, is manufactured into the form of cement or rock plaster, which is displacing in many portions of the country the ordinary lime plasters.

PERMIAN BLUFF AT MANHATTAN, KANSAS.

Gypsum Beds Near Top.

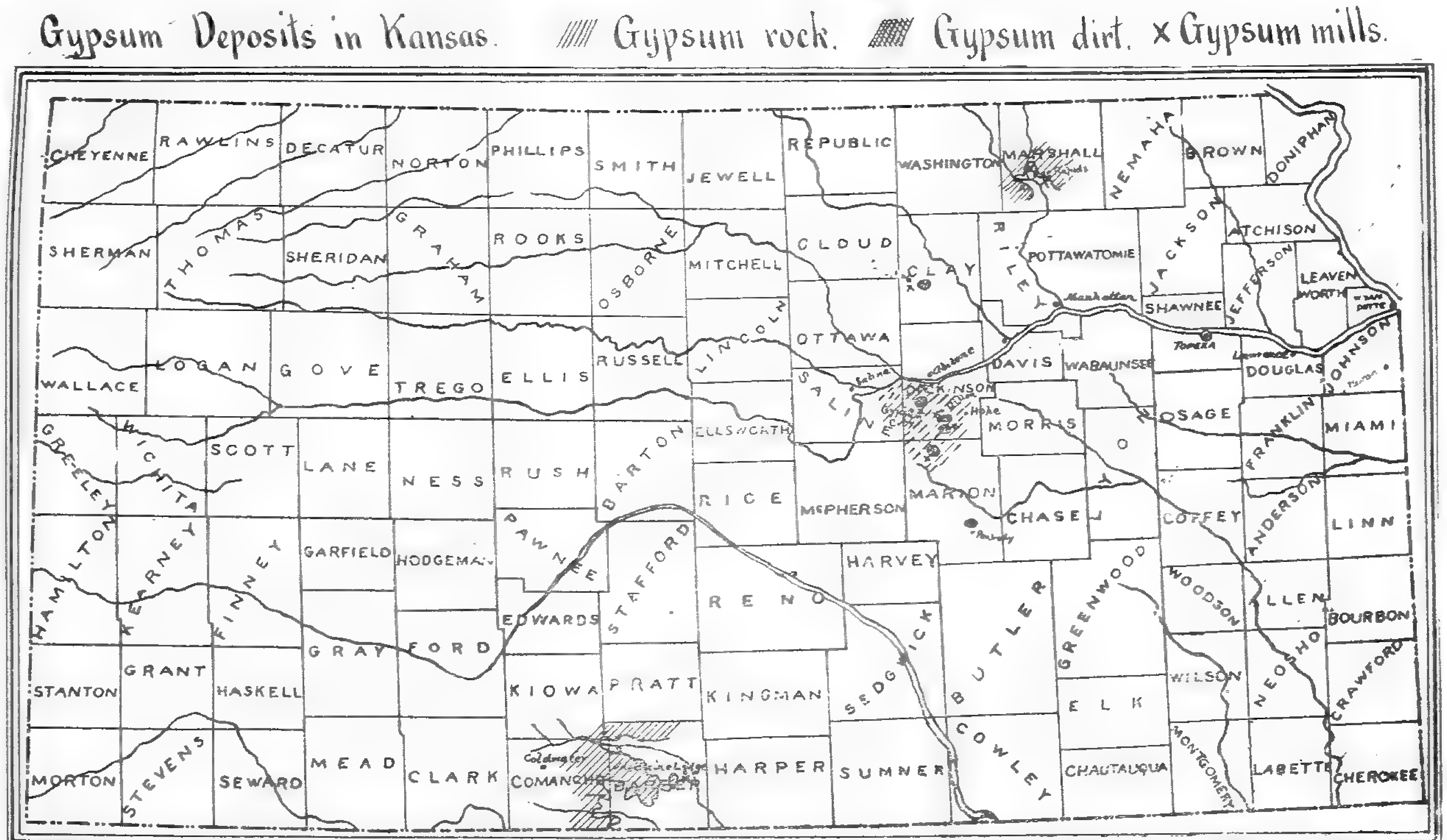
(Photographed by E. Haworth, 1895.)

FLOWER POT MOUND, RED BEDS HILL, NEAR MEDICINE LODGE, KANSAS.

(Photographed by C. S. Prosser, 1896.)

MANSARD HILLS IN RED BEDS, NEAR MEDICINE LODGE, KANSAS.

(Photographed by C. S. Prosser, 1896.)



By G. P. GRIMSLEY.

MAP OF KANSAS, SHOWING GYPSUM AREAS.

On the Chemical Composition of Some Kansas Gypsum Rocks.*

BY E. H. S. BAILEY AND W. M. WHITTEN.

(Preliminary Paper.)

The material used for these analyses was collected in the summer of 1896 by Mr. G. P. Grimsley. Great care was taken that the samples should be average samples, so that the analyses should represent the composition of the rock or dirt actually used at the mills. It is not necessary to give the details of the process of analysis, but it may be in order to state that special care was exercised, after the separation of the silica, that the calcium sulfate be fully dissolved by boiling, several times, if necessary, with dilute hydrochloric acid. The acid, if quite dilute, dissolved the sulfate very readily, but strong acid had little effect upon it. Water was determined by heating a sample in the air bath at 200° C. to constant weight. As a part of the water is driven off from gypsum at so low a temperature, it was deemed advisable to use the air dried samples for analysis.

The geological phases of this subject are more fully discussed by Mr. Grimsley. The occurrence of the rock, methods of manufacture, and the composition of the manufactured products, will be treated of in a later paper.

In Kansas there are at least three areas where the gypsum has been mined or quarried and used for commercial purposes. Other centers of the industry will, no doubt, soon be opened up. The three localities are, from the vicinity of Blue Rapids, the vicinity of Gypsum City, and the vicinity of Medicine Lodge. Analyses have been made of samples from two of these localities only. Those from the Gypsum City locality are from both Dickinson and Saline counties. It will be noticed that two kinds of material are used in manufacturing cement—the rock which is quarried and a soft, disintegrated material, which can readily be shoveled upon the cars. This is called "dirt," in the reports given below. It is

*An abstract of this paper was read before the Topeka meeting of the Kansas Academy of Science.

usually light brown in color and of such uniform texture that its true character would not be suspected. The results of the analyses are as follows:

Rock from Medicine Lodge mill, used by Best Brothers for the manufacture of cement.

	Per Cent
Silica and insoluble residue	.19
Iron and aluminum oxids	.10
Calcium oxid	32 53
Magnesium oxid	.16
Sulfuric anhydrid	45.73
Carbon dioxid (calculated)	.81
Water	20.46
Total	99.98

Calculating the above constituents as they probably exist in the rock, the result would be:

	Per Cent.
Silica and insoluble residue	.19
Iron and aluminum oxids	.10
Calcium sulfate	77.46
Calcium carbonate	1 43
Magnesium carbonate	.34
Water	20.46

The three following samples are from Hope: No. 1 is a sample from five cars at the entrance of Hope shaft; No. 2 is from a shaft west of Hope; and No. 3 is taken from boulders on a hill near Hope, and was formerly used at Hope mill.

	No. 1. Per Cent.	No. 2. Per Cent.	No. 3 Per Cent.
Silica and insoluble residue	.52	.34	.41
Iron and alumium oxids	.26	.16	.29
Calcium oxid	32.28	32.64	32.53
Magnesium oxid	.98	.62	.29
Sulfuric anhydrid	44.61	45.28	46.03
Carbon dioxid	1.90	1.42	.56
Water	19.47	19.63	19.70
Total	100.02	100.09	99.81

Calculating the above constituents as they probably exist in the rock, the result would be:

	No 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.
Silica and insoluble residue	.52	.34	.41
Iron and aluminum oxids	.26	.16	.29
Calcium sulfate	75.84	76.98	78.25
Calcium carbonate	1.87	1.68	.55
Magnesium carbonate	2.06	1.30	.61
Water	19.47	19,63	19.70

Three samples from the vicinity of Dillon were analyzed. No. 1 is a sample of the dirt that is used at the Dillon mill. No. 2 is a sample of the dirt that is collected at a point about three miles south of Dillon. No. 3 is rock from a small quarry a little south of Dillon. It is not used at present.

	No. 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.
Silica and insoluble residue	12.13	17.10	.35
Iron and aluminum oxids	.99	2.04	.12
Calcium oxid	29.14	27.62	32.57
Magnesium oxid	.42	.59	.27
Sulfuric anhydrid	37.49	33.28	46.12
Carbon dioxid (calculated)	2.03	4.04	.57
Water	16.75	15.16	19.96
Total	98.95*	99.83	99.96

Calculating the above constituents as they probably exist in the rock, we have the following result:

	No. 1 Per Cent.	No. 2 Per Cent.	No. 3. Per Cent.
Silica and insoluble residue	12.13	17.10	.35
Iron and aluminum oxids	.99	2.04	.12
Calcium sulfate	64.63	56.58	78.40
Calcium carbonate	3.57	7.71	.56
Magnesium carbonate	.88	1.24	.57
Water	16.75	15.16	19.96

There are two samples from the vicinity of Solomon mills. No. 1 is a rock from the mine at the mill. No. 2 is the rock that occurs about a quarter of a mile east of Solomon mills. This material is used in small quantities mixed with the material from the mine at the mill.

	No. 1. Per Cent.	No. 2. Per Cent.
Silica and insoluble residue	.55	.38
Iron and aluminum oxids	.23	.16
Calcium oxid	32.64	32.04
Magnesium oxid	.22	.46
Sulfuric anhydrid	45.95	45.77
Carbon dioxid (calculated)	.63	.50
Water	19.54	20.37
Total	99.76	99.68

According to the above analysis the probable composition of the rocks is as follows:

*Alkalies undetermined.

	No. 1. Per Cent.	No. 2. Per Cent.
Silica and insoluble residue	.55	.38
Iron and aluminum oxids	.23	.16
Calcium sulfate	78.11	77.81
Calcium carbonate	.86	....
Magnesium carbonate	.47	.96
Water	19.54	20.37

One sample was analysed from the Tinkler farm. This is also a dirt and was formerly used at Gypsum City. The analysis is as follows:

	Per Cent.
Silica and insoluble residue	4.54
Iron and aluminum oxids	.54
Calcium oxid	32.31
Magnesium oxid	.28
Sulfuric anhydrid	42.10
Carbon dioxid (calculated)	2.54
Water	17.82
Total	100.13

Calculating the above constituents as they probably exist in the rock, the result would be:

	Per Cent.
Silica and insoluble residue	4.54
Iron and aluminum oxids	.54
Calcium sulfate	71.57
Calcium carbonate	5.07
Magnesium carbonate	.59
Water	17.82

One sample was obtained from Rhoades, a point about seven miles south of Banner city. This was also of the variety known as "dirt." The analysis is as follows:

	Per Cent.
Silica and insoluble residue	3.06
Iron and aluminum oxids	.34
Calcium oxid	33.90
Magnesium oxid	.41
Sulfuric anhydrid	39.60
Carbon dioxid (calculated)	5.34
Water	17.24
Total	99.89*

*Alkalies undetermined.

Calculating the above constituents as they probably exist in nature the result would be:

	Per Cent.
Silica and insoluble residue	3.06
Iron and aluminum oxids	.34
Calcium sulfate	67.32
Calcium carbonate	11.03
Magnesium carbonate	.90
Water	17.24

Only one specimen of the gypsum was obtained from Clay county. This was from the mill at Longford, in the southwestern part of the county. The composition is as follows:

	Per Cent.
Silica and insoluble residue	18.69
Iron and aluminum oxids	1.21
Calcium oxid	26.71
Magnesium oxid	.43
Sulfuric anhydrid	33.27
Carbon dioxid (calculated)	3.15
Water	15.29
Total	98.75*

Calculating the above constituents as they probably exist in the rock, the result would be:

	Per Cent
Silica and insoluble residue	18.69
Iron and aluminum oxids	1.21
Calcium sulfate	56.56
Calcium carbonate	6.10
Magnesium carbonate	.90
Water	15.29

It will be noticed by an inspection of the analyses that but one is given from Barber county, while seven are from Dickinson county, three from Saline county, and one only from Clay county. There has been great activity in Dickinson county, especially, in this industry for the past ten years.

But little need be said at this time in the discussion of the composition of these rocks. It has been noticed from the analyses above given and from a large number of other analyses of similar material made in the University laboratories, that the per cent of calcium sulfate is from sixty to eighty. The amount of water usually corresponds quite closely to the amount that theoretically

*Alkalies undetermined.

belongs to Gypsum. If the gypsum be pure the per cent of water approximates quite closely to 20.9 per cent, the theoretical amount. If on the other hand it contains large quantities of calcium carbonate or of silica and insoluble material; the per cent of water sometimes falls as low as 5.5.

Calcium carbonate is seldom found higher than twelve per cent, while it frequently, in the *rocks* especially, is less than one per cent. The magnesium salts are usually present, but in very small quantity, and, indeed, so small that their presence or influence could usually be ignored. It is difficult to decide just what part the silica plays in increasing the efficiency of the cementing material. It seems quite probable, however, that within certain limits the silica would tend to form silicates, after the manufactured material has been mixed with water and begins to "set." This problem, however, can be more satisfactorily discussed in connection with the process of manufacture and the composition of the commercial cements.

Restoration of Ornithostoma (Pteranodon).

BY S. W. WILLISTON.*

With Plate II.

In the Annals and Magazine of Natural History for January, 1871, Prof. H. G. Seeley proposed the name *Ornithostoma* for a genus of toothless Pterodactyls in the following words: "A new genus appears to be constituted by some three portions of the jaws from the Cambridge Greensand. Unfortunately the extremity is not preserved. They have the ordinary dagger-shaped snout, but appear to be entirely destitute of teeth. I provisionally name the genus *Ornithostoma.*" It was not until 1876 that Marsh announced the discovery of the toothless character of the American Pterodactyls, giving them the name *Pteranodon.* Concerning this genus Seeley further says:† "There is, so far as I can discern, no evidence of generic difference between *Ornithostoma* and *Pteranodon.* There is perfect correspondence in the dagger-shaped form of the jaw, in the relations between the height of the jaw and the breadth of the palate, in the flattened sides of the snout, and their convergence superiorly into a rounded ridge, in the thin, rounded margin of the jaw which represents the alveolar margin, and in the smooth palate formed by a single, wide, concave channel." All this, and other evidence, Seeley obtained from the figures and descriptions given by Marsh.

In the article last cited Prof. Seeley figures the shoulder-girdle of *Ornithocheirus,* adding the statement, "I believe this form of shoulder-girdle is substantially the same in all the Cretaceous group." In this he is correct, so far as the genus *Pteranodon* is concerned. The very peculiar and remarkable structure of the scapula and coracoid is precisely that of the latter genus. In fact, every essential character that has been given so far for the European species of this group agrees quite with those of our Kansas specimens. This will demonstate how unimportant are the characters derived from the absence or presence of the teeth. Marsh

*For other papers on Ornithostoma by the writer see Kans. Univ. Quar., i, p 1; ii, p. 79; iv, pp. 61, 195,

†Ann. Mag. Nat. Hist., 1891, p. 440.

proposed a new order for these pterodactyls, baesd upon the absence of the teeth, but, as has been already shown for the orders of Ichthyosaurs and Birds based upon the same character, it is of subordinate value. Of course it is not yet certain that a perfect knowledge of the European species of *Ornithostoma* may not reveal generic characters to distinguish them from the American, but it is very doubtful, and the assumption that they are different, in the face of so much and direct evidence of identity, is unscientific. In Kansas rocks the genus is persistent in time, the species *O. ingens* reaching through nearly the whole thickness of the Niobrara rocks, and extending, as I believe, into the basal strata of the Ft. Pierre. I am confidently of the opinion that thorough examination of the Pierre deposits will reveal the genus throughout a large part of their extent.

From the study of the Kansas material in the University of Kansas Museum the following classification and characters seem to be most in accord with our present knowledge. I should prefer the term Pterodactyloidea for the suborder in place of Ornithocheiroidea. The character of the scapular union can not be of more than family value, since the resemblance otherwise between *Nyctodactylus* and *Ornithostoma* is too great to separate the forms into separate suborders.

Order Pterosauria.

SUBORDER ORNITHOCHEIROIDEA.—Tail short; wing metacarpal longer than the fore-arm; fifth toe rudimentary; nasal and ante-orbital vacuities more or less confluent.

FAMILY ORNITHOCHEIRIDÆ.—Distal end of scapula thickened and provided with articular facet for union with supraneural articulation. Carpal bones three in number.

SUBFAMILY ORNITHOCHEIRINÆ.—Jaws with well developed teeth.

SUBFAMILY ORNITHOSTOMATINÆ.—Jaws wholly edentulous.

FAMILY PTERODACTYLIDÆ.—Scapula thin on the upper end, not articulating with neural spine.

SUBFAMILY PTERODACTYLINÆ.—Jaws with teeth.

SUBFAMILY NYCTODACTYLINÆ.—Jaws wholly edentulous(?).

In the accompanying Plate II is given a restoration of *Ornithostoma ingens* Marsh. This species, of which *O. umbrosum* Cope is a synonym, is the most common one in the Kansas chalk. The characters which have been used to distinguish the species are, almost without exception, of doubtful value. The bones are invariably found crushed flat, with the articular surfaces distorted and changed.

For that reason I have yet failed to determine some of the species described previously. *O. ingens* is, however, more easily recognizable from the size alone, in which it seems very constant. Among the material of this genus in the University I have recognized four species, based partly upon size, partly upon structural differences. Such differences are found in the shape of the humerus, the terminal wing phalanx, the relative length of the bones, etc.

The material which I have referred to *O. ingens* includes some twenty specimens, which have furnished all parts of the skeleton save some of the cervical and dorsal vertebræ, the pelvis and the larger part of the skull. The pectoral girdle and anterior extremity, with the exception of the terminal phalanx, together with the complete leg, are from one specimen—the vertebræ from another. The pelvis is drawn from a specimen of another species, comprising the larger part of the skeleton. The resemblances of the skeleton throughout are so great that there can be little doubt that the pelvis would be equally indistinguishable, save by size. It is unnecessary to add that its size in the drawing has been made proportional to that of the other bones. Of the skull, the larger part of the lower jaws and some of the posterior portions are alone available in this species, and the remainder is taken from one belonging to a smaller form. I have assumed that this latter specimen is of another species, but the difference in size is all that I have so far been able to discover.

The number of dorsal vertebræ can not be determined. The relative positions of the pectoral girdle and leg in several specimens show pretty conclusively that the trunk could not have been longer than has been figured.

Altogether the skeleton of *Ornithostoma* presents some very remarkable characters. I believe there is no other reptile in which prosthenic features are carried to as high a degree as in this. The disproportion between the fore and hind extremities is almost ludicrous. The pelvis is exceedingly small, the legs not only small but weak in all respects. That the animal could have stood upon its feet free on the ground I do not believe possible. The neck vertebræ are relatively stout, but the neck was not remarkably elongated, to carry such a head as the animal possessed. Furthermore the remarkable mode of articulation of the neck and anterior dorsal vertebræ seems to indicate a restricted range of torsion, though tolerably wide sagittal flexion. The occurrence of the remains of the large species in strata evidently formed remote from the shore lines, as shown by the entire absence of other shore animals, turtles, etc., indicate great powers of flight. Furthermore, it is rare that a single bone of a pterodactyl is found unassociated with others, and almost invariably the bones of the wings are found more or less in connection indicating either tough and strong tendons, or a rapid sinking of the skeleton, which might happen from the rapid filling of the hollow bones with water through their pneumatic openings.

Notwithstanding the enormous expanse of the wings, these animals when alive must have weighed but little. I doubt very much if one of the largest species reached twenty pounds. When at rest, the phalanges of the wings were doubtless folded almost parallel with the metacarpal, as they are sometimes found preserved in this position. There was very little movement in the wrist, considerable in the elbow, and very much in the shoulder. In the humerus there is a remarkable projection for muscular attachment corresponding to the deltoid tubercle, but I doubt very much that it was for the exclusive insertion of muscles corresponding to the deltoid, inasmuch as its large and strong face for muscular attachments points away from the shoulder and towards the arm. On the inner mesial side there is also a strong projection proximally, which I doubt not was for the pectoral muscles, muscles which must necessarily have been most important in keeping the wings outspread. The imperfect or rudimentary claws and the weak toes mean that the animal could not have used the feet effectively for grasping, while the exceedingly free movement of the femur in the actetabulum must indicate great freedom of movement of the hind legs and corresponding lack of strength. Altogether, I believe that the function of the legs was chiefly for guidance in flight, through their control over the membranes. I suspect that the membrane from the wings extended a considerable distance upon the sides of the legs, and, perhaps, connected them in part. From the comparative heaviness of the head and vertebræ, and the structure of the latter, it is also probable that in flight the neck was curved backward in its lower part. If the animal hung in the upright posi: tion when at rest, it is difficult to see where the head was stowed away.

The length of this species from tip of outstreched bill to tip of toes was about eight feet, the expanse of the wings in the posture shown in the engraving was eighteen feet and six inches. It is often erroneously stated in text-books that the distance between the tips of the wings in this species was twenty-five feet.

Skull.

The shape and structure of the skull I have described in previous papers. In the present species the total length of this part of the skeleton was considerably less than four feet. A most careful examination of the alveolar borders of both maxillæ and mandibles, has revealed no indications of teeth, even rudimentary ones. The position of the occipital condyle is such that the head might have been flexed to an acute angle upon the neck. In the figure here given the width of the head is less than has been heretofore figured, but it is certainly more nearly correct.

Vertebræ.

The number of cervical vertebræ is seven, and, in all probability, not more. The atlas and axis I have never seen. It is probable that they do not differ materially from the bones of *Nyctodactylus*, as already described by me in a previous paper. The third cervical is the longest, the others successively decreasing in length. The first and second dorsal are short, and bear well developed, double-headed ribs. The difference between the last cervical and first dorsal is considerable. The third, fourth and fifth dorsals, if my determination is correct, have the centra and ribs co-ossified for the support of the scapula. The succeeding vertebræ are short, cylindrical bones, with a hemispherical ball, and with elongated transverse processes situated high upon the arch. The number is indefinite.

Fourth cervical vertebra.

The centrum is elongated. The ball is much broader than high, and strongly convex in both directions; its upper border is convex, but the inferior margin is emarginate on each side. On each side there is a stout process, jutting downwards and backwards from the side of the centrum on each side, having on the posterior surface a concave articular facet, oval in shape and touching or slightly separated from the articular surface of the ball. The facet looks downwards, backwards, and outwards. The under side of the centrum, between the two processes, is concave. The corresponding articular facets on the anterior end of the centrum are somewhat smaller, are convex and distinctly separated from the concavity of the centrum. The articulation of the centra with each other thus depends upon three distinct, or nearly distinct surfaces, the lateral inferior ones convex on the cup end, concave on the ball end. Such a mode of articulation would seem to limit the motion to one in a vertical, antero-posterior plane, while greatly strengthening the joints. I know of no similar arrangement in any other vertebrate animal, and will, for convenience, call the articulations exapophyses. The anterior zygapophyses project distinctly beyond the plane of the cup and are widely separated from each other. From the tip of the processes a ridge runs downward and inward to the outer part of the pre-exapophyses. The post-zygapophyses are concave and oblique. Above them there is a stout metapophysis. The spine is elongate and thin, and apparently only a ridge.

The third cervical is somewhat longer and has a distinct tubercular hypopophysis on the anterior end, near the margin of the cup. The sixth and seventh are shorter, and the spine is directed more backwardly and is a little longer.

First dorsal vertebra.

The centrum is short and broad, so different from the preceding vertebræ that it is possible there is an intervening one omitted. The ball is more than four times as broad as high, concave on the upper side, convex below. The post-exapophyses are large and confluent with the articular surface of the ball, but are concave. The convex pre-exapophyses, at the outer sides of the cup, are at the base of the lower root of the elongated transverse process.

The ventral surface of the centrum is flattened transversely. Near the margin of the cup there is a small, but prominent, bifid tubercle, projecting cephalad and ventrad. The transverse process is elongate, and compressed cephalo-caudad. It is incomplete, but, if of the same structure as in *Nyctodactylus*, it bears both articular facets for the rib. Its lower root arises from the sides of the centrum, having at its base the pre-exapophysis. The upper root arises from the sides of the pre-zygapophyses. The latter are oval in shape, with the faces looking upward and inward; they are remote from each other. The spine is broad and short, with its upper extremity bifid and thickened. The neural canal is of large size.

An imperfect vertebra, evidently following the one described above, has the centrum very similar, save that it is broader and shorter, and the hypopophysis is hardly perceptible. The transverse processes are broken off. The zygapophyses are stouter, but more approximated, and the spine appears to be less stout.

The next three succeeding vertebræ are evidently those co-ossified to support the scapula. The centra are firmly co-ossified, showing only a ridge between them. The cup anteriorly has the exapophyses laterally, from which arise the stout inferior root of the transverse processes. The upper root, which is broader, arises as in the preceding, its anterior border continuous with the zygapophyses. The process is very broad, elongated and stout, and evidently represents the co-ossified rib. There is a round foramen between the two roots. It is probable that each of the vertebræ has a similar co-ossified rib on each side, but only that of the anterior one is preserved.

In another specimen, the co-ossified neural spines, or, as I believe them to be, the ossified supraspinous ligaments or cartilages are united to form a stout vertical plate of bone, which bears on each side an oval articular facet for union with the end of the scapula.

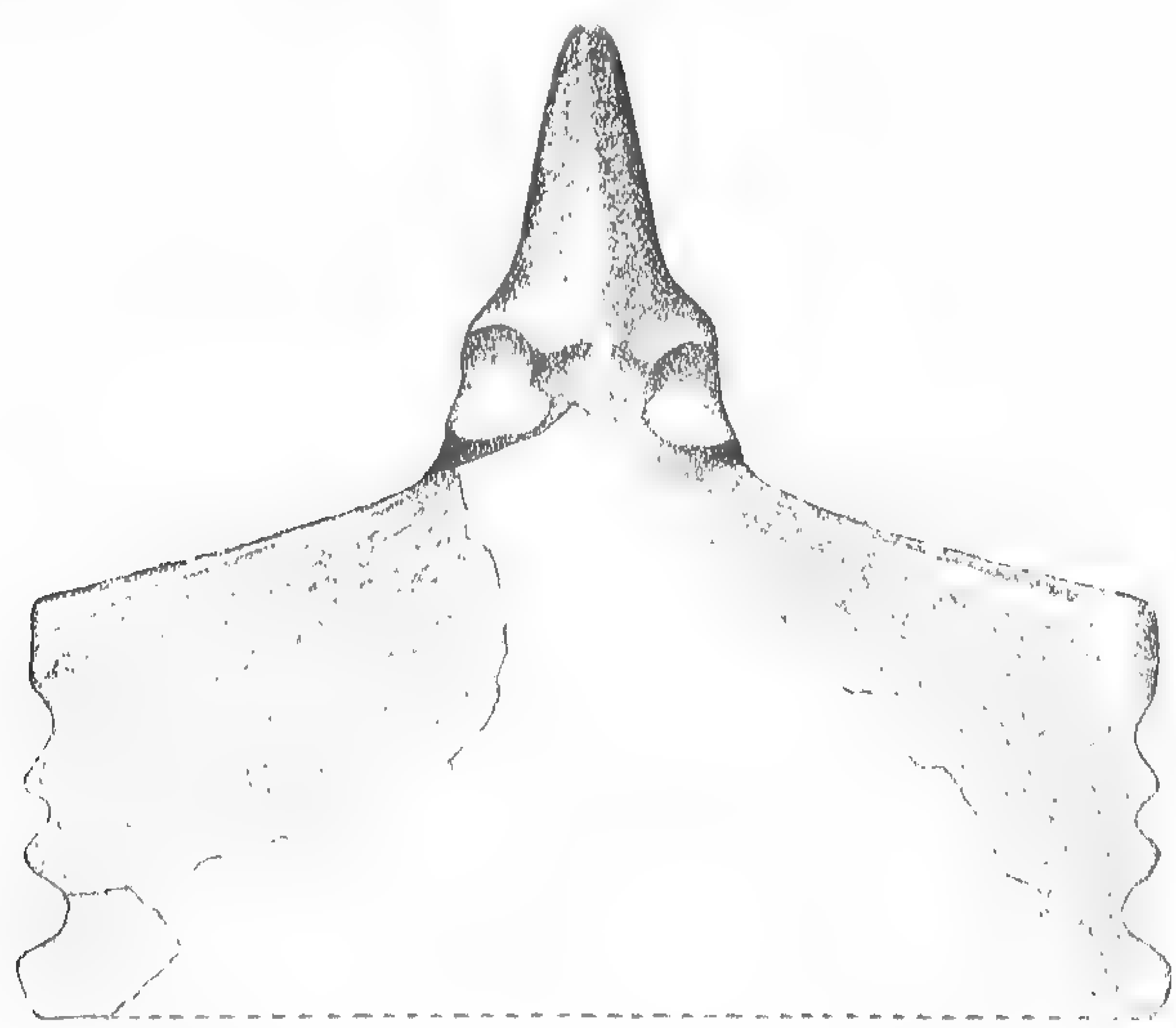
Measurements of cervical vertebræ, Ornithostoma sp. (No. 2211).

Length of centrum, third cervical	48 mm.
Length of centrum, fourth cervical	44
Width of ball	16
Height of ball in middle	8
Distance between pre-exapophyses	16
Diameter of pre exapophyses	6
Diameter of neural canal	7
Length of centrum, fifth cervical	42
Width of post-exapophyses	28
Length of centrum, sixth cervical	36
Length of centrum, seventh cervical	30
Width of ball	18
Length of centrum, first dorsal	13
Width of ball	20
Distance between anterior zygapophyses	14
Transverse diameter of neural canal	9
Width of neural spine at base	14
Height of vertebra, approximated	41
Length of centrum, second dorsal	12
Width of ball	25
Diameter of neural canal	10
Length of centrum, third dorsal	16
Width of cup, including lateral facets	25
Length of centrum, fourth dorsal	15
Length of transverse processes preserved, from pre-zygapophyses	64
Width of same	16

Ornithostoma ingens (No. 1951).

Length of centrum, fifth cervical	66 mm.
Width of ball	28
Height of ball in middle	12

Distance between pre-exapophyses	28 mm.
Diameter of pre-exapophyses	10
Diameter of pre-zygapophyses	12
Distance between pre-zygapophyses	22
First dorsal vertebra, length of centrum	25
Transverse diameter of ball	33
Second dorsal vertebra, length of centrum	30
Width of ball	25
Diameter of neural canal	12
Length of co-ossified transverse process and rib of third dorsal vertebra from anterior zygapophysis, as preserved	130
Diameter of same at distal extremity	10
Diameter of same near pre-zygapophysis	15



Sternum of *Ornithostoma species*, one half natural size.

Sternum.

The sternum is not preserved in any of the specimens of *O. ingens* in the museum, but is represented in a skeleton of a closely allied, smaller species. It is extremely thin and pentagonal in outline. Projecting in front of the articulations for the coracoids is a stout process, obtusely pointed, and evidently directed somewhat ventrally in life. The articular facets look dorsad and laterad and are gently convex from side to side and concave antero-posteriorly. Just back of the articulations the moderately thickened borders slope obliquely backward to the full width of the bone. The first articular facet for the ribs begins at the angles and runs backward a half inch. It is of considerable thickness, and may be for the attachment of the stout co-ossified rib attached to the first of the consolidated dorsal vertebræ. The lateral margins of the sternum, back of the angle, are thin, and have three emarginations, separating four articular projections. The three posterior ones are small and pointed, and could have given attachment to only slender ribs. The lateral borders are parallel with the longitudinal axis of the bone. The posterior border is not preserved, but from the general resemblance to the bone in *Nyctodactylus*, I believe that it is nearly straight, although it may have been gently concave or convex. The bone was in all probability concave above in life.

Length of presternal projection in front of articulations.	44 mm.
Diameters of coracoid articulation................	12, 14
Width of bone....................................	140
Length of bone....................................	120
Length of lateral margins.........................	55
Length of anterior oblique margins from coracoid articulation	55

Coraco-scapula.

This bone is stout, U-shaped, with the coracoid arm distinctly longer than the scapular. The distal extremity of the scapula has a large oval facet placed obliquely to the long axis, and evidently also obliquely to the transverse axis of the body, indicating that the bone was directed not only outward and downward, but also more or less forward. The shaft in all the known specimens below the articulation is trihedral or flattened, but in life it was evidently round or oval in cross-section. On the lower part the width is greater, due to a projection of the dorsal side before the glenoid articulation, for the attachment of muscles. The glenoid articulation is deeply concave from above downward, convex from side to side and bounded both above and below by a prominent ridge, that on the inferior border being much stronger than the upper one. The surface is markedly oblique to the plane of the bone, doubtless in life directed outwardly and posteriorly in the oblique position of the bone that I have described. The surface is considerably narrower from side to side below than above, and in this direction it is convex throughout. A rugose line, indicating the junction of the two bones, passes directly backward near the middle of the articular surface. At the bottom of the U, formed by the conjoined bone, there is a process arising from the scapula and reaching to the anterior surface of the coracoid, to which it is joined; it incloses a small, oval foramen just back of the middle of the glenoid surface. The diameter of the foramen is about twelve millimeters.

The shaft of the coracoid is flattened antero-posteriorly in all the specimens, though probably in life oval. On its proximal half there is a prominent process on the inferior border for muscular attachment. From beyond the middle the sides of the bone are parallel. The sternal articulation is gently concave in one direction and slightly convex in the other, to agree with that of the sternum, forming a reciprocal joint, which must have had considerable mobility. A little above the sternal end, on the posterior side, there is a narrow rugosity, more than an inch in length, for muscular attachment.

The side to which a given bone belongs may be determined by holding the bone with the sternal end toward one and the glenoid articular surface looking obliquely upward; the scapular end will then be directed to its proper side.

The bones have a close resemblance to those figured by Seeley in *Ornithocheirus* (Ann. Mag. Nat. Hist., 1891, 441.) The vertebra and sternum in this figure are, however, undoubtedly wrong. The ball of the centrum in this region does not have so much of the horseshoe shape, but is transverse, and undoubtedly the ribs are here stout and anchylosed to the centrum.

Length of coracoid to glenoid margin	181 mm.
Diameter sternal articulation	25
Width of shaft distally	30
Length of glenoid surface	50
Width of same	30
Length of scapula from glenoid margin	160
Distance between scapular and sternal articulations	170
Greatest diameter suprascapular articular surface	25

Humerus.

The humerus is the stoutest bone of the body. Its proximal articulation, for union with the glenoid, is concave from side to side, convex in the other direction, with its width much greater on the ulnar side. Beginning at the head, the radial border slopes outwardly with a gentle concavity, into a broad, rounded process. This process, the radial or deltoid, has its convex, rounded extremity directed obliquely forward and upward or outward; the broad surface for muscular attachment, about two inches in length and one in breadth, is directed almost opposite to that of the glenoid articulation. It is hardly possible that the process gives attachment to any shoulder muscle; certainly its chief use can not be for a deltoid muscle, and the name deltoid as applied to it is, I believe, improper. Below the process the bone suddenly narrows to its least width, which is distinctly above the middle. From this contracted place the bone again widens gradually to the extremity. The ulnar border of the bone is nearly straight throughout.

On the anterior ulnar side, immediately beyond the head, there is a large process, directed inferiorly and anteriorly, which is doubtless for the attachment of pectoral muscles, and may be known as the pectoral process. It does not extend so far as does the radial process, and is not so large; usually it is crushed flat to the shaft of the bone.

At the distal extremity there is a large, oval, articular surface on the radial side, inclined anteriorly, for articulation with the radius. Back of this there are two articular surfaces, separated by a pit or depression. The anterior one, the smaller one, is seen from the anterior side, while the posterior is on the posterior side, concealed by a process at the distal extremity of the humerus, which is strongly convex on the inferior margin, straight on the distal.

Length of humerus, ulnar side	285 mm.
Greatest diameter proximal articular surface	50
Greatest transverse diameter of same surface	30
Width of bone 110 mm. below upper extremity	39
Greatest width through radial process	100
Width of distal extremity	80

Ulna.

The ulna is the larger bone of the forearm. At the proximal end there are two concave articular surfaces, meeting each other in an angle, which is lodged in an excavation in the humerus. In life the ulna overlapped the radius to some extent when seen from in front. The bone is narrowed at the middle, expanding distally, more especially on the radial side. The distal extremity has two articular facets, of which the lower one is the larger. On its radial border the margin is expanded for about an inch and a half above the articulation, and is roughened. Near the distal end, between the two articular facets, there is a large pneumatic foramen.

	1951.	2217.	1960.
Length	374	385	380 mm.
Width proximally	60	60	62
Width distal extremity	83	81	77
Width in middle	45	48	45

Radius.

The radius is a much more slender bone than the ulna, its extremities not as much dilated. In a specimen compressed laterally the proximal end shows a deep pully-like articulation, divided by a ridge in the middle. At the distal extremity it is more expanded than proximally, with a single articular facet, and an expanded, non-articular radial margin.

	1951.	2217.
Length	370	380 mm.
Width proximal extremity	45	43
Width distal extremity	51	
Width of shaft	24	29

Carpus.

The carpus has three bones. By reason of the constant compression and distortion to which they are subjected, it is difficult to recognizably describe them. The proximal bone is the largest, and has two facets on the proximal surface for articulation with radius and ulna. The lateral carpal, the smallest, is sub-triangular or sub-quadrangular in shape, with an oval or rounded facet on the proximal end, and another, smaller, near the distal end, forming an emargination on the border. A good figure of this bone is given by Cope. Cret. Vert., p. vii, fig. 3. "Professor Marsh finds the carpus to have the same structure in the toothless Ornithosaurs from Kansas (as in Ornithocheirus) and discussed it fully in April, 1882 (Am. Jour. Sci.), though without mentioning memoirs in which the structure has been figured, and from which the interpretation appears to have been taken."*

Measurements:

Greatest diameter of proximal carpal, as compressed	75 mm.
Greatest diameter of lateral carpal	35

Metacarpals.

The first metacarpal or Pteroid, has a proximal expansion and articular surface, for union apparently with the distal articular surface of the lateral carpal. It terminates in a free, pointed distal end. One or two small ossicles, oval in shape, are found with the carpal bones. They are probably sesamoid bones. The three following metacarpals are slender splint bones about one-third of the length of the wing metacarpal. Professor Marsh has described the second as being thread-like proximally. They all terminate in an expanded end, which is curved outward and has a rounded articular surface for the phalanges. The phalanges

*Seeley, Ann. Mag. Nat. Hist., April, 1891.

of these fingers are of two kinds. The proximal ones are elongate, with a contracted shaft, about an inch and a quarter in length, with the proximal end concave and the distal convex with a median depression. The others are but little longer than broad, with similar articular surfaces. The ungual phalanges are broad, and strongly curved, terminating in a sharp point, and much resembling the claws of carnivores. The proximal end has the articular surface on the upper half only.

The fifth metacarpal is much broader at the base, gradually diminishing in size to near the distal extremity, where the bone must have been subcylindrical in section with the under surface flattened or grooved. Proximally the bone appears to have had a gentle convexity on the proximal end and a corresponding concavity on the under side. The articular surface for the carpal is large, with the dorsal border somewhat produced for muscular insertion. The distal extremity is placed somewhat obliquely to the shaft, being directed downward and forwards. The articulation is a very complete pulley-shaped mass, permitting motion through nearly half a circle. The posterior condyle extends through more than three-fifths of a circle, with its lower border directed forward and projecting beyond the anterior surface of the shaft, permitting the corresponding articulation of the first phalange to overlap the shaft to a considerable extent. The anterior condyle extends through a lesser arc and does not project beyond the surface of the bone, the corresponding articulation of the phalange being shorter. The articular surface is deeply grooved, the groove being before the middle, the broader surface belonging to the posterior condyle. The inferior surface of the shaft distally is concave, and behind the proximal ends of the articular surfaces there is a pneumatic foramen.

Measurements of wing metacarpal:

Length	580	590	594	615 mm.
Width at proximal end	78	70	70	70
Diameter of shaft before condyle	32	30	28	32
Diameter of anterior condyle	36	35	34	40

First Phalange.

The first phalange of the wing-finger is the longest bone in the body. On the proximal end the shaft is expanded, but beyond the proximal fifth the sides of the bone are nearly parallel and straight to near the tip, where the whole bone is bent downward. The proximal articular surface is deeply concave in outline, the chord of the concavity being at about 45° to the shaft of the bone. The two articular surfaces are gently concave and oblique, the posterior elongate oval in shape and extending to the inferior produced portion of the bone, which overlaps the inferior part of the shaft of the metacarpal when fully flexed. The anterior articular surface is narrower and situated more dorsally. The two surfaces are placed obliquely on the shaft, corresponding to the obliquity of the head of the metacarpal. The upper border of the bone has a prominent tuberosity on the beak, separated by an oblique notch from the thickened upper border of the bone. The notch is doubtless for the insertion of muscles. The distal end of the bone is curved downwards, the inferior border of the articulation reaching about a half an inch below the lower border of the shaft. The articulation is at right angles to the shaft of the bone with the upper angle broadly rounded. Doubtless in life the surface was oval in shape and like the two following bones.

Measurements:

Length	580	590	590 mm.
Breadth at proximal extremity	67	65	65
Breadth of shaft	30	27	24
Diameter anterior condyle	35	35	34

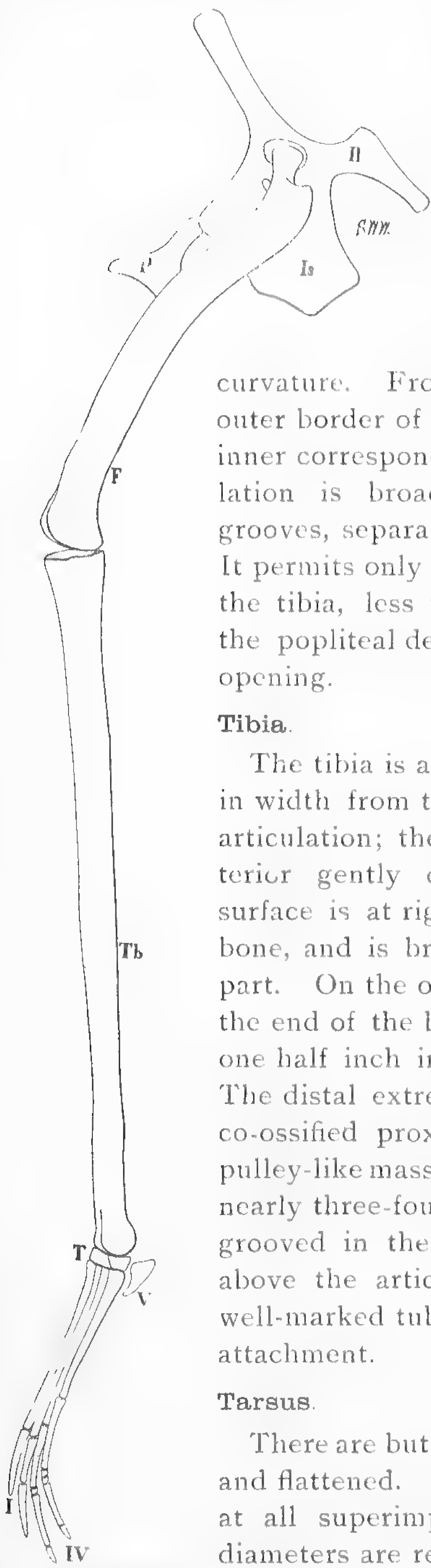
A partial description of the pelvis and leg has been given in a previous paper in this journal,* to which the reader is referred.

Second-fourth wing phalanges.

The second and third wing phalanges can not be distinguished from each other, save by size; nor can the side to which they belong be determined in the crushed specimens. They are most dilated on the proximal end, the sides narrowing to near the proximal third of the bone, whence they are nearly parallel or gently divergent to near the distal extremity. The proximal articular surface is concave and transverse to the long axis of the bone. This surface reaches quite to the inferior border of the bone, which is here curved downward. The upper border, for a short distance, is flattened and convex, with a roughened surface on the proximal end for muscular and ligamentous attachments. The terminal phalanx is curved throughout, ending in a free styloid extremity. In some of the smaller species this bone is straight.

	1951	2205
Length second phalange	500	485 mm.
Width proximal end	53	46
Width distal end	30	30
Width of shaft	22	20
Length third phalange	330	
Width proximal end	32	
Width of distal end	18	
Width of shaft	13	
Length fourth phalange (chord)		170
Width proximal end		20

*Kan. Univ. Quar., II, 79.



Leg of *Ornithostoma ingens*, one-fifth natural size.

Femur.

The head of the femur is nearly hemispherical, supported upon a cylindrical neck, placed at only a slight angle with the long axis of the bone. The trochanter is low and obtuse, situated at the top of the long axis of the shaft. The shaft is of nearly equal width throughout, with a strong anterior curvature. From a little below the trochanter, the outer border of the shaft is markedly concave, the inner correspondingly convex. The distal articulation is broad, with two, shallow, trochlear grooves, separated by a median convexity or ridge. It permits only a moderate amount of flexion with the tibia, less than 45° from a straight line. In the popliteal depression there is a small pneumatic opening.

Tibia.

The tibia is a slender bone, gradually decreasing in width from the proximal end to near the distal articulation; the front border is straight, the posterior gently concave. The proximal articular surface is at right angles to the long axis of the bone, and is broadest transversly on the posterior part. On the outer surface, about fifty mm. below the end of the bone, is a roughened tubercle about one half inch in length, for muscular attachment. The distal extremity, representing, I suppose, the co-ossified proximal row of the tarsus, forms a pulley-like mass, the articulation extending through nearly three-fourths of a circle, moderately deeply grooved in the middle. On the inner side, just above the articular border anteriorly, there is a well-marked tubercle for ligamentous or muscular attachment.

Tarsus.

There are but two tarsal bones, irregular in shape and flattened. They lie side by side, and are not at all superimposed. Their greatest and least diameters are respectively, 20 and 6, and 20 and 7 millimeters.

Foot

The first four metatarsals are very slender, straight and contiguous with each other, each having a flattened proximal articular surface and a rounded trochlear distal extremity. The metacarpal of the fifth toe is rudimentary, sub-triangular in shape, with the obtusely pointed distal part curved, altogether resembling an obtuse claw.

The first toe has a single phalange, which is long, cylindrical, gently curved and obtusely pointed.

The second toe has two phalanges, the first of which is elongate and grooved with a distal trochlear articulation. The second resembles that of the first toe, but is shorter.

The third toe has four phalanges, the proximal one of which is like that of the second toe, but is elongate; the second is broader than long; the third is like the first, but shorter; the fourth is a short, scarcely curved and obtusely pointed claw.

The fourth toe has five phalanges, of which the first, fourth and fifth resemble the first, third and fourth of the third toe, the second and third the second of the same toe.

The fifth toe has no phalanges.

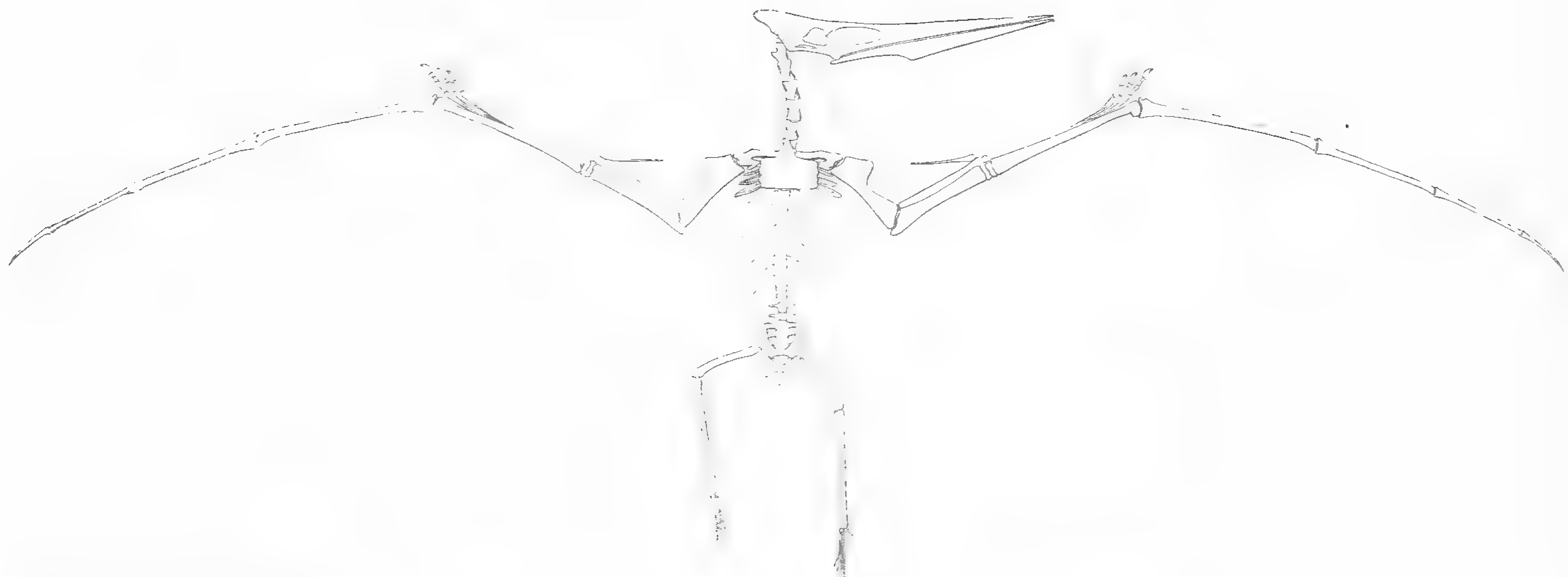
Measurements of leg bones

Femur, length	260 mm.
Femur, diameter of head	20
Femur, diameter of neck	12
Femur, width of condyles below	30
Femur, width of shaft	25
Tibia, length	362
Tibia, diameter of proximal end	34
Tibia, diameter of shaft at middle	19
Tibia, diameter of shaft above trochlea	16
Tibia, greatest diameter outer condyle of trochlea	20
Metacarpal, length of first	101
Metacarpal, length of second	105
Metacarpal, length of third	95
Metacarpal, length of fourth	80
Metacarpal, length of fifth	25
Metacarpal, width of same at base	15
Phalanges, first digit, length of proximal	41
Phalanges, second digit, length of proximal	25
Phalanges, " " length of second	31
Phalanges, third digit, length of proximal	35

Phalanges, third digit, length of second	....	4 mm.
Phalanges, " " length of third	....	27
Phalanges, " " length of fourth	....	12
Phalanges, fourth digit, length of proximal	....	40
Phalanges, " " length of second	....	3
Phalanges, " " length of third	....	3
Phalanges, " " length of fourth	....	26
Phalanges, " " length of fifth	....	12

Summary of Characters Ornithostoma.

Head much elongated, the jaws slender, pointed and wholly wanting in teeth. External nares and ante-orbital vacuities united; supratemporal fossa of large size; occipital crest elongated. Neck elongated, non-costiferous, with exapophysial articulations, and rudimentary spines. Three anterior dorsal vertebræ co-ossified and bearing a supraneural plate for articulation with scapula. Posterior dorsal vertebræ decreasing in size, procoelous, the trensverse processes situated high up. Sacrum composed of six or seven vertebræ, the anterior ones with long transverse processes, the posterior three sessile. Tail short, small, the vertebræ without transverse precesses and amphiplatyan. Anterior ribs strong, double headed, those of the co-ossified vertebræ anchyloned to vertebra. Posterior ribs weak, single headed; adbominal ribs present. Coracoid and scapula united, the latter articulating with supra-neural facet, the latter with the sternum; a scapular foramen present. Sternum pentagonal in outline, with stout anterior projection; the sides with four costal articulations. Ilium with an elongated anterior projection; pubes free, band-like, co-ossified, with anterior articular projection, the bone attached to tuberosities on the anterior border of the ischia. Ischia broad, uniting in a symphysis posteriorly, with "thyroid" foramen, below acetabulum. Bones of the forearm longer than the humerus, and shorter than wing metacarpal. Carpus composed of three bones, in two rows; median phalanges of second, third and fourth fingers short; four phalanges in the patagium, the terminal one curved or straight. Femur curved, trochanter small; tibia longer than the femur, with trochlear articulation below; fibula wholly wanting; tarsus with two bones only, in a single row; four functional toes, elongate, slender, the fifth consisting of a rudimentary metatarsal; middle phalanges of third and fourth toes very short; first and second without true claws.



S. W. WILLISTON, from nature.

RESTORATION OF ORNITHOSTOMA INGENS M.

Niobrara Cretaceous. Western Kansas. One-thirtieth natural size.

Notice of Some Vertebrate Remains from the Kansas Permian.

BY S. W. WILLISTON.

Some months ago numerous fragments of bones, obtained from an excavation of a well in Cowley county, were sent me for examination by Mr. C. N. Gould. The horizon whence the bones came is clearly lower Permian, not far from its base, as accepted by Professor Prosser, the recognized authority on the Kansas Permian stratigraphy.

Not knowing whether additional material will be obtainable I give here a description of some of these bones, which will be more fully illustrated in the future, should no better specimens be secured.

An intercentrum clearly belongs to the genus *Cricotus*, and is closely allied to the typical species described by Cope from the Permian of Illinois.* His description applies so well to the specimen in hand that I use his language, amended:

"The caudal intercentrum best preserved is short, discoidal in form and deeper than wide. The articular faces are deeply concave, the posterior more strongly so, and the middle is occupied by a foramen, whose diameter is about equal to one-half that of the intercentrum on either side. The lateral borders of the posterior articular face are less rounded than the anterior ones. The chevrons are slender and directed very obliquely backward, their bases are firmly co-ossified with the intercentrum. On the superior surface two shallow pits occupy considerable space. They are separated by an obtuse ridge, and are bordered by a raised ridge from the polished layer of the lateral surface."

"Several phalanges of short, wide proportions show much resemblance to those of certain dinosaurs."

Diameter of intercentum, vertical..................	18 mm.
Diameter of intercentrum, transverse...............	17
Diameter of intercentrum, longitudinal..............	11

*Proc, Phil. Acad. Nat. Sci , 1875, p. 405.

Proximal width of phalanges	12	12	13 mm.
Proximal depth of phalanges	8	7	6
Length of phalanges	14	15	11

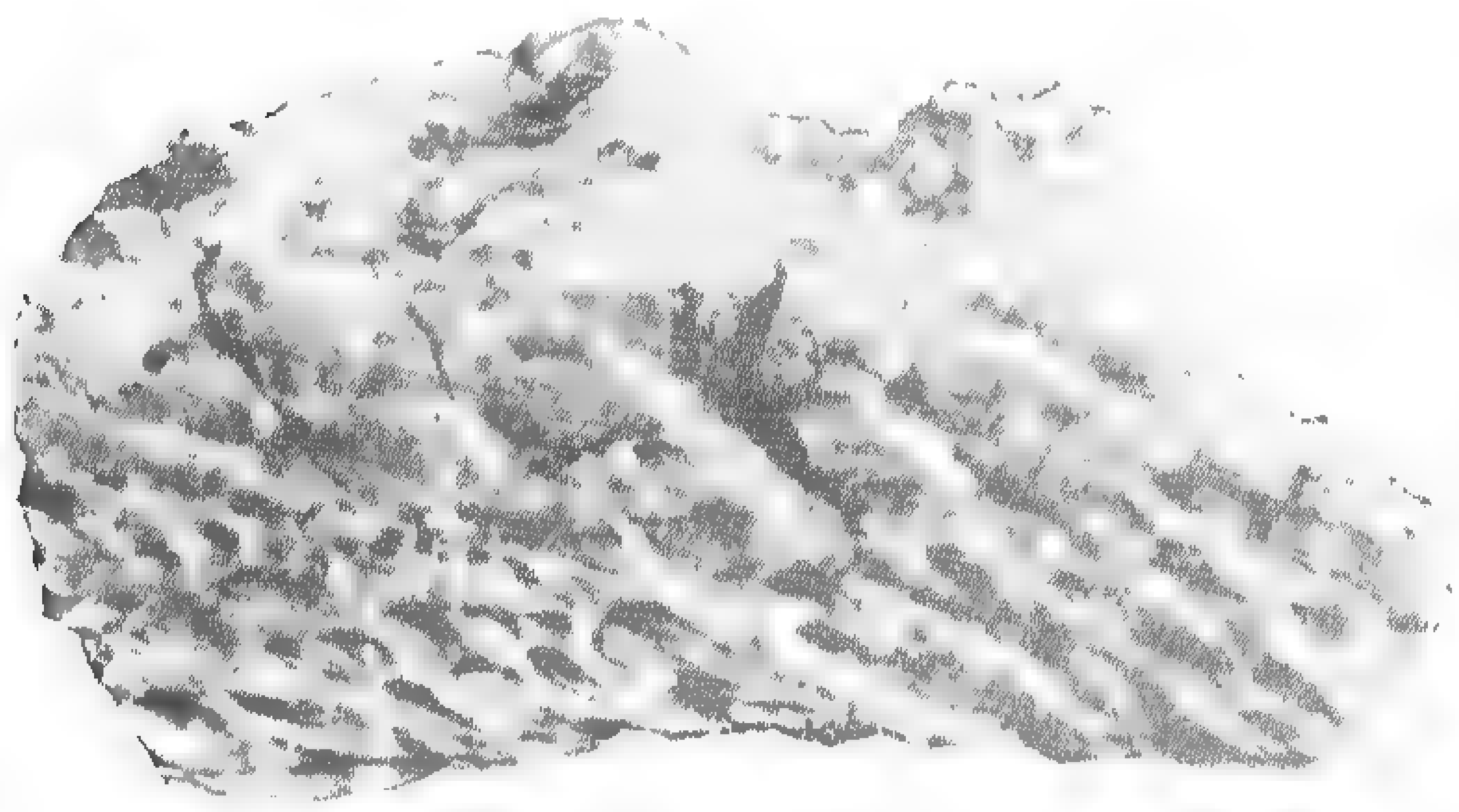


Fig. 1. Fragment of jaw of *Cricotus* sp. enlarged two diameters.

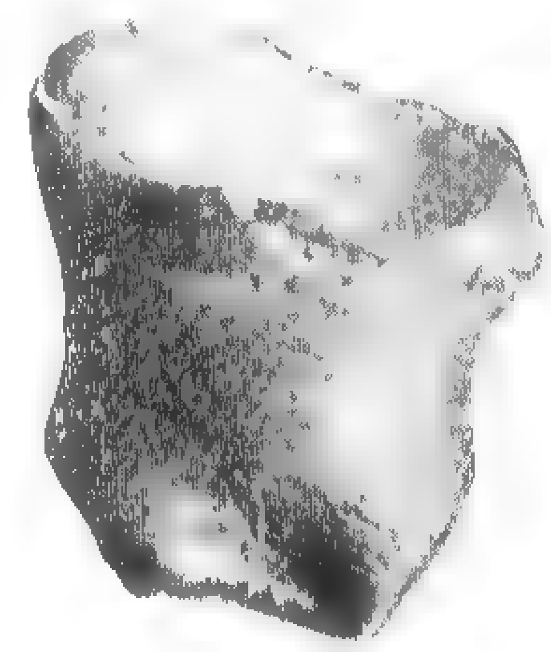


Fig. 2. Phalange. Fig. 3. Tooth of Cricotus. Both enlarged.

Another vertebra, of smaller size, doubtless represents a true centrum (see Cope. Trans. Amer. Phil. Soc., xvi, p. 245). It differs very materially in having remote satural surfaces for the attachment of the neural arches, in being somewhat cordate in shape and in showing no surfaces for articulation of the chevrons. The ends are concave as in the intercentrum, and the notochordal foramen is of the same relative size. The anterior lips of the cup are more beveled than the posterior ones. The outer surface is concave longitudinally with an obtuse keel below. The posterior sutural surface for the arch is much larger than the anterior. There are no longitudinal ridges on the sides of the centrum, as shown in the figures of *C. crassidiscus* Cope (labeled C. *heteroclitus* by Zittel). The floor of the neural canal is flat.

Transverse diameter of centrum	15 mm.
Vertical diameter of centrum	13
Length of centrum	7
Width of neural surface	5

Numerous portions of sculptured scutes and plates and a fragment of a jaw with one complete tooth I doubt not belong with the vertebræ. The outer side of the jaw fragments is shown in the accompanying photographic illustration, together with the tooth and a phalange; they are all enlarged. From a microscopic section of the base of the tooth I have made, with the aid of a camera lucida, the accompanying drawing. It would be of interest to know how nearly the figure resembles that of the other known species.

None of the characters are sufficient to distinguish the species from the other described ones, especially C. *heteroclitus* Cope.

A single dorsal vertebra, and, perhaps, some phalanges, belong clearly in the genus *Clepsydrops* Cope, also originally described

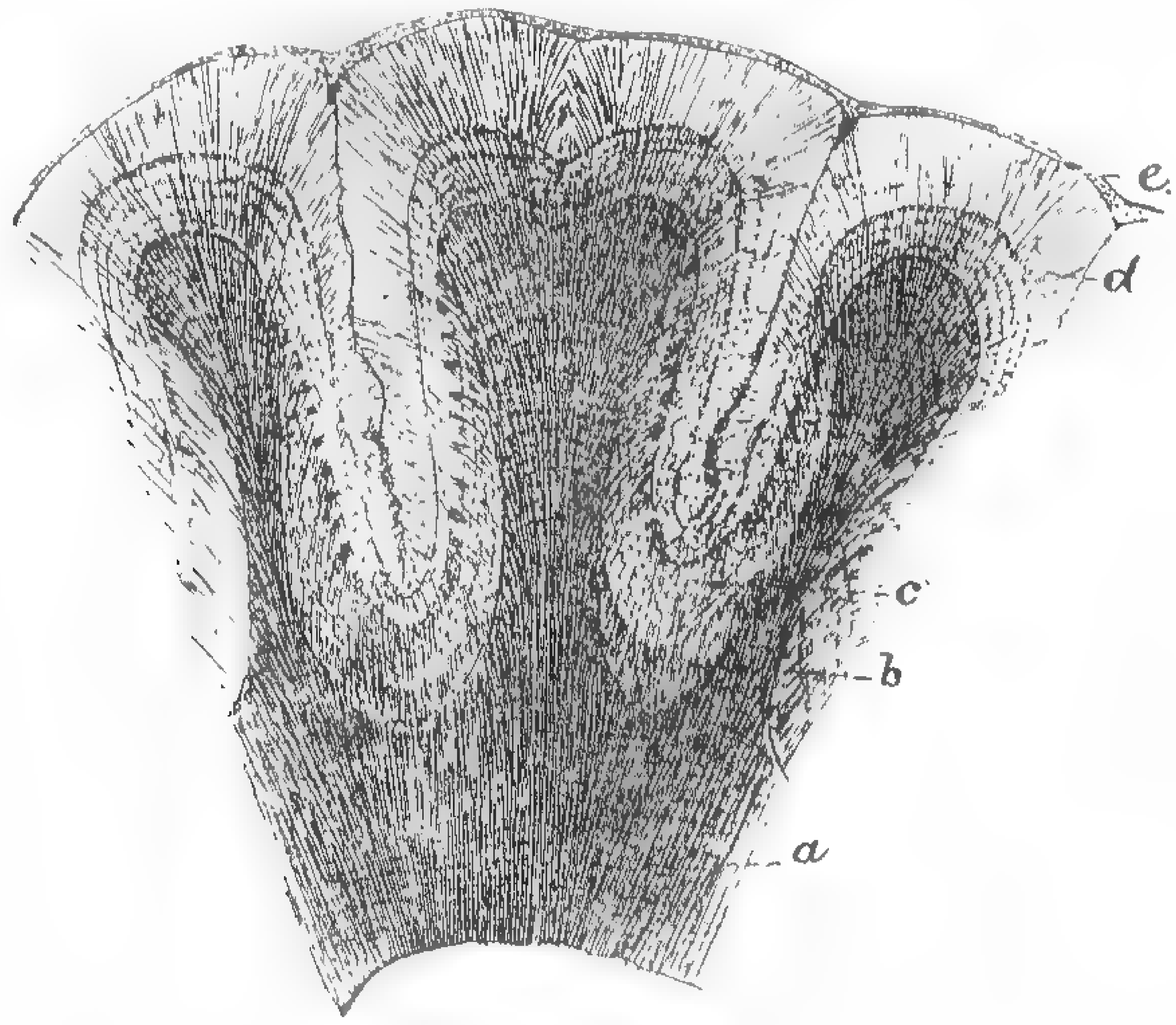


Fig. 4. Section of tooth, *Cricotus*.

from Illinois, and are closely allied to the typical species. In its description I follow Cope's language in the paper first cited for a dorsal centrum: "It is deeply bi-concave, the articular cavities being funnel-shaped and continuous, thus perforating the entire length of the centrum. * * The cavities communicate by a very small orifice. In an anterior dorsal the anterior cavity is as widely excavated at the border as the posterior funnel. Another peculiarity is the absence of processes of the centrum, and a small capitular articulation is seen sessile on the border of the cup of two of the dorsals. The dorsal vertebræ have their sides somewhat contracted; in one specimen the inferior face is longitudinally acute. In this dorsal the floor of the neural canal is interrupted by a deep fissure; which has a triangular shape with the apex downward, when seen in profile. The diapophysis does not project far beyond the base of the neural arch." It is sessile with an elongated cupped articular surface.

The phalanges are of more slender form than those of *Cricotus* The shaft is depressed and the distal condyle is not emarginate.

Length of centrum	15	14 mm.
Depth behind	14	12
Width behind	14	12
Length of phalange	13	
Depth proximally	5	
Width proximally	8	

As will be seen, the centrum, while nearly the same size as that measured by Cope of *C. collettii* (second column), are of somewhat different proportions, but not sufficiently so to justify specific separation.

Associated with these remains are numerous teeth and spines of *Pleuracanthus* (*Didymodus ?*) and plates of a ganoid fish.

Altogether we have here an interesting series of forms, so closely resembling the species described by Cope from Dansville, Illinois, that I cannot distinguish them specifically. It would seem to demonstrate the contemporaneity of the two formations, as also that of the Texas Permian, whence species of all these genera have been described by Cope.

Above the stratum in which these bones are found are several hundred feet of limestone and shales, above which come the red beds of Clark and Comanche counties, which have been variously referred to the Permian and Trias. That this basal Permian fauna continued throughout all the time represented by eight hundred or a thousand feet of deposits does not seem probable to me, and I believe yet more strongly, what I always have believed, that the red beds of Kansas are Triassic in age. If they be Triassic, and corresponding to the red outcrops of the foot-hills in Colorado, it would seem strange that the intervening deposits between them and the Dakota, in the regions separated by only a few hundred miles, and agreeing in many lithological characters, should be in one case Cretaceous and in the other Jurassic.

A New Plesiosaur from the Kansas Comanche Cretaceous.

BY S. W. WILLISTON.

Plesiosaurus Gouldii n. sp.

Several nearly complete dorsal vertebræ from the Comanche shales of Clark county, Kansas, represent a hitherto undescribed species of a Plesiosaurid, differing very distinctly from P. Mudgii Cragin in its much larger size and the shape of the centrum. It is probable that the cervical vertebra described and figured by me in this journal, vol. iii, p. 2, belongs with the same or a closely allied species.

The dorsal vertebræ are markedly characterized by the peculiarly cordate form of the centrum. The anterior face is rather deeply concave, for this part of the column; clearly cordate in outline, with a small emargination above. The anterior zygapophyses are spout-like, the notch between them not extending further than the middle of the articular surfaces. The spine is short and small. The transverse processes are compressed, springing in part from the centrum, in part from the base of the pedicles. The body is compressed in the middle, forming an obtusely rounded surface below. About midway on the sides, below the lower root of the transverse process, the side is pinched in, with a small vascular foramen at the bottom of the depression.

Width of anterior end of centrum	110 mm
Vertical diameter, same end	75
Length of centrum	79
Height of centrum	175
Expanse of diapophyses	175
Width of neural canal	30
Expanse of anterior zygapophyses	50

Table for the Calculation of Analyses.

BY EDWARD BARTOW AND JOHN NAVARRE MACOMB, JR.

This table was compiled for use in the chemical laboratory of the University of Kansas, using the atomic weights taken from, "A Recalculation of the Atomic Weights," by F. W. Clarke, Revised Edition, 1897, page 364, "Smithsonian Miscellaneous Collection" No. 1075:

H 1.

Found.	Sought.	Factor.	Logarithm.
$(NH_4)_2PtCl_6$	N_2	0.06326	8.801183
	$2NH_3$	0.07689	8.885889
	$2NH_4Cl$	0.24122	9.382409
Sb_2S_3	Sb_2	0.71455	9.854035
As_2	As_2O_3	1.31999	0.120571
As_2S_3	As_2	0.60924	9.784790
	As_2O_3	0.80419	9.905359
$BaCO_3$	CO_2	0.22291	9.348138
$BaSO_4$	Ba	0.58855	9.769781
	BaO	0.65707	9.817614
	S	0.13735	9.137836
	SO_3	0.34293	9.535202
	SO_4	0.41145	9.614320
$CaCO_3$	Ca	0.40032	9.602409
	CaO	0.56021	9.748350
	CO_2	0.43979	9.643246
CaO	Ca	0.71459	9.854059
	$CaCO_3$	1.78505	0.251650
$CaSO_4$	Ca	0.29428	9.468759
	CaO	0.41181	9.614700
	$CaCO_3$	0.73511	9.866350
CO_2	C	0.27289	9.435993
Cr_2O_3	Cr_2	0.68476	9.835536
CuO	Cu	0.79899	9.902540
Cu_2S	Cu_2	0.79863	9.902346
	2CuO	0.99956	9.999807
	Cu_2O	0.89910	9.953805
Cl	NH_4Cl	1.50966	0.178881
	KCl	2.10346	0.322936
	NaCl	1.65037	0.217581
Fe_2O_3	Fe_2	0.70008	9.845146
	2FeO	0.90002	9.954254
Fe_2	2FeO	1.28561	0.109110
	Fe_2O_3	1.42842	0.154855
	Fe_3O_4	1.38082	0.140136

Found.	Sought.	Factor.	Logarithm.
$PbSO_4$	Pb	0.68292	9.834369
	PbS	0.78877	9.896950
$Mn_2P_2O_7$	Mn_2	0.38719	9.587919
	2MnO	0.49986	9.698847
Mn_3O_4	Mn_3	0.72046	9.857611
$Mg_2P_2O_7$	Mg_2	0.21816	9.338772
	2MgO	0.36191	9.558598
	$2MgCO_3$	0.75731	9.879273
	P_2	0.27872	9.445165
	P_2O_5	0.63809	9.804883
Pt (from$(NH_4)_2PtCl_6$)	2N	0.14405	9.158503
	$2NH_3$	0.17507	9.243209
	$2NH_4Cl$	0.54920	9.739729
K_2PtCl_6	K_2	0.16103	9.206922
	2KCl	0.30697	9.487098
	K_2O	0.19397	9.287740
2KCl	K_2O	0.63189	9.800640
K_2SO_4	K_2O	0.54061	9.732883
SiO_2	Si	0.47014	9.672224
AgBr	Br	0.42553	9.628930
	HBr	0.43090	9.634370
AgCl	Cl	0.24724	9.393121
	HCl	0.25427	9.405294
	Ag	0.75276	9.876655
AgI	I	0.54030	9.732634
	HI	0.54459	9.736072
NaCl	Na	0.39407	9.595579
2NaCl	Na_2O	0.53083	9.724956
Na_2SO_4	Na_2	0.32429	9.510928
	Na_2O	0.43682	9.640305
	2NaCl	0.82290	9.915349
SnO_2	Sn	0.78814	9.896602
H_2O	H_2	0.11186	9.048662
ZnO	Zn	0.80344	9.904954

Editorial Notes.

Within recent years there has been no field of geology which has produced more abundant and fruitful results than that of glaciology. So many able workers have cultivated it that it has become difficult for any save the specialist to keep pace with the developments, and every teacher of geology has felt the great need of some work of moderate size, for his own information or for placing in the hands of his pupils for collateral reading. Such a work, by Prof. I. C. Russell,* has just appeared, and teachers of Geology, will heartily welcome it. In his "Glaciers of North America" is given a sufficiently full discussion of the science of glaciers in general, their origin, flow, physical features, effects their bearings on climate, etc., together with a detailed description of the North American glaciers, big and little. The work is clear, it is interesting, it is most admirably illustrated and the author's reputation as a geologist is a sufficient guarantee of its accuracy. No continent offers better material for the study of glaciers than does our own, and now their science is put into an available shape for both teacher and student.

S. W. W.

During the past year there have appeared three most excellent works in general entomology. All are indispensable, supplying, as they do, the different needs of the student. The first and most pretentious of these is by Dr. D. Sharp in the "Cambridge Natural History." Dr. Sharp's extraordinary acquaintance with the literature of insects, as editor of the Zoological Record, has given him the ability to produce a most excellent and readable work of general reference for the library.

The "Manual for the Study of Insects," by Prof. J. H. Comstock is a text book for use in colleges and universities where systematic and structural entomology are pursued, and in these fields it is unequalled. For the first time it permits the student to ascertain to which families the insects that he studies belong. The figures, by Mrs. Comstock, are nearly all new, a feature that is welcome, and, best of all, they are very accurate and clear.

The third work, "Economic Entomology," by Prof. J. B. Smith, while not as extensive as Prof. Comstock's work, is one that is most heartily welcome. It has no rival in its own field, that of applied entomology and is also an excellent adjunct in systematic entomology. Prof. Smith's long experience in both economic and systematic entomology has well fitted him for the task he undertook, and he is to be congratulated upon the success with which he has accomplished it. S. W. W.

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*Glaciers of North America. A Reading lesson for students of Geography and Geology, Ginn & Co., 1897.

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Types of Projective Transformations in the Plane and in Space.

BY H. B. NEWSON.

With Plate I.

The object of this paper is to determine the different types of projective transformations in space and to classify them according to their invariant figures. In order to do this it will be necessary to summarize the results already known for one and two dimensions, and to state the principles which will be used in the development of the method here employed.

§1. Types of Projective Transformations in one Dimension.

The one dimensional transformations* which we shall have occasion to make use of in this paper are the transformations of the range of points on a line, of the pencil of lines through a point, and the pencil of planes through a line. We know that there are just two types of projective transformations of a one dimensional form, viz: the kind that leaves invariant two distinct elements, either real or imaginary; and the kind that leaves invariant two coincident elements. By elements of a one dimensional form are understood the points of a range, the rays of a flat pencil and the planes of an axial pencil.

There are only two types of transformations of a one dimensional space. Type I leaves two distinct elements invariant; type II leaves two coincident elements invariant.

Much use will be made in this paper of the following theorem.

*Throughout this paper the word *transformation* must always be understood to mean projective transformation.

A projective transformatfon which leaves invariant three elements of a one dimensional space is an identical transformation and leaves every element of the space invariant. (Lie: Continuierliche Gruppen, S. 117.) In the case of a transformation of the second type leaving two coincident elements invariant one other invariant element suffices to render the transformation identical.

§2. Types of Projective Transformations in the Plane.

A projective transformation of the plane is a self dualistic transformation in the sense that it is both a point to point and a line to line transformation, and hence every plane figure invariant under a projective transformation must be a self dualistic figure. This necessary condition will often enable us to determine whether any given plane figure can be the invariant figure of a projective transformation.

Every type of transformation in the plane is characterized by its invariant figure. We assume the well known theorem that the most general form of projective transformation in the plane leaves a triangle invariant. Proceeding from this fact it is easy to enumerate all the special forms of the invariant figure, and thus all the types of projective transformations in the plane. We shall in this way determine five types (Fig. 1, Pl. I,) of transformations in the plane, of which type I is the kind of transformation whose invariant figure is a triangle. In this case the one dimensional transformations along the invariant sides and through the invariant vertices are all of the first kind leaving two elements invariant.

If two vertices of the invariant triangle of type I coincide, then two sides must also coincide. The change is a self dualistic change and the modified figure is also a self dualistic figure. This is the invariant figure of type II. The one dimensional transformations of the range along AB and of the pencil through A are both of the first kind; those along b and through B are both of the second kind.

If the two points A and B of the invariant figure of type II coincide while the lines b and c do not coincide, the resulting figure is not self duatistic; the same is true if the two lines c and b coincide, but not the points A and B. Neither of the resulting figures is self dualistic, and hence there are no types of transformations in the plane characterized by these figures. But if A and B coincide and at the same time b and c, the change is self dualistic and also the modified figure. This gives us type III. The one dimensional transformation along the invariant line is of the second kind; so also is that of the pencil through the invariant point.

A projective transformation of the plane which leaves invariant four points of the plane, no three of which lie on a line, is an identical transformation and leaves every point of the plane invariant. It may happen, however, that a third invariant point is situated on one of the sides of the invariant triangle of type I. In that case every point on this side is an invariant point, and hence every line through the opposite vertex is an invariant line. The resulting figure, which consists of all the points on a line c and all the lines through a point C not on the line c, is self dualistic. This is the invariant figure of a transformation of type IV, which is called a *perspective* transformation. The one dimensional transformations along all lines through C and in all pencils with vertices on c are of the first kind.

A special case of the last figure is when the vertex of the invariant pencil is on the line c of invariant points. This special case is also obtained when we assume a third invariant point on the line c of the invariant figure of type II; likewise when we assume another invariant point on the invariant line of the linear element of type III. The resulting figure is self dualistic and is the invariant figure of a transformation of type V, which is called an Elation.* The one dimensional transformations along all invariant lines and in all invariant pencils are of the second kind, leaving one element invariant.

This completes the list of types of projective transformations of the plane; for if we modify these invariant figures in all possible ways we can get no new self dualistic figures.

There are five types of projective transformations in the plane; each type is characterized by one of the self dualistic invariant figures of Fig. 1.

Lie in Vorlesungen ueber Continuierliche Gruppen, pp. 65-6 and 510-12, has determined all the types of projective transformations in the plane with the same results as given above. See also a paper by the writer in this QUARTERLY Vol. IV, page 243-49. The method here employed is important because it lends itself immediately to the determination of all types of projective transformations in space.

§3. Types of Projective Transformations in Space.

All projective transformations in space are self dualistic, for they transform points into points and planes into planes. Therefore the conditions of dualism employed in last section for determining

*Lie: Continuierliche Gruppen, S. 262.

types of projective transformations in the plane apply equally well to the determination of types in space. A projective transformation in space leaves invariant certain points, lines and planes. In an invariant plane the transformation is two dimensional and must be one of the five types enumerated above or an identical transformation. Along an invariant line and in an invariant pencil of planes the transformation must be either of the first or second kind or identical.

We know that the projective transformation of the most general kind in space leaves a tetrahedron invariant. From this starting point, by the aid of the principles just stated, it is easy to enumerate all the special forms of the invariant figure and hence all the types of projective transformations in space. We shall find in this way thirteen types (Fig. 2, Pl. I), of which type I is characterized by the tetrahedron itself The two dimensional transformations in the four invariant planes are all of the first kind leaving a triangle invariant. The one dimensional transformations are all of the first kind leaving two elements invariant.

If two vertices of the tetrahedron coincide, then two faces also coincide. The modified figure then consists of three invariant points, three invariant planes, three invariant lines in a plane and three invariant lines through a point. The resulting figure is thus self dualistic and characterizes type II. The two dimensional transformation in the plane ABC is of the first kind leaving a triangle invariant; those in the planes ABl and ACl are both of the second kind.

Let the vertices of the tetrahedron coincide two and two; i. e. let D coincide with A, and C with B. The resulting figure then consists of two points, two planes and three lines not lying in a plane. It is self dualistic in every respect and characterizes type III. The two dimensional transformations in the planes ABl and ABm are both of second kind.

Next let three vertices of the tetrahedron coincide at A, then must three faces of the tetrahedron also coincide. The resulting figure characterizes type IV. It consists of two points, two planes, and two lines. The two dimensional transformation in the plane ABl is of the second kind, that in the plane π is of the third kind.

Finally let all four vertices and all four faces of the tetrahedron coincide. The single invariant point lies in the single invariant plane, and there is an invariant line in this plane through the invariant point. This is best seen if considered as a special case of type IV. If in type IV A be made to coincide with B, the plane π

must coincide with the plane ABl; and also the line l must coincide with the line AB. The two dimensional transformation in the single invariant plane is of the third kind. This invariant figure characterizes type V.

In the five preceding cases if any transformation leaves invariant the invariant figure and one other invariant point not in an invariant plane or one other invariant plane not through an invariant point, the transformation is an identical one, and every point, line and plane in space is invariant. But the transformation is not necessarily identical when an extra invariant point is found on an invariant line or in an invariant plane.

If an extra invariant point is taken in one of the faces of the invariant tetrahedron of type I, but not on an invariant line, then all points in that face are invariant points and consequently all lines through the opposite vertex are invariant lines of the transformation. The resulting invariant figure is self dualistic and characterizes type VI. The corresponding transformation is called a perspective transformation. The one dimensional transformations along the invariant lines and in the invariant pencils of rays and of planes are all of the first kind leaving two elements invariant.

As a special case of the above the vertex of the bundle of invariant rays may lie in the plane of the invariant points. Such a figure is self dualistic and characterizes type VII. All the one dimensional transformations involved in it are of the second kind leaving one element invariant. The transformations of this type are called Elations in space.

It should be remarked that these two types VI and VII are the only types of projective transformations in space that leave all the points of a plane invariant. This can be shown by examining all the possible forms of this kind to be derived from the first five types. If an extra invariant point be taken in one of the invariant planes of type I, the result is type VI. If an extra invariant point be taken in the plane ABC of type II, the result is type VII. If it be taken on either of the planes ABl or ACl, the result is type VI. If such a point be taken in either of the invariant planes of type III, the result is type VII. If such a point be taken in the invariant plane ABl of type IV, the result is type VII. But if taken in the plane π of type IV, the result is type VI. If such a point be taken in the invariant plane of type V, the result is type VII. In all these cases it is understood that the extra invariant point is not taken on an invariant line of the invariant plane. We have thus exhausted the possibilities and have obtained only the two types VI and VII.

Again, another set of special types may be found by taking an extra invariant point on one or more of the invariant lines of the first five types.

If a transformation leave invariant a third point on one of the edges of the tetrahedron of type I, the one dimensional transformation along that edge is identical and every point of the edge is invariant. The resulting figure characterizes type VIII. It consists of all points on the line AD, the points B and C, and all planes through the line BC. The two dimensional transformations in the planes BAD and CAD are both of the fourth kind; those in the other invariant planes are all of the first kind.

If a third invariant point occur on the line BC of type II, then all points on that line are invariant and the resulting figure characterizes type IX. The two dimensional transformation in the plane ABC is of the fourth kind; the two dimensional transformations in the invariant planes through AI are all of the second kind.

If an extra invariant point occur on the line BC of the invariant figure of type VIII, the resulting figure characterizes type X. The invariant figure consists of all points on two non-intersecting lines and of all lines joining two invariant points. The one dimensional transformations along the invariant lines are all of the first kind. The two dimensional transformations in the invariant planes are all perspective transformations.

In the invariant figure of type II if an extra invariant point is found on the line AB, the resulting figure characterizes type XI. The two dimensional transformation in the plane ABI is of the fourth kind; that in the plane π is of the third kind; that in every plane through AB is of the second kind.

In the invariant figure of type III if an extra invariant point be taken on the line BC, then all points on that line are invariant and also all planes through the line of invariant points. The resulting figure, consisting of all points on a line and all planes through the line, characterizes type XII. The two dimensional transformations in the invariant planes are all of the fifth kind.

In the invariant figure of type IV if an extra invariant point be taken on the line AB, all points on that line and also all planes through AI are invariant. The resulting figure characterizes type XIII. The two dimensional transformation in the plane ABI is of the fifth kind, while the two dimensional transformations in the planes through AI are all of the third kind.

This completes the list of thirteen types. The invariant figures characterizing the last six cases are all seen to be self dualistic. There is in every case an identical transformation along at least one invariant line and in one invariant pencil of planes. The reader may verify that this list is complete by assuming in turn an extra invariant point on each of the invariant lines of the first five types. No new self dualistic figure will be found.

There are thirteen types of projective transformations in space; each type is characterized by one of the self dualistic figures of Fig. 2.

The determination of these thirteen types of transformations is preliminary to the more extensive problem to determine all the continuous groups of projective transformations in space and to classify them according to these thirteen types. The writer has completed the investigation of this problem for a majority of the thirteen types and will soon begin publishing the results.

Fig. 1

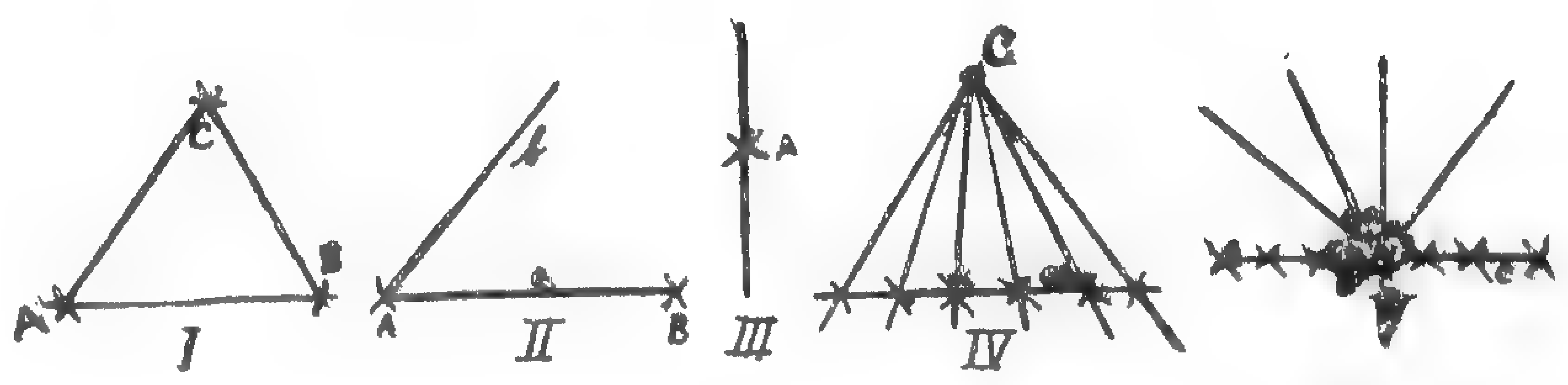
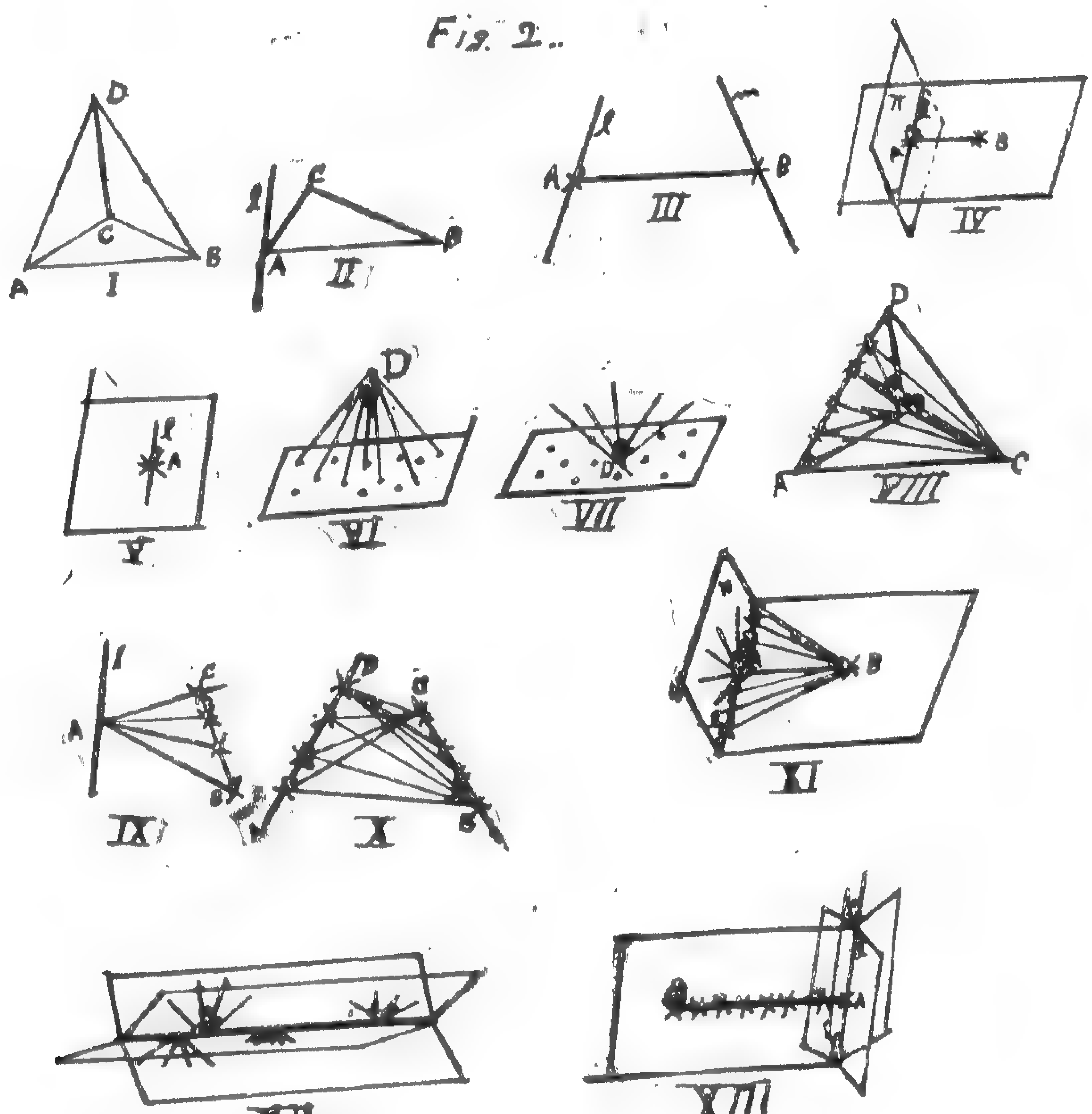

C
A
B
I
A
B
II
A
III
C
IV

Fig. 2.


D
C
A
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VII
D
A
C
VIII
A
IX
X
B
XI
XII
XIII

A New Explosive Compound formed by the Action of Liquid Ammonia upon Iodin.

BY HAMILTON P. CADY.

During the progress of some work on liquid anhydrous ammonia it became necessary to investigate its action on iodin.

Several investigations on the action of dry ammonia gas upon iodin have been carried out from time to time with rather varying results. Bineau* measured the volume of dry ammonia gas absorbed by a weighed quantity of iodin and deduced the formula $3\,NH_3, 2I$. The product was a brilliant dark blue liquid. Milton† however found a very much smaller absorption, which was not materially increased by cooling to $-18°$. Raschig‡ made a third investigation in order to clear up these discrepancies, and found that the composition varied with the temperature. At $80°$ he found the composition NH_3I, at $20°$ $(NH_3)_3I_2$, at $0°$ $(NH_3)_2I$, at $10°$ $(NH_3)_5I_2$. These results were based not on analysis but upon the gain in weight when dry ammonia gas was passed over a weighed quantity of iodin. These are all non-explosive liquids, the last one gives up part of its ammonia when taken from the freezing mixture.

Seamon§ obtained a non-explosive liquid, solidifying at $-8°$ having the composition NH_3I_2 by the action of ammonia gas upon iodin. G. Gore‖ mentions the fact that iodin is soluble in liquid ammonia but in the brief abstract given in Watts Dictionary, Third Sup. VIII, Pt. I, p. 74, nothing is said about the products found.

It seemed probable that the action of liquid ammonia upon iodin would be practically the same as that of gaseous ammonia, and that the results would be an addition product. In order to test this conclusion the following experiments were then made:

*Ann. Chim. phys. [3] 15, 80

†Ann. Chim. phys. [?], 6, . .

‡A. 241, 253

§C. N. 44, 188.

‖Prov. Roy. Soc. XX, 441.

A few grams of iodin were placed in the bottom of a vacuum jacketed test tube and liquid ammonia was then run in from the wrought iron cylinders in which it was purchased. The whole apparatus was at ordinary temperature, so of course considerable gas preceded the liquid. As soon as this gas came in contact with the iodin the latter melted and a portion of it even volatilized. The remainder dissolved in the liquid ammonia, forming a dense black solution. For every 4 or 5 grams of iodin used 25 to 30 cc. of ammonia was added.

The solution was protected from water vapor by a chlorid of calcium tube filled with soda lime, and being surrounded by a vacuum of course the ammonia evaporated only very slowly.

The color of the solution was at first a dense black through which light could not penetrate, in a few moments, however, it began to change to a yellowish green and in a short time an olive green, crystalline precipitate separated out leaving the liquid above almost clear and colorless. This precipitate was taken up on a perforated platinum spoon washed with liquid ammonia and quickly transferred to a platinum crucible lid and dried over sulfuric acid in a desiccator. If the solution has been properly protected from water and the transfer has been made with sufficient rapidity the dried product is crystalline and has a beautiful olive green color, otherwise it generally melts to a black liquid and afterwards forms black amorphous solid.

The olive green substance is violently explosive, although more stable than nitrogen iodid. It explodes at the slightest touch or on very slight rise in temperature, it does not, however, seem to be more unstable when in contact with wood and paper than it is with other substances. The dried compound is only slightly volatile, much less so than iodin, and may be kept in desiccators for for several days but will generally explode in less than a week. It may be weighed together with the platinum lid upon which it was dried. It is soluble in ether, alcohol, and chloroform, in each case with the evolution of gas. It is insoluble in dilute hydrochloric, sulfuric and nitric acid, but is slowly decomposed by them, generally exploding a few minutes after being placed in the liquid, and always doing so instantly if the acids are concentrated. It is dissolved by potassium iodid in solution, often with explosion, is decomposed and dissolved in very dilute hydrochloric acid and sulfurous acid or hydrogen sulfid, also by potasium hydroxid. In every case gas is evolved during the process of solution and in the majority of cases the experiment is interrupted by an explosion violent enough to shatter the beaker and then in some case to blow a hole through the crucible lid.

Two determinations of iodin were made by decomposing the substance with sulfurous acid in the presence of very dilute sulfuric acid, acidulating with nitric acid and precipitating with silver nitrate.

No. I. 0.0817 grams substance gave 0.1076 grams AgI.

No. II. 0.1185 grams substance gave 0.1568 AgI.

No. I. I = 74.33 per cent.

No. II. I = 74.68 per cent.

Calculated for $(NH_3)_3I = 71.26$ per cent., $(NH_3)_2I = 78.88$ per cent., $(NH_3)_5I_2 = 74.85$ per cent.

An attempt was then made to determine the ammonia by decomposing the compound in same way, then making the solution alkaline with potassium hydroxid and distilling into known volume of deci-normal sulfuric acid and liberating the excess of acid.

No. III gave 3.17 per cent. NH_3.

No. IV gave 3.26 per cent. NH_3.

Calculated for $(NH_3)_5I_2$ 25.15 per cent.

As has been said above, gas is always given off when this compound is dissolved. An effort was made to collect and measure this gas but failed chiefly on account of the numerous explosions. About seven out of eight of the samples blew up before they could be decomposed. After trying a great many different methods of decomposing the body in order to determine the nitrogen and failing in all of them, it was finally exploded over mercury, ane the volume of the gas was measured. The products of the reaction were N, NH_4I and I, the latter united with the mercury.

The substance was weighed out on a little platinum cup with a hollow stem welded on to the bottom. An iron wire was then inserted into the stem and the whole introduced into a eudiometer partly filled with a measured quantity of pure nitrogen to act as a cushion. A few cc. of pure electrolytic gas was then run in and the whole exploded. The electrolytic gas in its explosion set off the iodin compound and the gain in volume over that of the pure nitrogen was of course that portion of the nitrogen in the compound which did not combine with the hydrogen and iodin to form ammonia iodid.

0.0869 grams of the compound gave 15.3 cc. nitrogen at 0° 760 m. m. = 22.12 per cent. N exclusive of what remained behind as ammonium iodid.

	I	NH_3	N
No. I.	74.33 per cent.		
No. II.	74.68 per cent.		
No. III.		3.17	
No. IV.		3.26	
No. V.			22.12
Av.	74.51	3.22	22.12

3.22 per cent. NH_3 = .57 per cent. H, 2.65 per cent. N. So the body would have the following percentage composition:

		Calculated for HN_3I.	
I	74.51	I	74.70
N	24.77	N	24.71
H	.57	H	.59
	99.85		100.00

The compound HN_3I would probably decompose in this way when treated with sulfurous acid:

$$6\ HN_3I + 3H_2SO_3 + 3H_2O = 2NH_4I + 4HI + 3H_2SO_4 + 8N_2,$$

and this would yield 3.33 per cent. of its weight of NH_3, agreeing well with what was found.

If the compound had been analyzed in the way that nearly all the nitrogen iodid compounds have been, by dissolving the moist substance in HCl and determining the ratio of NH_3 to I it would have given the ratio N to 3I.

The molecular weight could not be determined because the substance decomposed in all solvents, so it is impossible to say whether it is HN_3I or a multiple.

The reaction for the formation of this substance may be represented as follows:

$$11\ NH_3 + 9I = HN_3I + 8NH_4I.$$

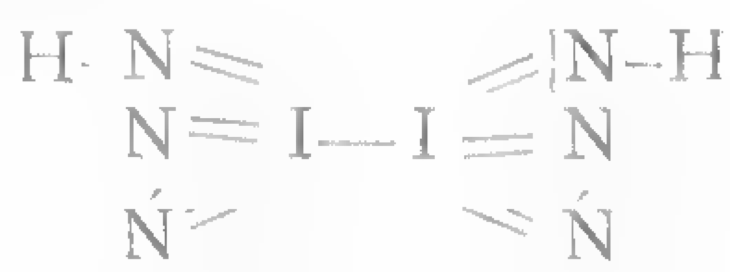
No hydrogen is liberated during the reaction and ammonium iodid is found in the mother liquor, so the above reaction must be essentially correct.

No corresponding reaction takes place with bromin and chlorin. Ammonium bromid or chlorid and nitrogen are the only products.

So we may conclude that the action of liquid ammonia upon iodin is not the same as that of gaseous ammonia and that in one case substitution products are found and in the other addition products.

As to the constitution of the body nothing definite can be said at present. The formula

suggests itself but is rather contradicted by the fact that NH_4I, N, and HI are formed by the action of sulfurous acid and water upon it and not hydroazoic acid as would be expected. It might also have the formula



But nothing is known which tends to favor this view. In fact it seems useless to speculate until some means can be found for determining its molecular weight. The intention is to continue this work in order to see whether by more extended study its structure can be made out.

The Effect of Magnetism Upon the Spectral Lines of Sodium.

BY A. StC. DUNSTAN, M. E. RICE, AND C. A. KRAUS.

Dr. P. Zeeman (Phil. Mag. March, 1897,) has announced the discovery of an effect of magnetism upon radiation. Analyzing by means of a concave grating the light radiated from a sodium flame placed between the poles of an electromagnet, he finds that upon exciting the magnet, the spectral lines are very decidedly broadened. Upon cutting off the exciting current the lines regain their usual appearance.

Zeeman also gives a number of other experiments which seem to show that the effect is not due simply to changes of pressure in the flame but is caused by a real influence of magnetism upon the radiations emitted. He considers his results to be confirmatory of the theory of Lorentz.*

The discovery considered from a theoretical standpoint is one of great importance, in that it establishes another relation between magnetism and light and is in accord with the electromagnetic theory.

The subject, therefore, seemed to the writers to be worthy of quantitative investigation, and this paper is for the purpose of giving an account of preliminary measurements of the phenomenon.

METHOD.

For the purpose of determining the breadths of the spectral lines and the distribution of light in the same the writers have used Michelson's Interferometer, which succeeds precisely where the diffraction grating fails: i. e., in the analysis of a single line or narrow group of lines.

A full description of the instrument is given below.

APPARATUS.

The light under examination was that given off by a bunsen flame, colored by a piece of asbestos saturated with NaOH solution and wrapped around the top of the bunsen burner.

*"La Theorie Electromagnetique de Maxwell." Leyde 1892. "Versuch einer Theorie der electrischen und optischen Erscheinungen in bewegten Korpern." Leiden 1895.

The flame was turned low, not over five centimetres in hight.

The flame was placed between the poles of an electromagnet, A. By means of a screen, B, with a .75 cm. hole, light was used from that portion only of the flame which was just between the pole pieces.

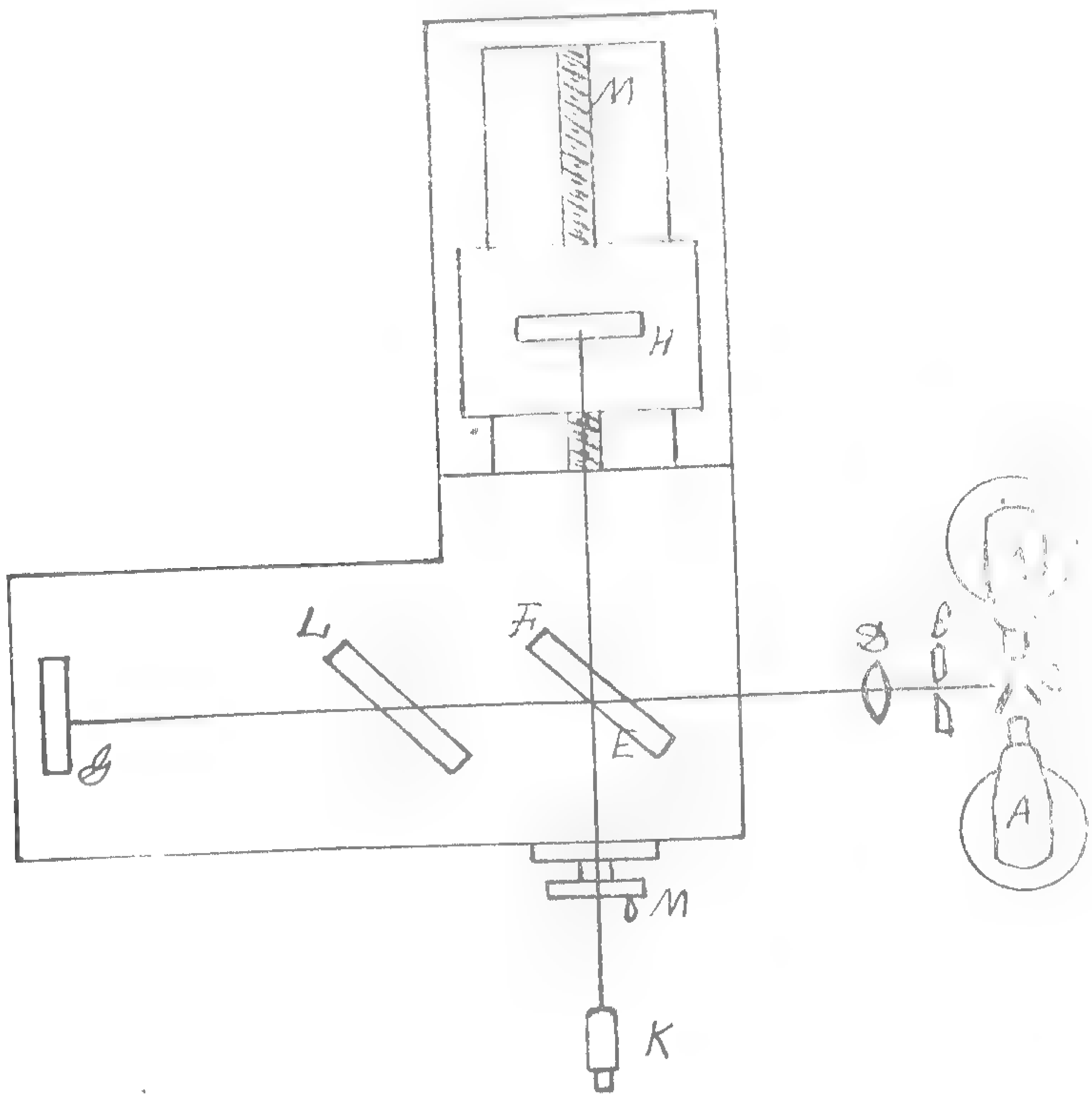


Fig. 1.

The general arrangement of the interferometer is shown in Fig. 1. Light from the flame C is rendered slightly convergent by the collimating lens D and falls upon the semi-silvered surface E of a plane parallel glass F. Here the beam of light is divided, one part (approximately half) being transmitted to the mirror G, the other part reflected to the mirror H. After reflection at the mirrors G and H the two pencils reunite at the surface E; part of the first pencil being reflected and part of the second transmitted to the telescope K or to the unaided eye.

The two plane parallel glasses F and L are set at an angle of 45^0 with the mirrors G and H, and the distances of the two mirrors G and H from the semi-silvered surface E are at first made approximately equal by turning the screw M. The parallel glass L acts as a compensator, so that the two pencils shall have traversed equal thicknesses of glass before reaching the eye.

Under these conditions, after adjusting slightly the mirror G, the observer will see a series of brilliant interference bands.

By turning the screw M so as to increase slightly the distance of the mirror H from the surface E, thereby increasing the difference of path of the two interfering pencils, and suitably adjusting the mirror G, the interference bands, or fringes, can be made circular and concentric. It is upon the "visibility" or distinctness of these concentric circular interference fringes, as the difference of path is further increased and the magnet excited or not excited, that the results stated in this paper are based.

The fringes were observed by means of the telescope K, focused for parallel rays.

The observations consist in estimating the "visibility" or distinctness of these fringes for successive differences of path of the interfering pencils. Curves are then plotted, using differences of path in mms. as abscissas and visibilities expressed as a proper fraction, as ordinates. From these curves the distribution of light in the source may be deduced, which distribution may also be expressed by a curve with wave lengths in Angström units as abscissas and intensities expressed as a proper fraction as ordinates.

Michelson (Phil. Mag. Vol. 31, p. 338, and Vol. 34, p. 280,) has discussed fully the theory of the interferometer, which he shows will give the same interference phenomena as would be given by two plane luminous surfaces vibrating in the same phase, making a small angle with each other. When the mirror G is adjusted so as to show circular fringes, the angle between the two luminous surfaces is zero. It is under these conditions that we have used the instrument, consequently we give the theory only for this case.

If the distribution of light in the source is given by $y = \phi(x)$ where y is intensity and x is expressed in differences of wave numbers, measured from the mean wave number of the source, Michelson has shown that the "visibility", V, is given by $V^2 = \frac{C^2 + S^2}{P^2}$.

Where;

$$C \quad \int \phi(x) \cos 2\pi D x dx$$

$$S \quad \int \phi(x) \sin 2\pi D x dx$$

$$P \quad \int \phi(x) dx$$

D being the difference of path of the interfering pencils in mms. (read from the screw M). The limits of integration are chosen so as to include the entire source. The visibility, V, is defined as the difference of intensities of a bright and a dark band divided by the sum of these intensities, or algebraically $V = \dfrac{I\ \text{bright} - I\ \text{dark}}{I\ \text{bright} + I\ \text{dark}}$.

And it has also been shown by Michelson's investigations that eye estimates of visibility agree fairly with the true values.

The distribution of light in the source resulting from Maxwell's law of molecular velocities is given by $\phi(x) = \epsilon^{-\frac{px^2}{a^2}}$ and it has been further shown experimentally that the actual distribution of light in a single spectral line in most cases approximates closely to that given by the formula. The visibility curve resulting from a single line with this distribution is $V = \epsilon^{-\frac{\pi^2 n^2}{p}}$ and for a source consisting of two such lines, the distribution in each being given by the above formula, the visibility is given by

$$V = \epsilon^{-\frac{\pi^2 n^2}{p}} \left\{ \frac{1 + r^2 + 2r\cos 2\pi Da}{1 + 2r + r^2} \right\}^{\frac{1}{2}}$$

Under the conditions of temperature and pressure existing in a bunsen flame this formula represents very well the visibility curve given by the yellow sodium lines.

For convenience of calculation this formula may be put in the form

$$V = A2^{-\frac{D^2}{\Delta^2}} \left\{ \frac{1 + r^2 + 2r\cos 2\pi Da}{1 + 2r + r^2} \right\}^{\frac{1}{2}}$$

and $\phi(x) = 2^{-\frac{x^2}{\delta^2}}$

In these expressions A is a constant not greater than unity, r is the ratio of intensities of the two lines constituting the source, a is a quantity proportional to the distance between the centres of the lines in wave numbers, and D is the difference of path in mms. of the two interfering pencils as determined by the screw M.

$\triangle$ is a quantity which varies inversely as the half breadth of one of the lines in the source.

The formula shows that the visibility is a periodic function of the difference of path D, and hence that as the difference of path is gradually increased the visibility passes through successive maxima and minima. These maxima will touch the curve given by

$V=A2^{\frac{D^2}{\triangle^2}}$ and hence steadily decrease as the difference of path becomes greater. Hence this envelope, determined by observation at points of maximum visibility will give a curve expressed by

$A2^{\frac{D^2}{\triangle^2}}$ and from this curve may be determined A and $\triangle$; where $\wedge$ is the abscissa of the point at which $V=\frac{1}{2}A$ and A is the visibility at the point where $D=o$.

It may be proved further that $\triangle$ is connected with δ, the half width of the line in the source by the expression $\delta=\frac{\log_\epsilon 2}{\pi\triangle}$ and hence from the value of $\wedge$ may be determined the width of the line.

The magnet used was a large one with movable pole pieces. It was capable of carrying a current of fifty amperes for short periods, and this current was used in some of our experiments. The space between the pole pieces varied from 3 to .75 cm. and thus gave a great range of field intensities. Field intensities were measured by means of exploring coils of known area, which were suddenly jerked out from between the pole pieces. The throw of a Horizontal Pattern D'Arsonval Ballistic Galvanometer, which was connected through a resistance box to the exploring coil, gave data for the calculation of the strength of the magnetic field. In order to avoid error due to damping, which in this form of galvanometer is considerable, the exploring coil was arranged so that it broke the circuit immediately upon being jerked out of the field and hence left the damping of the galvanometer the same as upon open circuit. By changing the resistance in the box the galvanometer throws were kept nearly constant in magnitude and hence the errors due to damping, reduction to arc, etc,, were avoided.

The galvanometer constant was determined by means of an Elliott standard condenser and two Carhart-Clark cells.

For each position of the pole pieces a curve, whose co-ordinates were strength of field and exciting current, was drawn, thus enabling the strength of field to be interpolated from an ammeter reading. The two exploring coils used were wound with a single layer of No. 36 wire and had total areas of 102.37 and 34.99 square centimeters respectively.

OBSERVATIONS.

SERIES I.

D in Millimetres.	Visibility	Intensity of Magnetic Field.
3.52	.70	0
"	.70	1166
"	.70	1878
"	.70	2950
4.68	.70	0
"	.70	1166
"	.70	1878
"	.70	2950
6.38	.68	0
"	.68	1166
"	66	1878
"	.66	2950
8.10	.65	0
"	.65	1166
"	.64	1878
"	.56	2950
10.44	.60	0
"	.55	1166
"	.55	1878
"	.40	2950
12.12	.55	0
"	.54	1166
"	.35	1878
"	.20	2950
12.70	.53	0
"	.48	1166
"	.30	1878
"	.10	2950
13.20	.50	0
"	.43	1166
"	.30	1878
"	.12	2950
13.90	.47	0
"	.37	1166
"	.25	1878
"	.05	2950
14.48	.45	0
"	.35	1166
"	.06	2950
"	.20	1878
15.06	.45	0
"	.15	1878
"	.04	2950
"	.30	1166
15.64	.45	0
"	.04	2950
"	.30	1166
"	.10	1878
16.18	.43	0
"	.09	1878
"	.25	1166
"	.00	2950
16.79	.40	0
"	.25	1166
"	.07	1878
17.96	.37	0
"	.20	1166
"	05	1878
19.08	.35	0
"	.15	1166
20.26	.35	0
"	.10	1166
23.78	.30	0
"	.05	1166
24.44	.28	0
"	.06	1166

SERIES II.

D in Millimetres.	Visibility	Intensity of Magnetic Field.
1.76	.78	0
"	.78	7843
2.26	.78	0
"	.76	7843
2.82	75	0
"	.72	7843
3.38	.75	0
"	.70	7843
4.00	.75	0
"	.68	7843
4.62	.74	0
"	64	7843
5.20	.70	0
"	.60	7843
5.78	.70	0
"	.45	7843
6.38	.65	0
"	.29	7843
6.98	.63	0
"	.10	7843
7.58	.60	0
"	.01	7843
8.18	.57	0
"	.00	7843
18.32	.20	0
20.82	.15	0
23.92	.10	0

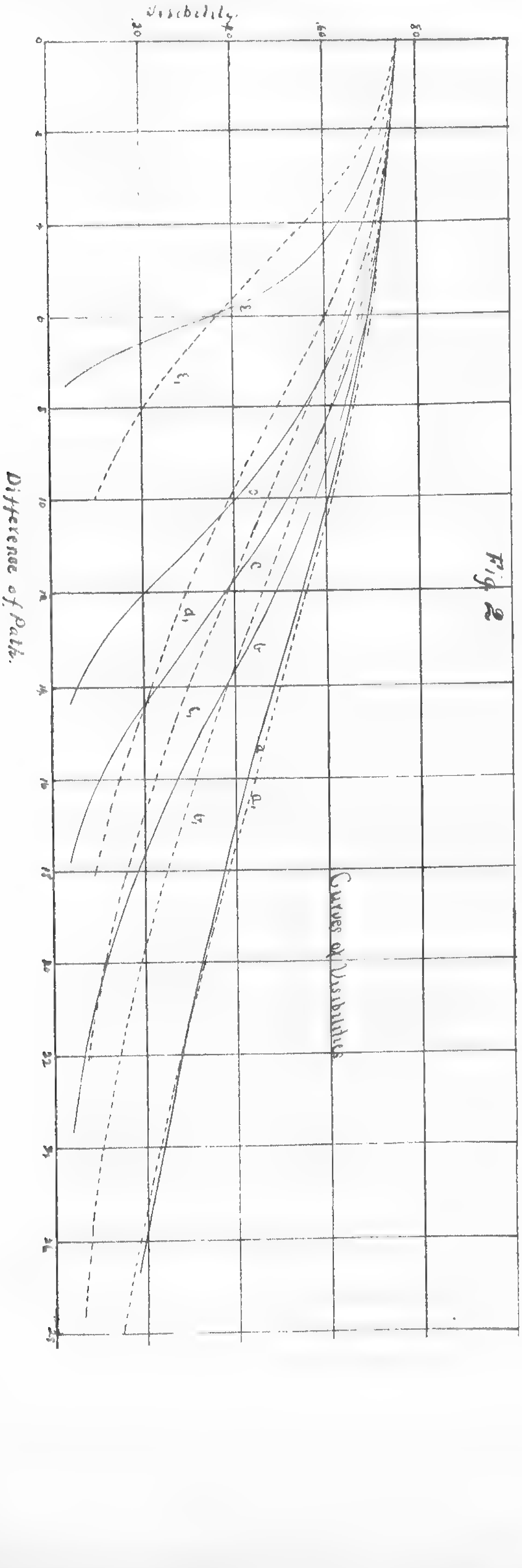


Fig 2

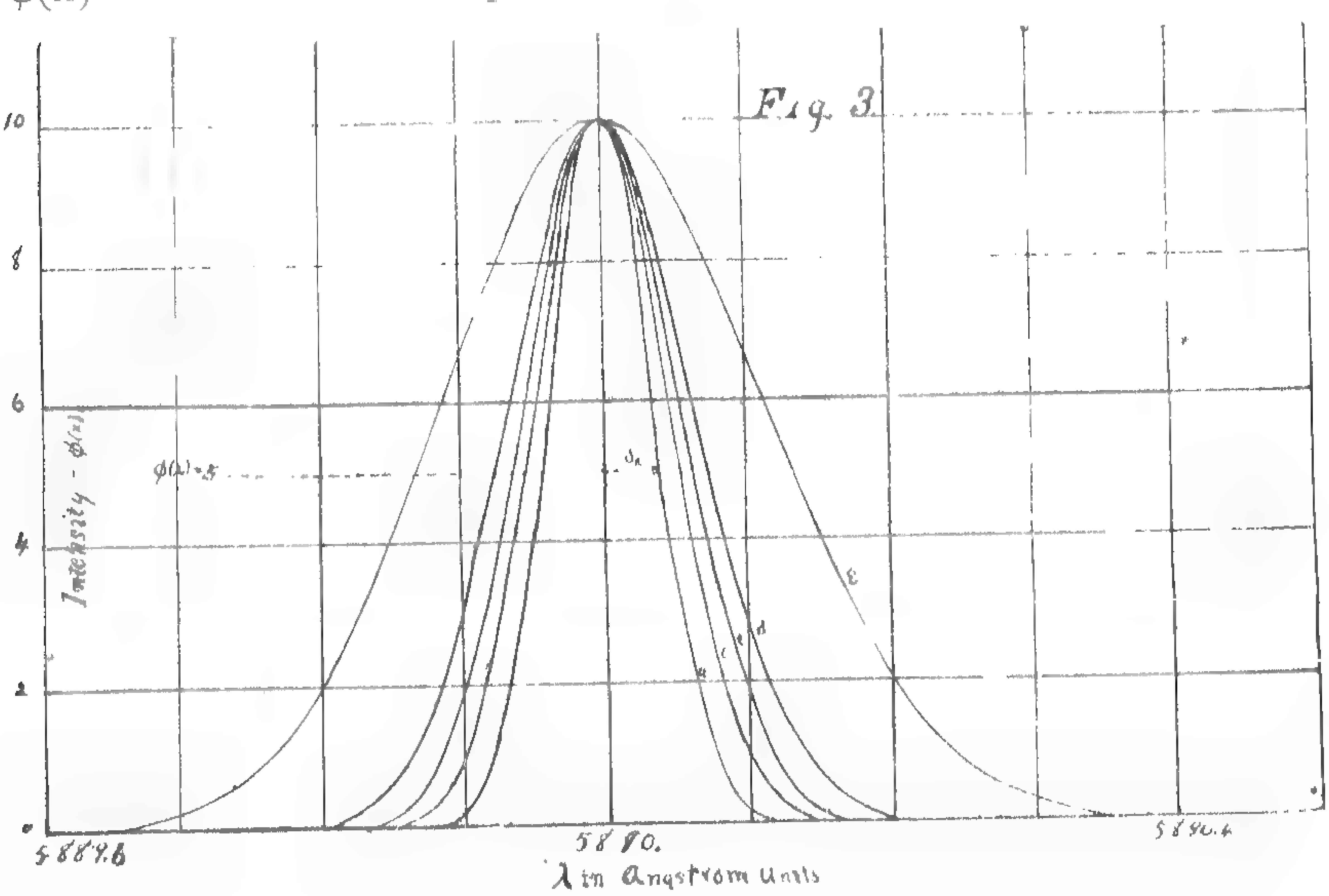
In making his estimates of visibility the observer was kept in ignorance of the field strength or whether the magnet was excited at all. The visibilities for the second set of observations, which were taken on another day, are all multiplied by $\frac{76}{80}$ before plotting in order to reduce them to the same initial ordinate as the others.

RESULTS.

In Fig. 2 curves a to e are the visibility curves for maxima, plotted from the preceding observations.

Curve a, Magnetic Field = 0 C. G. S. units.
Curve b, Magnetic Field = 1166 " "
Curve c, Magnetic Field = 1878 " "
Curve d, Magnetic Field = 2950 " "
Curve e, Magnetic Field = 7843 " "

It is seen that the visibility curves fall off more and more rapidly for increasing field strengths, indicating a general broadening of the spectral line. Curve a agrees very closely with the dotted curve a′, whose equation is $V = .76 \times 2^{-\frac{D^2}{18^2}}$ and from which is calculated the half width of one of the sodium lines to be $\delta_1 = \frac{.2206}{18} = .0123$ wave numbers, which can be reduced to Angström units by multiplying by the factor 3.47 which gives $\delta_1 = .0425$ Angström units. Hence the distribution of light in a single sodium line free from the effect of magnetism is given by the expression $\phi(x) = 2^{-\frac{x^2}{\delta^2}}$ which is plotted as curve a Fig. 3.



Exponential curves b′, c′, d′, e′, of the same form are also drawn through the points of half initial visibility of the curves b, c, d, e, Fig. 2.

It is evident from these curves that the visibility curve has changed form, and hence the distribution of light in the source has been somewhat modified by the influence of the magnetic fields; but still the visibility curves for maxima are non-periodic, and a fair approximation to the form and breadth of the source may be obtained from these exponential curves b′, c′, d′, e′, whose equations are:

$$\text{Curve } a'; \; V = .76 \times 2^{-\left(\frac{D}{18}\right)^2}$$

$$\text{Curve } b'; \; V = .76 \times 2^{-\left(\frac{D}{14}\right)^2}$$

$$\text{Curve } c'; \; V = .76 \times 2^{-\left(\frac{D}{12}\right)^2}$$

$$\text{Curve } d'; \; V = .76 \times 2^{-\left(\frac{D}{10.2}\right)^2}$$

$$\text{Curve } e'; \; V = .76 \times 2^{-\left(\frac{D}{5.8}\right)^2}$$

It may be noted in passing that the period of the complete visibility curve is not changed by the influence of the magnetic field, so that the mean distance between the two sodium lines is not thereby altered, but only the distribution of light in each line. Also, that very considerable changes in the bunsen flame itself make no difference in the visibility curves of the sodium lines, and hence the effects observed cannot be explained on the ground of variations in the brilliancy or intensity of the flame.

From the equations of the curves a′, b′, c′, d′, e′, Fig. 2, are calculated the half widths of one of the sodium lines under the influence of various magnetic fields.

The values are:

$\delta_1 = .0425$ Angström units.
$\delta_2 = .0549$ " "
$\delta_3 = .0638$ " "
$\delta_4 = .0750$ " "
$\delta_5 = .1320$ " "

and the curves $\phi(x)$ for the assumed exponential law of distribution of intensities in the source are plotted in Fig. 3 as curves a, b, c, d, e, whose equations are:

Curve a; $\phi(x) = 2^{-\left(\frac{x}{.0425}\right)^2}$

Curve b; $\phi(x) = 2^{-\left(\frac{x}{.0549}\right)^2}$

Curve c; $\phi(x) = 2^{-\left(\frac{x}{.0638}\right)^2}$

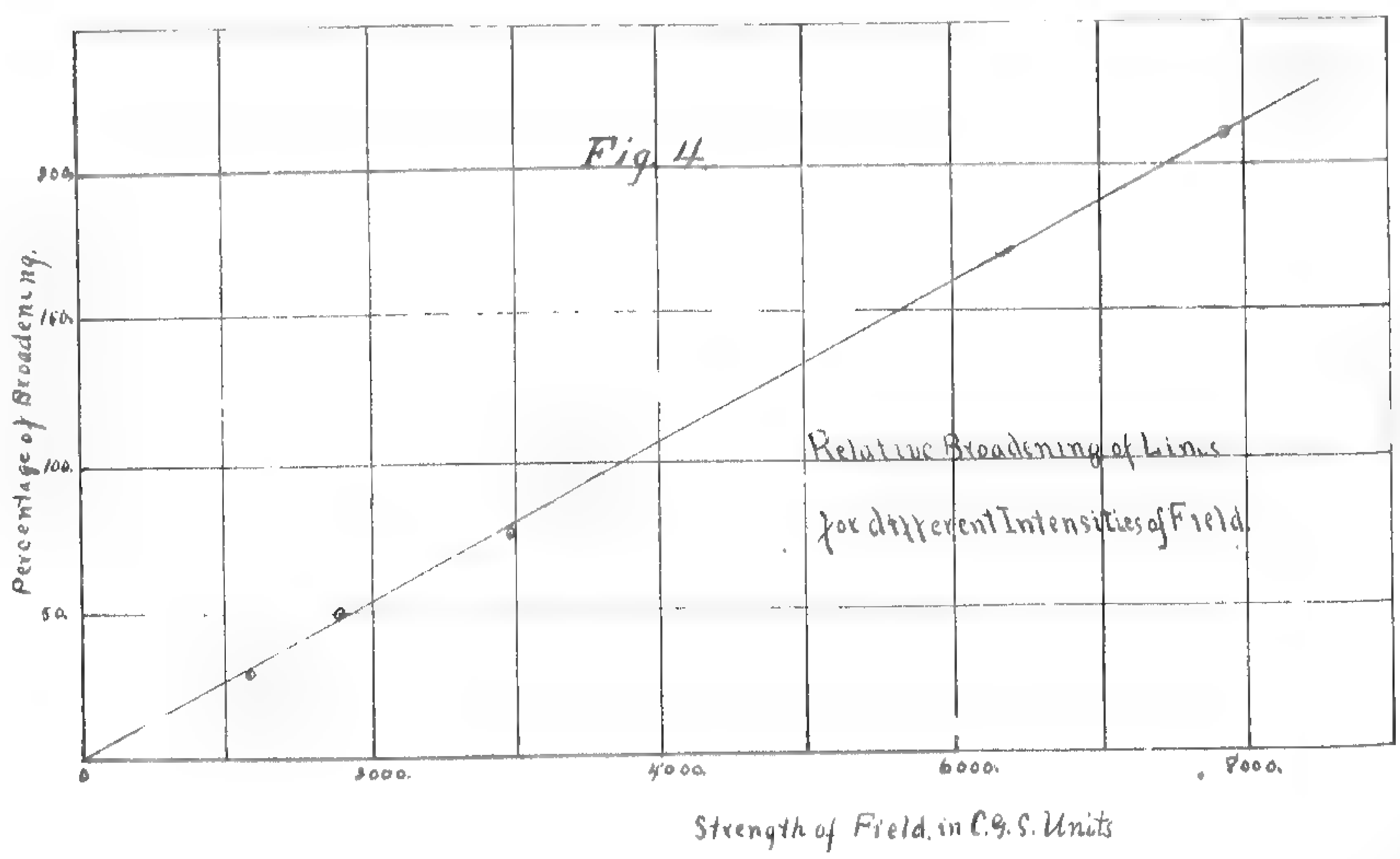
Curve d; $\phi(x) = 2^{-\left(\frac{x}{.075}\right)^2}$

Curve e; $\phi(x) = 2^{-\left(\frac{x}{.1320}\right)^2}$

The broadening of the lines for field strength, 7843, is given by the ratio $\frac{\delta_5 - \delta_1}{\delta_1} = 210$ per cent, and similar expressions for the broadening for other field strengths give:

Field Strength.	Percentage of Broadening.
0	0
1166	29
1878	50
2950	76
7843	210

These results are plotted in Fig. 4, and seem to show conclusively



that the broadening is directly proportional to the strength of the magnetic field.

Zeeman, on the basis of Lorentz's theory, deduces that the change of the period of any vibrating molecule, divided by the original period, that is $\frac{T-T'}{T}$ should be equal to $\frac{e}{m}\cdot\frac{HT}{4\pi}$ where e is the charge on the vibrating particle in electromagnetic measure, m is the mass of the same particle, H is the strength of the magnetic field in C. G. S. units, T is the original period of the vibrating particle, and T′ the period when vibrating in the magnetic field H. Inserting his observed values he finds that $\frac{e}{m}$ is of the order of 10^7 C. G. S. units.

The writers have thought it worth while to attempt a verification of this result from the measures given in this paper.

Let λ be the wave length of the light emitted by some particle in the unbroadened line, then $\lambda + (\delta_5 - \delta_1)$ equals wave length of the light emitted by the same particle in the broadened line.

From Lorentz's formula

$$\frac{T-T'}{T} = \frac{e}{m}\cdot\frac{HT}{4\pi}$$

$$T = \frac{\lambda}{v},\quad T' = \frac{\lambda + (\delta_5 - \delta_1)}{v}$$

Where v is the velocity of light. Then substituting in the formula above,

$$\frac{\delta_5 - \delta_1}{\lambda} = \frac{e}{m}\cdot\frac{H\lambda}{4\pi v}$$

Expressing all quantities in C. G. S. units,

$$\lambda = 5890\times 10^{-8},\qquad \delta_5 - \delta_1 = .0895\times 10^{-8}.$$
$$H = 7843.\qquad v = 3\times 10^{10}.$$

This gives

$$\frac{e}{m} = 1.25\times 10^{7}.$$

If this number is assumed to represent the ratio between the number of electromagnetic units of electricity on a sodium atom and its mass, a rather interesting conclusion may be drawn as to the order of magnitude of the mass of this atom. For Mr. G. J. Stoney has calculated that for every chemical bond of a monovalent substance ruptured a charge of 10^{-20} coulomb is transferred, or in C. G. S. units 10^{-21}, and if it is further assumed that this is the charge upon a monovalent atom, it follows from inserting this value in the formula for $\frac{e}{m}$ that m equals $.8\times 10^{-28}$ grams. Using the value of $e=17x10^{-20}$, given by Budde, the value of m comes out $13.6x10^{-28}$ grams.

In conclusion it seems to the writers that their results justify them in stating that the broadening of the spectral lines of sodium is directly proportional to the strength of the magnetic field, and that the broadening of the line for unit field is 11.47×10^{-6} Angström units.

It is proposed to continue this work, extending its scope to include other substances, under various conditions.

Results of Windmill Tests.

P. C. MURPHY.

In Vol. 4, No. 2 of the KANSAS UNIVERSITY QUARTERLY the writer gave the results of some tests of windmills which he made during the summer of 1895. These tests were made with inferior instruments—the only ones then at his disposal—and on small mills operating small pumps raising water mainly for stock purposes.

During the summer of 1896 with much better instruments furnished by the Hydrographic branch of U. S. Geological Survey, he has continued this work testing the large steel mills working large pumps and raising the water for irrigating purposes.

We have also extended the work to include "power" as well as pumping mills. In this paper we wish to give some of the results of these tests, and conclusions to be drawn from them. The complete discussion of results will be found in the forthcoming report of the writer on "Windmills for Irrigation Purposes."

During the season of '95, wind velocity was measured with a small anemometer held on a board at the height of platform of mill. The number of strokes per minute were counted. In '96 the wind velocity was measured with a U. S. Weather Bureau cup anemometer placed on a pole out of the influence of mill and at the height of axis of wind wheel. Each mile of wind and also the number of strokes of pump were recorded electrically on a two pen register. The results of the tests of pumping mills are given in Table I. Examining these results the following conclusions may be drawn:

(1). The power of pumping windmills or the useful work they do is small. None of those tested gave more than .65 of a horse power in a 30 mile wind.

(2). All mills of the same size are not doing the same amount of work. No. 11 for example, is doing twice as much work in a 30 mile wind as No. 3. The chief reason for this is the difference in the load on the mill or the number ft. lbs. of work per stroke of pump. The influence of load on power of mill will be shown in tests of power mills.

(3). Some of the small mills are doing nearly as much work as those of larger diameter. Compare Nos. 9 and 11, also Nos. 12 and 11.

(4). The back-geared steel mills do more work than the direct stroke wooden mills. Compare No. 21 with No 11 or No. 2. or

TABLE I.

Mill No.	OWNER.	NAME.	Size.	Number of strokes per mile of wind when velocity is — miles per hour.						Number of strokes per minute when velocity is miles per hour.					
				8	12	16	20	25	30	8	12	16	20	25	30
2	I. L. Diesem..	Woodmansee Mogul.......	12 ft.	....	26	60	61	56	51	....	5.2	16.0	20.3	23.3	25.3
3	—— Carless...	Aermotor	12 ft.	10	60	62	60	56	50	5.3	12.0	16.1	19.8	23.1	25.0
4	E. S. Austin..	Ideal...... ...	8 ft.	..	52	73	76	68	50	....	10.2	19.3	25.3	28.1	25.0
5	Ella Horner..	Aermotor	8 ft.	.. ..	93	91	90	83	77	....	18.6	25.1	29.8	31.6	38.5
6	W. J. James..	Gem	8 ft.	....	62	67	66	61	58	....	12.1	17.9	22.0	25.4	28.5
7	O. V. Folsom.	Aermotor	12 ft.	....	57	59	57	53	47	....	11.1	15.8	19.0	22.1	23.5
8	J. C. Kitchen.	Star	10 ft.	210	150	.....	...	....	..	28.0	30.0	....	...	....	....
9	F. M. Dunn...	Aermotor	16 ft.	....	53	53	52	47	42	...	10.6	11.1	17.2	19.6	21.0
10	F. M. Dunn...	Ideal	8 ft.	106	125	125	.	....	...	14.1	25.0	33.3	....	....	....
11	F. M. Dunn ..	Ideal.....	12 ft.	....	24	48	57	56	50	....	4.8	12.7	18.8	23.3	25.0
12	D. M. Frost...	Ideal	14 ft	23	55	59	58	52	....	3.1	10.9	15.7	19.2	21.5	.. ..
13	Wm. Coulters	Aermotor	12 ft.	...	55	64	63	59	55	...	11.0	17.1	21.0	24.6	27.5
15	Jas. Allen	Gem	10 ft.	....	39	45	44	35	.. ..	...	7.8	11.9	14.7	14.6	....
16	Jas. Allen.....	Halliday......	10 ft.	30	113	127	128	126	.. .	4.0	22.6	33.9	42.7	52.5	....
17	D. R. Menke..	Gem	12 ft.	....	30	48	52	....	....	....	6.0	12.8	17.3	....	....
18	Fred. Pile....	Ideal	8 ft.	60	101	111 / 98	102 / 84	79 / 66	..	8.0	20.2	26.1	28.0	27.5	.
19	W. E. Trell...	Gem	12 ft.	....	31	45	44	38	....	.. .	6.2	11.9	14.7	16.0	....
20	W. T. Cowhick	Jumbo.........	15½	....	....	20	32	42	.. ..	..	...	5.3	10.7	17.5	....
21	J. E. Hunt....	Halliday......	12 ft.	....	70	107	112	107	....	...	14.0	28.5	37.3	44.6	...
22	Wm. Brown.	Fairbanks....	8 ft.	92	146	110	114	80	....	12.3	29.2	37.3	38.0	33.3	....

TABLE I -CONCLUDED

Mill No.	Number gallons pumped per hour when wind velocity is miles per hour.						Useful work in horse-power when wind velocity is miles per hour.						Foot lbs. useful work per stroke of pump.	Vane area in square feet.	Lift (feet).	Size of pump*
	8	12	16	20	25	30	8	12	16	20	25	30				
2	.....	1,131	3,480	4,415	5,069	5,503	...	.085	.260	.322	.379	.411	536.2	69.4	47.75	9⅝x12
3	1,153	2,610	3,567	4,306	5,014	5,137	.067	.151	.207	.250	.291	.315	115.3	72.9	13.75	9½x12
4	......	306	579	759	843	750	....	.015	.029	.038	.043	.038	50.0	36.1	12	5⅜x8
5	......	977	1,318	1,564	1,817	2,021	....	.053	.072	.086	.099	.111	94.9	33.7	13	6x8
6	......	725	1,047	1,287	1,486	1,667	.	.029	.042	.051	.059	.065	77.6	36.9	9.60	6⅜x8
7	...	2,445	3,387	4,075	4,740	5,011	...	.160	.221	.266	.309	.329	161.9	72.8	15.50	9½x12
8	101	108	.....	.....	.....	.....	.013	.011	.....	....	.....	....	15.0	59.8	30	3x5
9	....	1,749	2,326	2,838	3,234	3,465	.. .	.325	.433	.448	.601	.644	1,013.3	133.6	41.35	8x16
10	70	125	167	...	.....	.....	.010	.017	.023	.032	.....	...	22.8	12.0	33	2½x6
11	......	648	1,744	2,538	3,150	3,375	..	.123	.325	.484	.600	.639	843.7	75.3	45	7¾x12
12	535	1,880	2,708	3,312	3,709	....	.025	.087	.125	.153	.172	....	263.5	103.6	11	6½x12
13	.....	2,376	3,694	4,536	5,314	5,940	..	.110	.171	.210	.247	.275	330.0	72.8	11	10x12
15	.. .	819	1,250	1,543	1,533	.....	..	.053	.082	.101	.099	...	219.0	47.3	15	7x8
16	180	1,017	1,526	1,922	2,362	....	.012	.067	.103	.130	.159	..	100.0	61.3	16	6x8
17	....	765	1,632	2,206	. .	. ..	..	.070	.149	.202	......	....	385.0	75.8	21.75	8x12
18	348	879	1,135	1,218	1,196	....	.022	.054	(.082) .070	(.092) .076	(.088) .074	....	89.2	12.0	14.75	5¼x8
19	......	1,116	2,142	2,646	2,880	......	....	.085	.162	.201	.219	....	450.0	77.6	18	10x10
20	......	......	795	1,605	2,625	.....	..	... .	.017	.095	.154		291.2	73.6	11	Two. 6x12
21	....	945	1,921	2,518	3,010	. ...	....	.060	.121	.159	.184	....	141.5	69.7	15	7¾x5
22	57	136	173	177	155		.002	.005	.007	.008	.005	....	5.5	30.2	8½	2¼x4

*Inside diameter of cylinder by length of stroke.

any other 12 foot mill. The results of tests of a 12 foot "Power" mill are shown in Fig. 1. The wheel of this mill is like that of mill No. 3. table I. The power was measured with a friction brake on a 9½ pulley which runs the grinder or other machine. The speed of pulley was measured with a Pratt speed indicator.

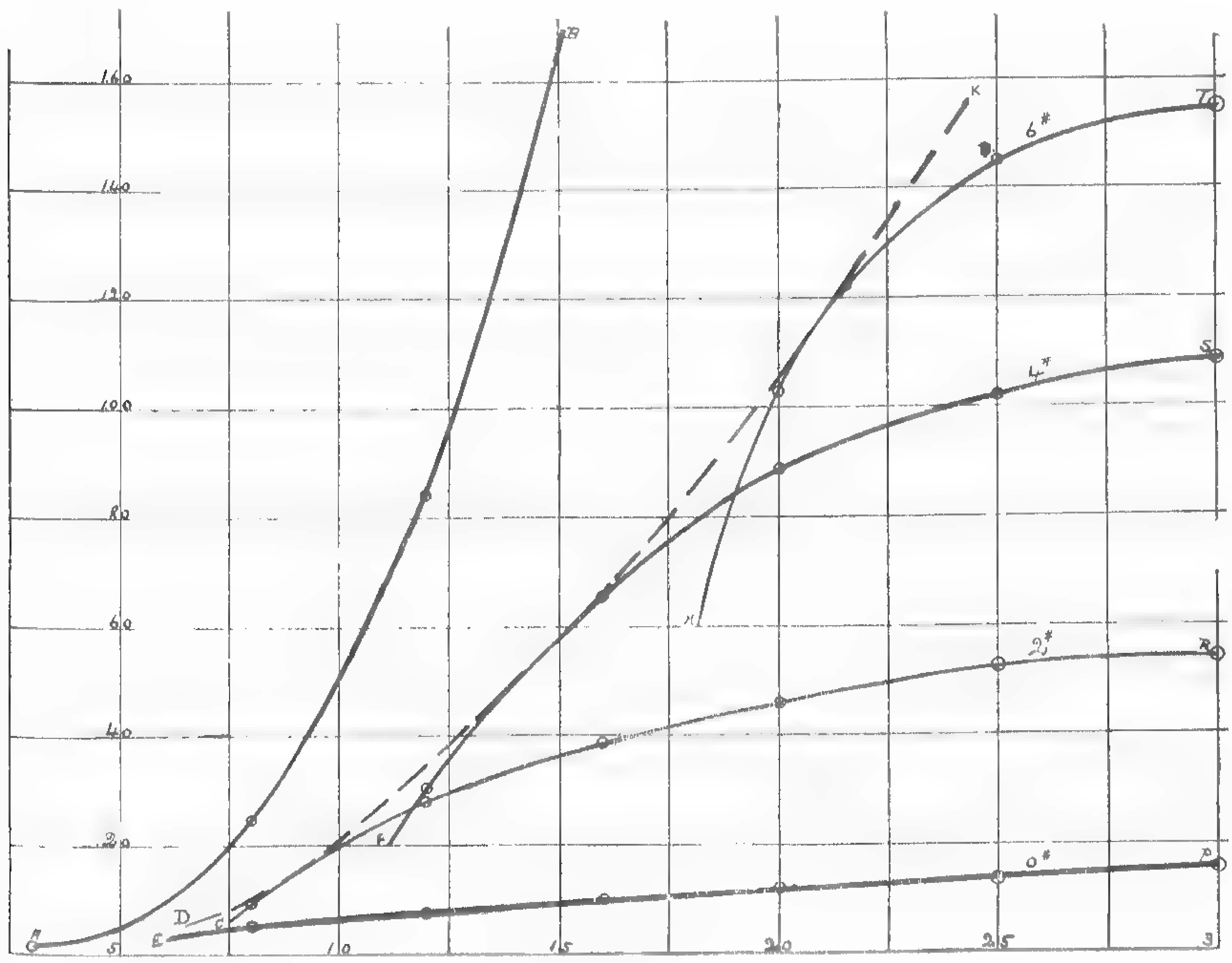


Fig. 1.

The four curves marked 0 lbs. 2 lbs. 4 lbs. and 6 lbs. give the relation between H. P. and wind velocity in miles per hour. The 0 curve is for no brake load, the brake was off the pulley The 2 lb. curve is for a brake load of 2 lbs; the 4 lb curve for a brake load of 4 lbs. and the 6 lb. curve for a brake load of 6 lbs.

It is easily seen that the power increases with the load above certain velocities. At 30 miles per hour the power is nearly proportional to the load on the mill This fact which accounts for much of the difference in the pumping power of windmills has never been clearly shown, to the writer's knowledge. We noticed it in our tests made in '95 and stated the fact in the paper already referred to. (p. 104 Vol. 4 KANS. UNIV. QUARTERLY). This fact is also referred to by Mr. J. A. Griffiths, Associate Member Institution C. E. in a paper on "Windmills for Raising Water"—published in 1895 in "Proceedings of the Institution of Civ. Eng: Vol. 119. He says "In spite of the paucity of data the results obtained with this mill show conclusively that the most important element in the efficiency is the pump load factor."

The brake load of 2 lbs. corresponds to a useful pump load of 740 ft. lbs. per stroke. This is somewhat less than the load of mill No. 11 and greater than the average pump load of this size of mill. It is seen that this 2 lb. curve is nearly a straight line for the usual jumping velocities of 10 to 20 miles per hour. That is, the power of a power mill as well as that of a pumping mill increases nearly as the first power of the wind velocity for a constant load of 2 lbs.

The dotted curve D. K. is drawn tangent to these load curves and is the envelop of them. It is very nearly a parabola whose vertex is at the origin, with axis vertical. It is easily seen that this curve gives the relation between wind velocity and horse power for a constantly increasing load on the mill. The power of the mill would be greatly increased by some device for increasing the load of the mill it would then vary as the second power of the velocity instead of the first power.

The curve A. B. gives the relation between wind velocity and horse power for the total energy of the wind which strikes the fans of this mill. That is, if this windmill could utilize all the energy of the wind which strikes the surface of its fans its power would then be given by the curve A. B. which is of the third degree. The efficiency of the mill being the ratio of the horse power developed by the mill to the total horse power of the wind which strikes it, it is seen to be the ratio of the ordinate of any load curve to the corresponding ordinate of curve A. B. It is seen to decrease for a constant load as the velocity increases, and to increase for a constant velocity as the load increases. The maximum efficiency is the ratio of the ordinate of curve D. K. to the corresponding ordinates of curve A. B.

It is seen that the useful work that a windmill will do when working under a constant load at all velocities is small, the horse power varying as the first power of the velocity. By some device for automatically increasing the load as the wind velocity increases the power may be much increased at high velocities, and will then vary as the second power of the velocity. Even with this device for increasing power there is still a great difference between the power possessed by the wind and the power developed by the mill and this difference increases as the velocity increases. The question may be asked—"Why does not the windmill utilize a larger amount of the energy of the wind?"—Let A. B., Fig. 2, be a strip taken from the outer end of one fan of a windmill; it is curved, but for this purpose it may be considered a plane. This strip makes an angle δ with the absolute direction of the wind. c represents the

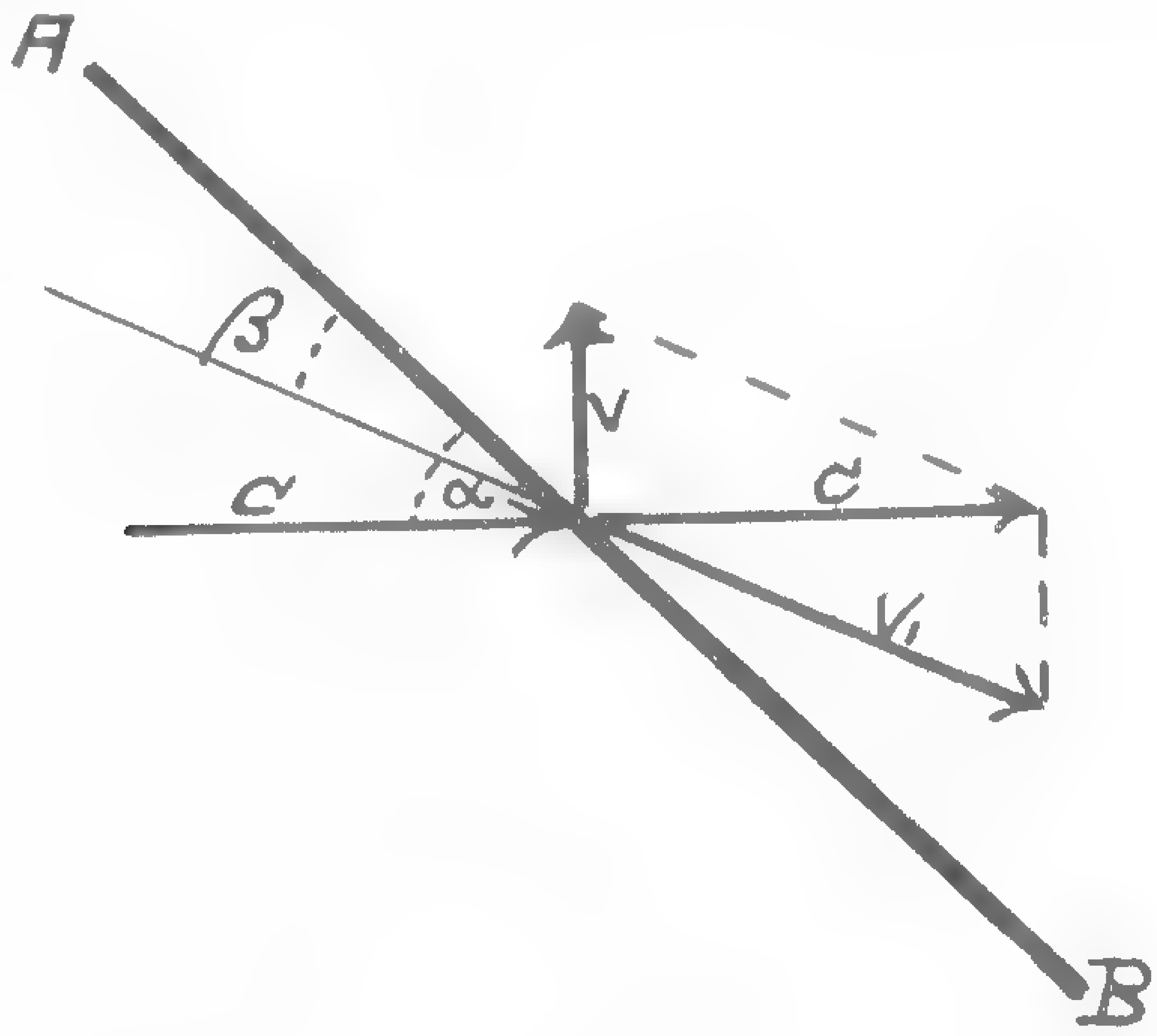


Fig. 2.

amount and direction of the wind, v represents the amount and direction of the velocity of the surface A. B. Then the relative velocity of the wind, that is its velocity with respect to the moving surface A. B. is v_1, the diagonal of the parallelogram constructed on v or c as sides. v_1 makes an angle β with the absolute direction of the wind. If $v = o$, that is, if the wheel is held so that it cannot revolve the angle $\beta = \delta$. As v increases β grows less and less and finally becomes zero in which case v_1, is parallel to surface A. B. In this case the surface receives no pressure from the wind—this portion of the fan is not utilizing any of the energy of the wind.

If v be still farther increased, β becomes negative and the wind pressure is on the opposite side of A. B. This portion of the fan is then doing work on the wind instead of the wind doing work on the fan. The effective wind area of a fan being the projection of the fan on a plane at right angles to the relative velocity of wind over it—that is to v_1, it is seen that as v increases the effective area decreases. The energy which the fan takes from the wind is proportional to the effective wind area. It is seen then that this reduction of effective wind area is the reason why the efficiency is low at high wind velocities. If this effective wind area could be kept constant by some device for changing the angle of the fans then the relation between wind velocity and horse power might vary nearly as a third degree of the wind velocity.

In this discussion we have not taken into account the reduction of wind area due to the wind wheel swinging out of the wind or "regulating." The mill can be built strong enough so that it will not need to regulate for velocities less than 30 miles.

Brachysaurus, a New Genus of Mosasaurs.

BY S. W. WILLISTON.

With Plate VIII.

The University Geological Expedition of 1894 was fortunate in discovering in the Ft. Pierre deposits, of South Dakota, two remarkable specimens of Mosasaurs, one of them representing a new species of Mosasaurus in remarkably perfect preservation, the other a new genus. A brief reference to the most peculiar characters presented by the species representing this genus was given by me in this journal, Vol. III, p. 169, under the specific name Overtoni, from its discoverer, my assistant. I did not feel sure of its distinction from some of the forms previously described, and refrained from giving the genus a name. Its characters are, however, peculiar in so many respects that I venture to more fully describe it in the present communication under the name Brachysaurus.

The horizon whence the specimen was obtained is near the top of the Pierre deposits of the Cheyenne river of South Dakota, and probably a hundred or more feet above that of *Mosasaurus horridus* described by me. It thus, it is seen, represents one of the latest forms hitherto made known from North America. That it may be found identical with some of the forms hitherto described from fragmentary material from New Jersey under names that have been supposed to be synonymous with better known genera, is not impossible. The generic name here proposed is, therefore, in a measure provisional.

The material upon which the genus and species are based is as follows: One mandible nearly complete, both maxillæ, the most of the frontal bone, one quadrate, portions of the very massive pterygoid, and other fragments of the skull; some twenty or more vertebræ in more or less imperfect preservation; both humeri; and two smaller paddle bones. The generic characters, derived from these parts of the skeleton, are as follows:

Brachysaurus, *gen. nov.*

Frontal bone as broad or broader than long, the orbital margins not at all emarginate, the posterior portion projecting in the middle and emarginate for the pineal foramen. Maxillæ very stout, with twelve teeth. Mandibles stout, with fourteen teeth. Teeth very stout, moderately recurved, wholly smooth, without facets, and with an anterior and posterior carina. Supracolumellar process of quadrate long and stout, and broadly co-ossified with the body of the bone below, enclosing a large, oval, auditory meatus, above which is situated the large stapedial pit. Zygosphene of vertebræ rudimentary or wanting; chevrons co-ossified with centra; hypopophyses of cervical vertebræ free; cervical and dorsal vertebræ cordate in outline; pygial and caudal vertebræ subtriangular. Humerus very stout and broad; radial process wanting, the ulnar process stout.

In the absence of other parts of the skeleton, it is not possible to say with certainty to which family the genus belongs. The co-ossified chevrons have hitherto been characteristic of the Mosasauridæ, but the absence of the zygosphene points more to the Tylosauridæ.

Brachysaurus overtoni Williston, Kans. Univ. Quart., iii, 169, 1895.

The quadrate bone has some of the general characteristics of *Mosasaurus horridus*, but the supracolumellar process is much stouter and longer, and is firmly co-ossified below, a unique character among the American forms. The stapedial pit, of large size, is situated below an overhanging ridge, and is much higher up than in the forms used for comparison (*Mosasaurus*, *Platecarpus*, *Clidastes* and *Tylosaurus*). The wing is apparently thin, and is preserved only in part; it does not seem to be of large size. The external auditory cavity is much less expanded than in the other genera, not extending nearly to the inferior margin of the bone. It may not be amiss to state here that this cavity in the Kansas specimens of the order is frequently filled with thick plates of cartilage, which extend through the auditory slit or foramen and surround the stapedial pit to a greater or less degree. The maxillary articulation is elongate, and broader on the outer part.

The mandibles are remarkably stout, and have not more than fourteen teeth implanted in them. I formerly erroneously gave the number as thirteen. The jaws are distinctly convex along their under border and somewhat concave above. The coronary bone is stout, but apparently does not extend as high as in *Mosasaurus* and

Clidastes. The maxillæ are likewise stout, and have twelve teeth implanted in each. The teeth are remarkably stout, much more so than in the other genera, save, perhaps, *Tylosaurus.* They are moderately recurved and are smooth throughout, with a weak carina fore and-aft. From the shape of the maxillæ, the length of the lower jaws, and the breadth of the frontal bone, it is quite evident that the rostrum was not much prolonged in front of the teeth.

The frontal bone is remarkably broad and heavy; the orbital borders are convex and apparently free, the prefrontal not being prolonged back to the postfrontal. The strong median projection behind is very different from the usual shape of this part. The borders of the bone are stout and thick.

The cervical and thoracic vertebræ have the centra cordate in outline at the convex end, and are relatively small for so large and broad a head. The cervical hypopophyses are free,* but the process for their attachment is not smaller than usual. The pygial and caudal vertebræ have their outline subtriangular, much as in *Tylosaurus.* The chevrons, in the caudal vertebræ preserved, are firmly co-ossified with the centra.

The coracoid is of the usual shape, and has a deep emargination.

Perhaps the most peculiar of any of the elements preserved, aside from the quadrate, is the humerus. Its proximal end is much thickened, strongly convex from side to side, with a projecting angle at one side of the middle. The deltoid ridge is narrow and proportionally small. There is no radial process, as in *Mosasaurus* and *Clidastes*, but there is a stout ulnar process, with a large round surface, projecting nearly upwards. The free radial border is remarkably short, that of the ulnar side much longer and curving obliquely forward to the ulnar tuberosity.

A single paddle bone (fig. 7) is of such peculiar shape that I can not place it.

Altogether, the animal possessed a remarkably stout and broad head, with stout jaws and teeth, and evidently short, broad and stout paddles, and short body.

Measurements:

Quadrate, total length	130 mm.
Frontal bone, expanse	270
Mandible, length from articulation to extremity	650
" length of dental series	580
" width opposite last tooth	160

*The co-ossification of the cervical hypopophyses is of minor value. A specimen of *Clidastes tortor* Cope in the museum has them firmly united throughout.

Mandible,	width between seventh and eighth teeth.....	90 mm.
"	heigth of eleventh tooth above jaw..........	50
"	antero-posterior diameter of same at base of enamel..............................	25
"	total length of jaw......................	1050
Humerus,	length....................................	140
"	greatest width proximally..................	100
"	greatest width distally.....................	120
"	length of ulnar border.....................	25
"	length of radial border.....................	60
"	greatest thickness proximally...............	55

EXPLANATION OF PLATE VIII.

Fig. 1. Mandibular tooth, natural size; *1a*, basal cross-section of the same.

2. Frontal bone, upper surface.

3. Quadrate, inner aspect.

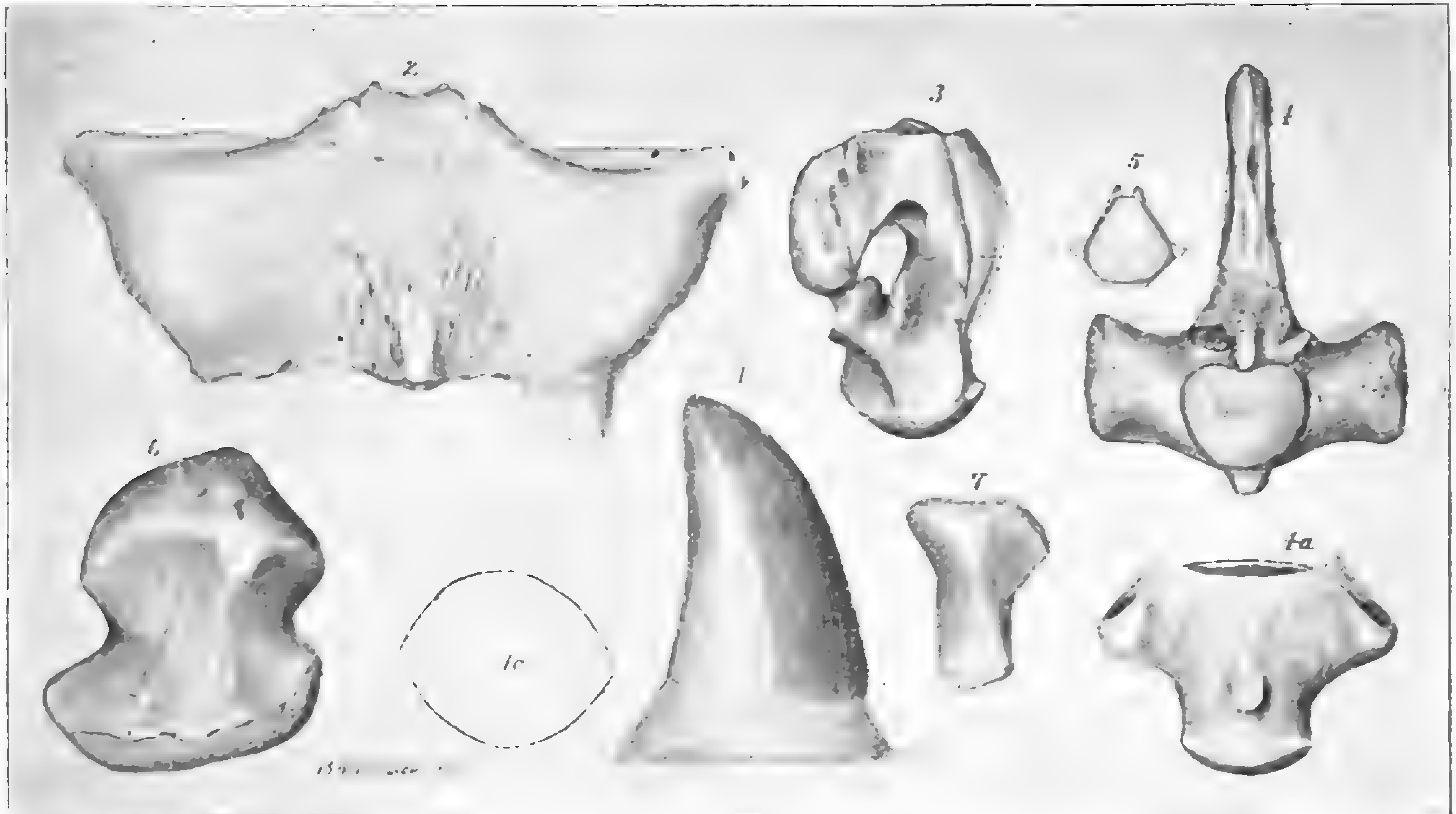
4. Posterior cervical vertebra, anterior aspect; *4a*, the same from below.

5. Caudal vertebra.

6. Humerus, palmar aspect.

7. Paddle-bone.

All figures, save those of the teeth, one-fourth natural size.



Brachysaurus overtoni Williston.

On the Extremities of Tylosaurus.

BY S. W. WILLISTON.

With Plates IX-XII.

All that has been published hitherto concerning the extremities of this genus of saurians are the figures of the femur by Marsh*, of the humerus, femur, tibia, fibula and various phalanges by Cope (Cret. Vert.) and a sketch of the front paddle by Professor F. H. Snow.†

The specimen figured by Chancellor Snow—one of the best of the order in our collection—has since been more thoroughly cleaned from the matrix, enabling a more accurate drawing to be made, which is presented herewith. This paddle is the most perfect that I have ever seen in any specimen from the Kansas Cretaceous, and determines some interesting points about which there has been doubt hitherto. A photographic reproduction of the paddle is given in plate IX, as it lies upon the chalk slab. The parts there concealed beneath the ribs and vertebræ have been carefully laid bare from the opposite side and their position is shown in the accompanying outline figure.

This specimen, it will be remembered, is the one in which the excellent casts of the skin are preserved, a figure of which was given by Snow in the paper cited. This engraving is so accurate, that, together with a photographic reproduction of a portion of the cast, (plate XII) additional description is unnecessary. A comparison of the scales with those of the Monitor, from the same region of the body, shows them to be remarkably alike, both in size and shape.

The position of the paddle is evidently a natural one and the fact is of interest as showing the general expansion and general curvature of the digits. The limb is undoubtedly more flexible than is the case with either *Clidastes* or *Mosasaurus*, as is shown by the considerable space between the different bones, which while partly filled out with cartilage, must have left very free articulations.

*Amer. Journ. Sci., 1872.
†Trans. Kans. Acad. Sci., Vol. vi, p. 54.

The scapula, not preserved in connection with the other bones, is of smaller size than the coracoid, and relatively smaller than in either *Clidastes* or *Platecarpus*. At the mesial end of the coracoid there is a thick plate of cartilage of considerable extent and closely united with the bone. Nowhere in this specimen, or in any other

Fig. 1. Front paddle of Tylosaurus.

specimen of this genus that I have seen, is there any indication of a sternum, even a cartilaginous one. Were it existent it would have been most certainly preserved in this specimen, inasmuch as the skin lies intact in the region where the sternum should have been, so that it could hardly have been lost. There can then seem to be little or no doubt that its absence in this genus, as in all the Tylosauridæ, is a fundamental character of the family, as I have previously defined it. Marsh has figured the coracoids of *Clidastes* as meeting in the middle line, but this is certainly an error. They are separated by a considerable expanse of cartilage as would indeed be expected from the relationship to modern lizards.

In the present specimen remains of the skin are found between the bones, from which it is evident that the membrane was very thin and pliable and extended fully between the fingers to their tips. Small scute-like scales are found as far as the metacarpals, beyond which they are wanting everywhere, apparently. The numbers of phalanges in this specimen were apparently as follows: I–6, II–9, III–10. IV–11, V–11. The distal one is preserved only in the fifth finger, and is, as is seen, very small and imperfect. I am much inclined to the opinion that the number of the phalanges is not always uniform in different individuals of the same species, though probably varying only within small limits. It will be observed that the fifth finger is longer by far than in either *Platecarpus* or *Clidastes*. In this, as in other respects, *Platecarpus* holds an intermediate position between the two genera. *Tylosaurus* is the least lizard-like of the American genera of the Pythonomorpha. The paddles are more slender, more flexible and relatively longer than in the other genera.

The structure of the hind paddle, as shown incompletely in the accompanying photographic illustration, (plate X) is of great interest, as proving, conclusively, I think, that there were five functional toes, though the fifth is evidently undergoing reduction and the first is not as long as in the front paddle. The femur is much more elongate than is the humerus. The tibia is an unusually broad and flat bone; the fibula small and slender. In the front paddle only a single carpal bone is preserved, and I do not think that there were others in the living animal. It is a bony nodule evidently set in a plate of fibro-cartilage, and it is possible that in older individuals there may be additional ones. It is not at all unlikely that the same variations in the number of carpals and phalanges exists in this genus as does among the Cetacea. In the hind paddle the single tarsal preserved is of the same character as the carpal.

Marsh has figured the hind paddle in *Platecarpus*, and I have no doubt of its general accuracy. Dollo suspected that it might be wrong, and that the genus had but four toes, as in *Mosasaurus*.

The shape of the present paddle seems to be not unlike that of *Platecarpus*. The two larger metatarsal bones are undoubtedly the first and fourth, the former in position, the latter displaced proximally, while the displaced smaller phalanges must represent the fifth toe, which is evidently divaricate, as in *Platecarpus*. The fifth metatarsal is probably the short, irregular bone lying contiguous with the fourth metatarsal. The complete hind paddle of *Clidastes* is not known, but I believe that it is like that of *Mosasaurus*, and, if so, there were but four functional toes, as has been shown by Dollo. It is upon this character, together with that of the sternum and others, that I have established the two families, Tylosauridæ and Mosasauridæ, the two typical genera representing the extremes of development in this order of reptiles.

A restoration of *Tylosaurus proriger* will be given in the next number of this journal.

EXPLANATION OF PLATES.

Plate IX. Front paddle of *Tylosaurus proriger*.

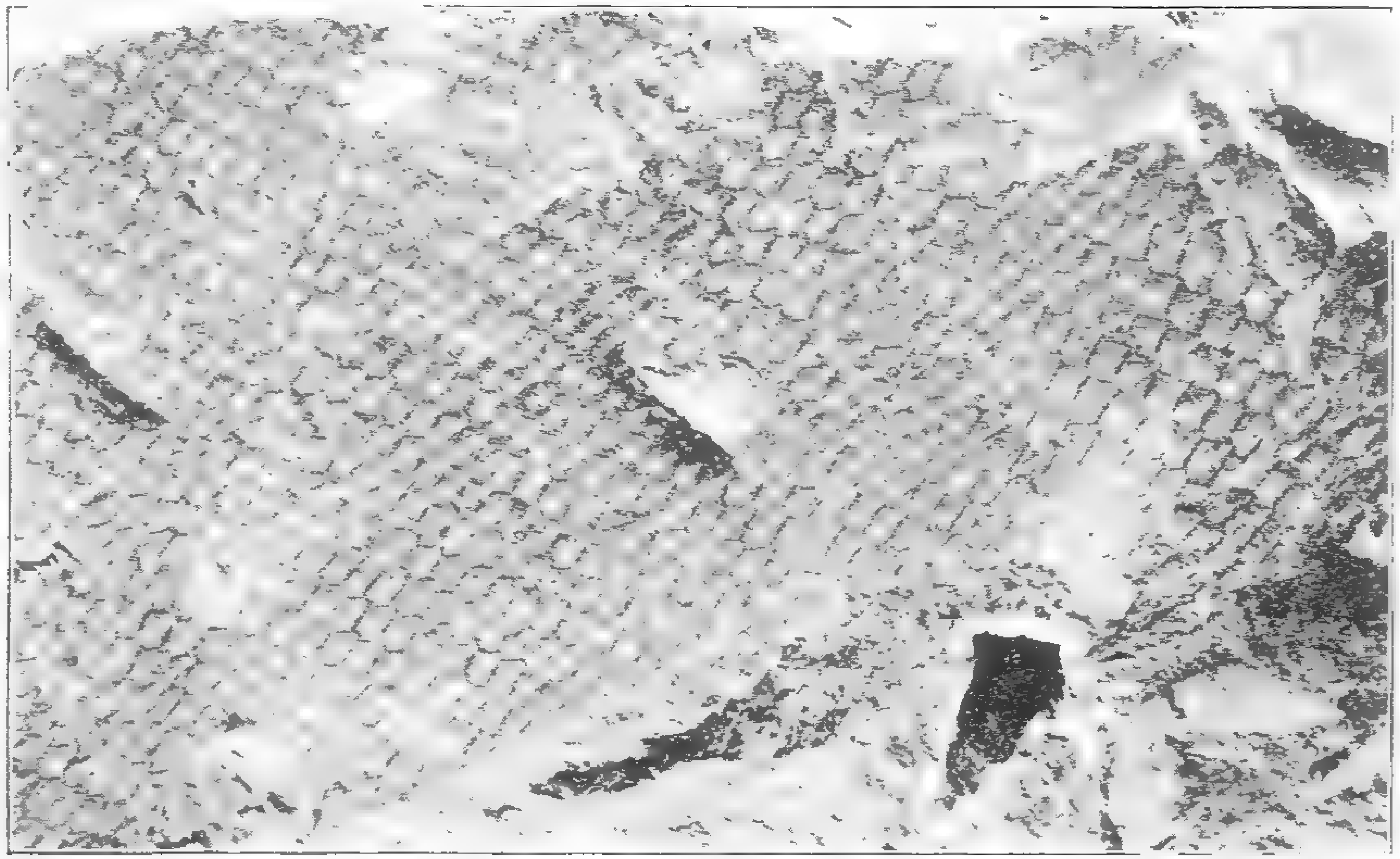
Plate X. Hind paddle of *Tylosaurus proriger*.

Plate XI. Pelvic bones of *Tylosaurus*.

Plate XII. Skin of *Tylosaurus*, natural size.

All the foregoing figures are from the same specimen, collected by Prof. F. H. Snow and now in the University Museum.

FRONT PADDLE OF TYLOSAURUS.



SKIN OF TYLOSAURUS. Natural size.

Two New Species of Asilids from New Mexico.

BY BARNUM BROWN.

Nusa abdominalis, n. sp.

Female. Abdomen red; thorax thinly pollinose; hind tibiæ much curved. Length, 12 millim.

Head black; face and front thickly white pollinose; the former with abundant, long, white hair, moderately protuberant below. Occiput white pollinose, with white hair. First and second joints of the antennæ red; third black, except at the proximal end, dilated distally. Thorax brownish red; mesonotum with a darker median and two large, partly confluent spots on each side; sparsely clothed with short white hairs. Abdomen light red or yellowish red; short, with nearly parallel sides, clothed with short, sparse, decumbent white hair; moderately shining, finely punctate; a single bristle present near the lateral margin of each segment. Legs black, somewhat reddish at base of tibiæ and tarsi; hair short, sparse, white; hind femora considerably thickened distally; hind tibiæ much curved and moderately dilated at the tip. Wings nearly hyaline; first posterior cell closed remote from the border.

One specimen, collected by myself at Cuba, Bernalillo County, New Mexico.

Nusa similis, n. sp.

Female, Like *N. abdominalis*, but differing in the following characters: Antennæ black; third joint not so long as the first two together, thickened distally. Thorax black, densely white pollinose. On the lateral margin of each abdominal segment four bristles present. Hind femora only moderately thickened; hind tibiæ but little curved.

Two specimens, from the same locality as the preceding.

Editorial Notes.

The April number of the Annals of Mathematics contains an article by Prof. H. B. Newson, on Hessians and Steinerians of higher orders. In this paper a substantial advance is made in the theory of cononical forms of binary quantics of odd order.

The "Elements of Physics" by E. L. Nichols and W. S. Franklin, issuing from the press of the Macmillan Company, has reached its third and final volume. Vol. I treating of Mechanics and Heat and Vol. II on Electricity have already been noticed in these pages. Vol. III deals with Light and Sound, the two allied departments of Physics in which the phenomena find their explanation in the properties of wave motion.

Accordingly Vol. III opens with a mathematical discussion of wave motion. The authors have wisely given this discussion a geometric rather than an analytic form; wisely because of the fact that analytic formulæ are often handled with ease by the student and yet they convey to him very imperfect conceptions of the physical phenomena they are intended to represent. This is because the formulæ are imperfectly interpreted; in other words the language of analysis, however elegant, is badly translated into the vernacular of familiar ideas. The results of analysis are never realized in the mind of the student until they are graphically presented either to the outward or the inward eye. Hence in Physics graphical methods when simple and direct are, pedagogically speaking, always to be preferred to analytical ones.

Herein lies the secret of much of the surpassing clearness of this volume on light and sound. An abundance of well drawn geometric figures serve to convey to the mind accurate images of the abstract ideas. When perfection in this method is reached we shall have the true royal road to knowledge. The writers of this text-book have produced a work that comes nearer to the above ideal than any similar work known to us. We doubt not but that this treatise on Physics will find a ready acceptance in such American colleges and universities as require of their students a working knowledge of calculus before admitting them to the courses in experimental and theoretical physics.

H. B. N.

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Restoration of Kansas Mosasaurs.

BY S. W. WILLISTON.

With Plate XIII.

In the present communication are given restorations of the three principal genera of Kansas Mosasaurs, based upon the material now in the University of Kansas Museum. A detailed description of this material is now in preparation to be shortly published as a volume of the University Geological Survey, of which Chancellor Snow is Director. At present only the more striking characters of the three forms will be discussed.

The three genera herewith given comprise all the authentic types known from Kansas. In addition, *Holosaurus* Marsh, *Sironectes* Cope and *Baptosaurus* Marsh, have been described from or accredited to the Cretaceous of the state. *Sironectes*, is, I believe, a synonym of *Platecarpus.* It was based upon the presence of the zygosphene in connection with free chevrons. In *Platecarpus* there is, in most species, a rudimentary zygosphene, and in some it is nearly as large as in some species of *Clidastes.* It is possible that *Holosaurus* is a good genus, but specimens of it must be exceedingly rare. The type specimen, now in the Yale Museum, was collected by myself and represents nearly the complete skeleton. *Baptosaurus* is practically known only from the posterior part of the jaw, described by Merriam. This is very peculiar in having the articular bone reflected upwards at the extremity.

The material upon which the restorations here given are based is as follows: *Clidastes* is restored from a single specimen, complete in all details, save the terminal phalanges of the front paddle and most of those of the hind paddles. The present restoration differs from the one previously published only in the less flattened skull, and in the curvature of the digits.

Platecarpus is based chiefly upon one specimen, comprising a nearly complete disarticulated skull and a connected series of vertebræ to beyond the middle of the tail, the sixty-fifth, together with the pectoral and pelvic girdles and most of the bones of the limbs. The arrangement of these bones has been copied, from Marsh, with some changes. The only parts conjectural are the number of long ribs and the number of chevron-caudal vertebræ. Isolated bones and partly connected series of caudal vertebræ are preserved in other specimens, from which there seems to be very slight differences from the corresponding parts of *Tylosaurus*. The tail has, therefore, been made to correspond with that of *Tylosaurus* in length.

Tylosaurus is drawn from three specimens, one with the posterior part of the head and the vertebral column complete to the tip, the second with the skull and cervical vertebræ in perfect preservation, the third with the paddles nearly complete, together with the larger part of the vertebræ and ribs. This last specimen is the one of which figures of the paddles and skin were given by me in the last number of this journal. All of these specimens agree closely in size and characters, clearly belonging to the same species.

A comparison of these genera, as shown by the restorations, will be of interest. *Platecarpus* has an intermediate position between *Clidastes* and *Tylosaurus*, which represent the extremes of development of the Kansas forms. In *Clidastes* the thorax is elongate, the tail relatively short and modified into a powerful propelling organ. The limbs are small, the hind ones especially so. The animal throughout is more slender, and the head relatively short, agreeing in this respect more closely with their nearest modern relatives, the species of *Varanus*. The vertebræ have the firmest and closest articulations, with the interlocking zygosphene best developed of any of the Mosasaurs. The limbs are less flexible, but relatively stronger, as shown by the closely articulating bones and the fully developed carpus and tarsus, and the more pronounced processes for muscular attachment. The movement through the water in this form was more snake-like than in the others, and propulsion was largely by means of the tail.

In *Platecarpus* we have the same shortened muzzle as in *Clidastes*, the vertebræ also relatively slender, and the zygosphene imperfectly developed. The paddles are more of the *Clidastes* type than that of the *Tylosaurus*, though the carpus and tarsus are less well developed than in the former. The hind paddles are only slightly smaller than the fore ones, and all are powerful propelling organs, far more so than in any other known genus of the group. Altogether, in proportion to its size, *Platecarpus* was the most powerful and predaceous of the Kansas Mosasaurs. It will be observed that the teeth in this form, while not as numerous as in *Clidastes*, or as stout as in *Tylosaurus*, are more effective weapons than in either of these genera, being more elongated, more curved and more pointed. The neural spines do not form as close á series as in *Tylosaurus*, indicating greater flexibility.

In *Tylosaurus* we have in some respects the most specialized of the Mosasaurs. The almost wholly cartilaginous carpus and tarsus, the more elongated digits and the greater number of the phalanges, are characters brought about by aquatic habits. On the other hand, the hind paddle is actually larger than the front, and the fifth digit has undergone little or no reduction, characters of a more primitive rank. The paddles are more flexible than in either of the other genera, but they are relatively small and not at all strong. The skull is more elongated anteriorly and there is no trace of a zygosphene.

Dr. Dollo has expressed a doubt of the nature of the vertebræ called pygial by Mr. Case and myself in a former publication. He believes that some of them at least are true lumbar vertebræ, as all were previously thought to be. I feel yet more assured that they are basal caudal and have so restored the different genera. In the living lizard, with the sacral synchondrosis, the ilium is directed forward, throwing the symphysis ischii below the sacrum and leaving the outlet of the pelvis unrestricted. In *Varanus* there are as few as two non-chevron-bearing vertebræ back of the sacrum. More were not needed. In these marine lizards, on the other hand, the shaft of the ilium is directed obliquely forward, bringing the symphysis of the ischii below the fourth or fifth of the vertebræ succeeding the ligamentous attachment. If these or any of them bore chevrons, it will be immediately seen that they would project into the cavity of the pelvis. Not less than six pygal vertebræ are necessary to leave space for the free exit of the cloaca. The ilium must have been in every case attached to the first non-costiferous vertebra.

In these three species the number of vertebræ in the different regions may be given as follows:

	Clidastes.	Platecarpus.	Tylosaurus.
Cervical	7	7	7
Thoracic	11	13?	13?
Lumbodorsal	24	9	10
Pygal caudals	7	5	6
Diapophysial caudals	25	15	25
Non-diapophysial caudals	45	?	55

The zygapophyses in all three forms terminate at or near the end of the rib-bearing vertebræ. In the cervical region they are strong, diminishing but little in size through the thoracic region. In the region which I call lumbodorsal, they become weaker. The vertebræ increase in length through the thoracic region, but diminish very rapidly in length at the end of the costiferous series.

The length of *Clidastes velox* is about twelve feet, that of *Platecarpus coryphæus* nearly fourteen, while *Tylosaurus proriger*, one of the smaller species of the genus, was over twenty-three feet. The smallest species of *Clidastes*, *C. pumilus*, if it be a distinct species, was about six feet in life. The largest species of the Kansas Mosasaurs, *Tylosaurus dyspelor* had a length of nearly thirty feet. Only one other species of the group larger than *Tylosaurus dyspelor* has been described from America—*Mosasaurus maximus* Marsh, from New Jersey. If it had the same proportions as *Tylosaurus* its length would be about thirty-two feet. If like *Clidastes*, as it was in all probability, its length would not exceed thirty-six feet. European forms somewhat larger than this have been described, possibly reaching a length of nearly forty feet. The text-books and popular descriptions place the length of these animals at from seventy-five to one hundred feet!

The food of the Mosasaurs must have consisted chiefly of fishes of moderate size with occasional victims of their own kind. While the flexibility and loose union of the jaws undoubtedly permitted animals of considerable size to be swallowed, the structure of the thoracic girdle would not have permitted any such feats of deglutition as the Python and Boa are capable of. The animals must have been practically helpless on land. They were not sufficiently serpentine to move about without the aid of the limbs, and these were not at all fitted for land locomotion. They lived in the open sea, often remote from the shores. Their pugnacity is amply indicated by the many scars and injuries they received, probably from others of their own kind.

Fig. 1.

CLIDASTES VELOX Marsh. One-sixth natural size.

Fig. 2.

PLATECARPUS CORYPHAEUS Cope. One-seventh natural size.

Fig. 3.

TYLOSAURUS PRORIGER Cope. One-twelfth natural size.

S. W. Williston and S. Prentice, del.

Restorations of Kansas Mosasaurs.

Salicylic Acid and Calcium Sulfite as Preservatives of Cider.

BY E. H. S. BAILEY AND CHAS. M. PALMER.

The object of these experiments was to determine the preservative influence exerted upon cider (and hence other fermentable liquids), by salicylic acid and sulfurous acid, the latter being in the form of calcium sulfite, in various amounts; also to review the various methods of detecting these agents. The surrounding conditions were supposed to simulate those under which these substances are used by people generally, and considerable reference is also made to the literature of their use, effect, detection, etc.; especially in the case of salicylic acid.

Salicylic acid was discovered in 1838 by Piria (Amer. Jour. of Phar., Aug., 1843,), but it was not until Kolbe so improved the method of manufacture in 1874 (J. Prakt, Chem. 2, 10, '93,), as to render it commercially available that it was used as a preservative. He made an extensive study of its anti-fermentative action which extended over a year or two. His conclusions were that it restrained or prevented the action of organized ferments and also that of unorganized ferments to some extent, but that it was harmless to animal life, and he strongly advocated its use as a food preservative.

On August 7 and 8, 1882, at the Nuremberg meeting of the Independent Union of the Bavarian Representatives of Applied Chemistry, the association, after an exhaustive discussion of the propriety of the use of salicylic acid as a food preservative, refused, by a practically unanimous vote, to sanction its addition to beer (Bull. U. S. Dept. of Agric. 13, Pt. 8,). In Germany its use is prohibited, except in beers intended for exportation. In France its use in food or drink of any kind was forbidden by ministerial decree on the 7th of February, 1881.

In this country Dr. Cyrus Edson, of the New York board of health, seized, on November 11, 1886, 5,280 gallons of artificial wine which had been preserved with salicylic acid. It contained about 4.5 grains to the pint. (Am. Analyst, 416, 1886.)

Very little can be inferred as to the physiological effects of the continued use of salicylic acid, as reliable experiments upon human subjects are rare. Kolbe took a daily dose of it for over a year, beginning with one-half gram and gradually increasing it to 1.5 grams without noticeable effect. Two workmen (Methoden der praktischen Hygiene, Wiesbaden, 1890, 281,) to each of whom .5 grams were administered daily for seventy-five and ninety-one days respectively, by Lehmann, experienced no injurious effect. A case is recorded in the Virginia Medical Monthly, of death in forty hours from 48 grains of salicylic acid—this quantity being taken within four hours.

Dr. Bartley (Am. Analyst, April 1, 1887,) is of the opinion that the use of salicylic acid, as a preservative for foods and beverages, should receive a check at the hands of the authorities.

A special committee of the Paris Academy of Medicine reported upon the uses of salicylic acid, that the injection of such small quantities as are liable to be found in food might result in no injury to persons in good health, but to the aged or those in feeble health injury might follow. Those affected with diseased kidneys or dyspepsia they found to be especially sensitive to its action (Bull. de l'Acad. de Med., Paris, 1886,). They recommend that its use, as a preservative of food, even in small amount be absolutely prohibited.

The various commercial articles sold as "Extract of Salix," "Preservaline," "Conservaline," "Antispoil," etc., are generally found to contain salicylic acid or other well known substances as borax, boric acid, benzoic acid, etc.

Salicylic acid admits of ready detection in very small quantities and in great dilution. The sensitiveness of the ferric chloride test has been placed as high as one part in 100000. Two c.c. of a 1-20000 solution of salicylic acid in cider was neutralized with sodium carbonate and evaporated to dryness and the residue extracted with dilute salfuric acid. This acid liquid was shaken out with chloroform, the latter separated and allowed to evaporate spontaneously. The residue gave a very distinct violet color with ferric chloride. The ferric chloride reaction is prevented by a number of substances in consequence of which the acid should be purified before applying the test. It may be separated by dialysis, shaking out with an immiscible solvent and distilling the residue with steam, etc.

Blas (Jour. Prackt. Chem. 19, 43,) and others (U. S. Bull. Dept. Agric. 13, part 3), recommend using the body as a means of separation and applying the test to the urine. This proved very efficient in the hands of the writers. Of eight methods tried by Crampton and his fellow assistants (U. S. Bull. 13, part 3), extraction with equal parts of ethylic and petroleum ether, and extraction with ether, spontaneous evaporation and again extracting with benzine, were the two which gave decidedly the best results in working with beer. The writers found chloroform to give the best results with cider, used as above described.

There is no dearth of qualitative tests, but an easy and satisfactory method for the quantitative determination is yet wanting. The qualitative methods of extraction may be made complete and the pure crystallized acid weighed or dissolved in alcohol and titrated with a soda solution standardized with a like solution of salicylic acid of known strength. Colorimetric methods have also been proposed by Dr. Muter (Analysist 1, 193; Remont, Jour. of Pharm. Chem, (5), 4, 34; Chem. Cent. 1881, 773), and modifications of the last by Pellet and DeGrobert (Compt. Rend. 93, 278; Chem. Cent. 1881, 711). The last three references are from the U. S. Bull. Dept. Agric. 13, part 3.

In regard to the efficiency of the preservative action of salicylic acid, Dr. A. B. Griffiths (Chem. News, 53, p. 28) placed a drop of yeast on a slide under the microscope and then ran a few drops of salicylic acid solution, 1-5000, between the cover and slide and found it to have no action upon the true alcoholic ferment—Torula. But by treating in the same manner mounts of mycoderma aceti, bacterium lactis and the buteric bacillus, these ferments were quickly destroyed. He observed that the acid solution acted chemically upon the substance of the cell wall, in some cases causing perforation. He found also that the above solution of salicylic acid prevented yeast from converting cane sugar into dextrose and levulose, and also the action of ptyalin on starch. The experiments of the writers would seem to lead to different conclusions, at least concerning the Torula and Micoderma.

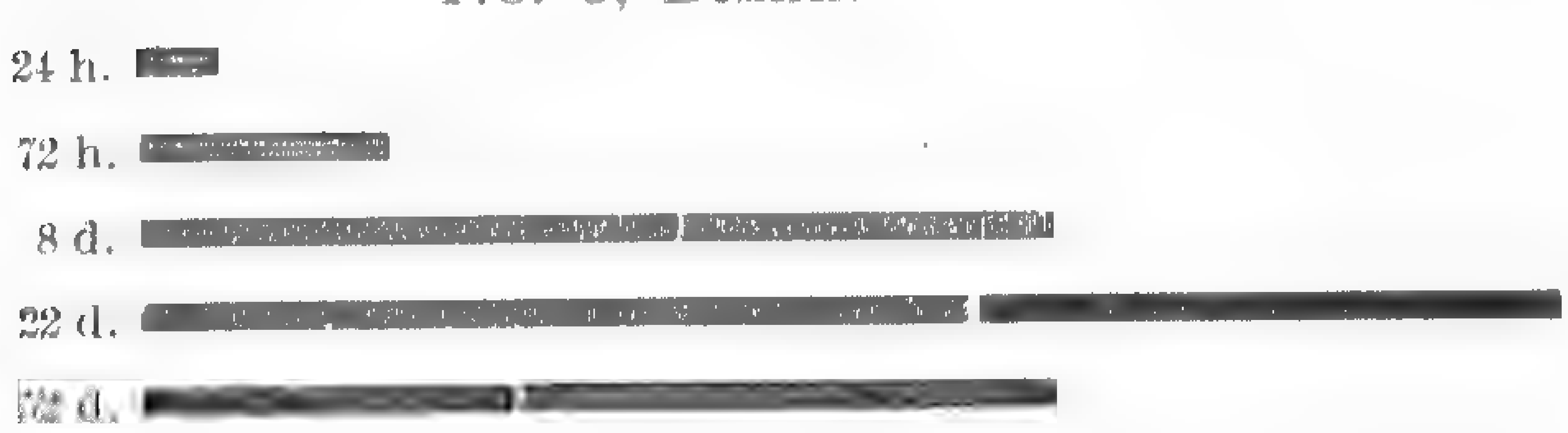
Six flasks, containing cider, were protected from dust by placing watch glasses over their mouths and set aside under ordinary atmospheric conditions and at temperatures ranging from 12 to 22 C. (53.6, in 71.6 F.). No. 1 contained 1-20000 of salicylic acid, No. 2 1-1000, No. 3 1-5000, No. 4 1-1000, No. 5 1-500, No. 6 and 6 (a) were blanks. The cider was fresh and contained .2 per cent of alcohol. Distillations were made in twenty-four hours, seventy-two hours, eight days, twenty-four days, and fifty-two days with the results as stated in table 1, below. Nos. 4, 5 and 6 (a) were started later with five other samples, and contained about 1-20000 of salicylic acid which had been added by the enterprising cider vender. At the last series of distillations titrations were made and the results given as acetic acid. Titrations, the results of which are given, were also made two months after the last distillations.

TABLE I.

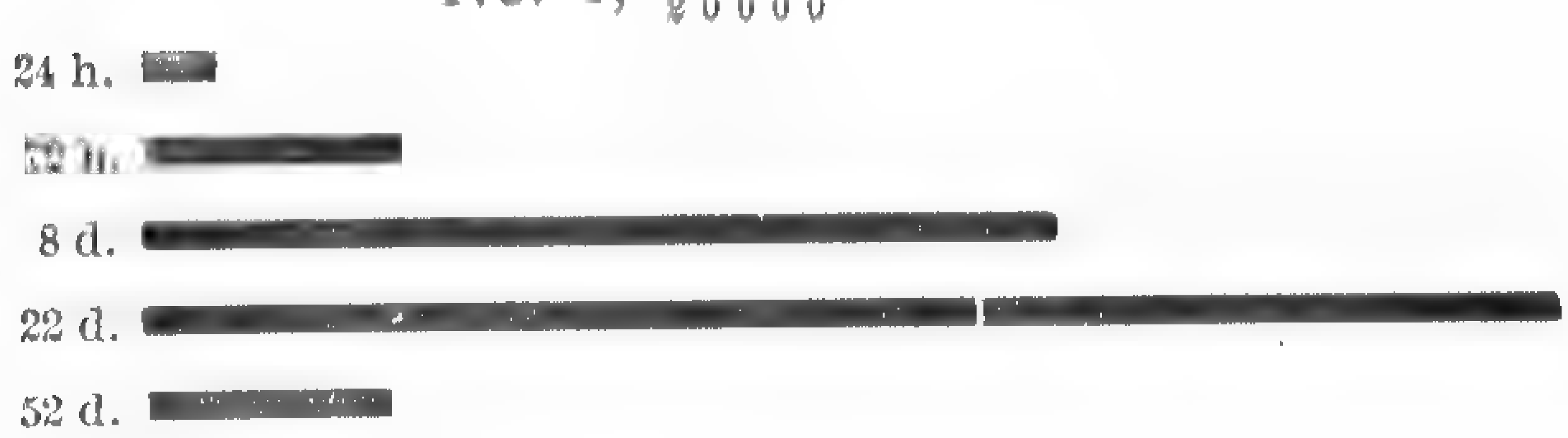
	PER CENT OF ALCOHOL.					P. C. OF ACETIC ACID.	
Interval. ☞	24 h.	72 h.	8 d.	22 d.	52 d.	52 days.	112 days.
Strength.							
No. 6, blank...	0.3	1.0	3.3	5.9	3.2	3.6	7.38
No. 1, 1-20000.	0.3	0.8	3.2	5.9	1.5	5.8	7.38
No. 2, 1-10000.	0.3	0.7	3.2	6.0	2.3	5.	7.87
No. 3, 1-5000..	0.3	0.5	2.7	6.0	2.6	4.7	7.79
No. 4, 1-1000...	0.3	0.3	0.3	4.0	4.8	0.4	0.4
No. 5, 1-500...	0.3	0.3	0.3	0.4	0.4	0.58	0.6
No. 6 (a) blank	1.0	1.2	2.3	5.3	6.3	1.6	3.48

These results are better shown graphically thus:

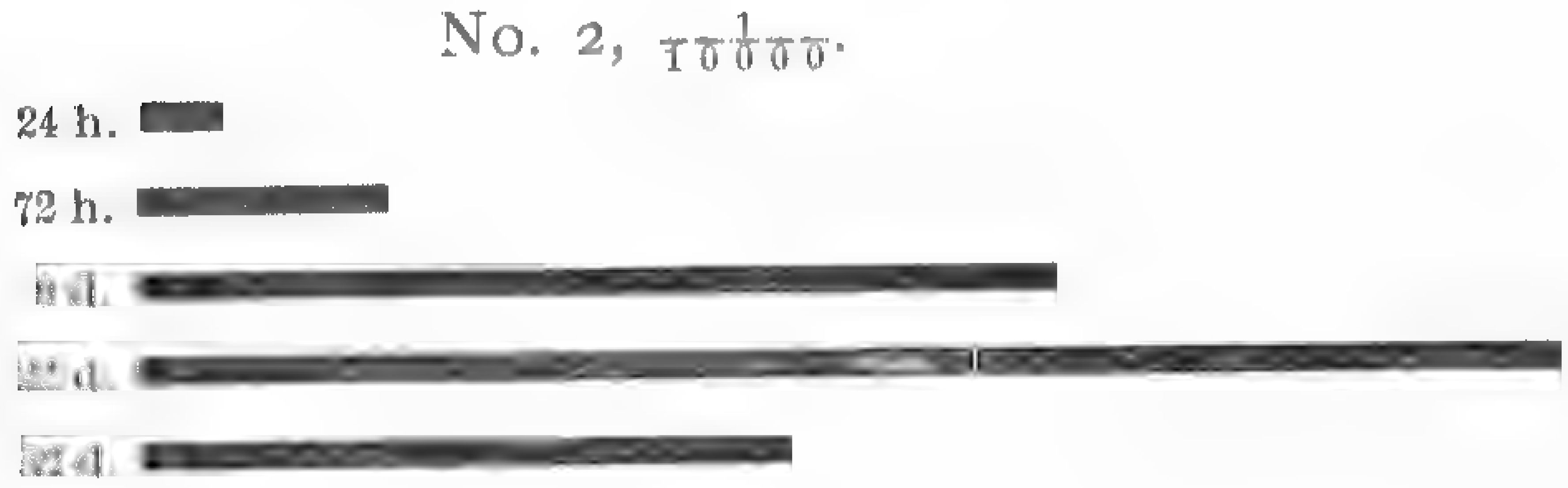
No. 6, Blank.



No. 1, $\frac{1}{20000}$.



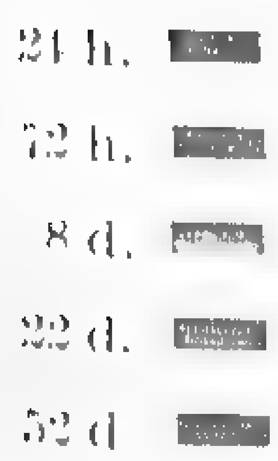
No. 2, $\frac{1}{10000}$.



No. 3, $\frac{1}{5000}$.

No. 4, $\frac{1}{1000}$.

No. 5, $\frac{1}{500}$.



No. 6 (a), Blank.

Though the effect of the preservative is not very marked till a $\frac{1}{1000}$ solution is used, yet it seems that 1-5000 solution of salicylic acid does have a noticeable effect upon the alcoholic ferments and the micoderma seems to do very well in a 1-1000 solution. But in the end it is probable that the maximum amount of both alcohol and acetic acid are produced, as the last distillations and titrations indicate in the case of Nos. 1, 2, 3, and 6. Attention might be called to the fact that 6 per cent of alcohol would theoretically yield respectively 7.8 per cent and 7.3 per cent of acetic acid.

There seems to be considerably less literature upon the use of sulfurous acid or its salts as preservatives, although it has long been known as an agent very destructive to bacterial life. Its detection in small quantity in the presence of organic matter is difficult, since it has been concluded that hydrogen sulfid is produced by zinc and hydrochloric acid with albuminous compounds or any compounds containing sulfur (U. S. Bull. 13, part 3,). But in quantities sufficient to exert any preservative influence sulfurous acid may be readily detected by zinc and HCl, as about 1 c.c. of a 2 2000 solution of calcium sulfite in cider when treated with a few scraps of zinc and about six c.c. of concentrated HCl, promptly gave the unmistakable odor of hydrogen sulfid and darkened lead acetate paper in less than one minute.

Neither HCl nor H_2SO_4 in 1-4000 and 1-2000 solutions in cider gave evidence of SO_2, but 1-1000, 1-500 and 1-250 solutions gave a somewhat pungent odor; none of them, however, produced a color with mercurous nitrate paper (paper saturated with mercurous nitrate solution). Potassium bichromate was not sensibly reduced by the amounts present in the above solutions, but the 1-250 solution gave an olive green color, not characteristic. Sodium nitroprusside gave no results whatever.

Quantitative determinations were not attempted, but for those interested reference might be made to the method in use by the Union of Baverian Chemists, described in U. S. Bull. 13, page 3. It consists in acidulating with phosphoric acid, distilling in a current of CO_2 then collecting in a solution of iodine. The sulfuric acid formed is then estimated in the usual way as barium sulfate.

Table 2 shows the effect of various amounts of calcium sulfite upon cider treated in the same manner as those previously mentioned. One more distillation was made of each sample and titrations were calculated as acetic acid as before, although in all probability the acidity in Nos. 1, 2, 3, and 4, was wholly due to the malic acid of the fruit.

TABLE 2.

	PER CENT OF ALCOHOL.						PER CENT OF ACETIC ACID.	
Interval. ☛	24 h.	72 h.	8 d.	22 d.	52 d.	112 d	52 d.	112 d.
Strength.								
No. 1, 1-250...	0.3	0.3	0.2	0.6	0.4	3.9	0.57	0.41
No. 2, 1-500...	0.3	0.3	0.3	0.3	5.4	3.9	0.48	0.41
No. 3, 1-1000..	0.3	0.3	0.3	3.9	6.1	3.9	0.41	0.41
No. 4, 1-2000..	0.3	0.4	0.9	4.8	6.3	4.0	0.41	0.41
No. 5, 1-4000 .	0.3	0.6	1.5	5.0	6.2	2.2	0.41	3.0
No. 6, blank...	1.0	1.2	2.3	5.3	6.3	2.2	1.62	3.48

This sample contained 0.3 per cent of alcohol at the beginning.

Here the effect of the increasing quantity of the preservative is very plainly shown, and even a $\frac{1}{4000}$ solution has a noticeable effect. The action of the sulfite seems to be retarding only, for considerable alcohol is produced after the fifty-second day, even in a $\frac{1}{250}$ solution. The formation of acetic acid is much retarded.

On the Composition of the Louisville Mineral Water.

BY E. H. S. BAILEY.

In Pottawatomie county, three miles north of Wamego, near Louisville, the former county seat, is a mineral spring that has attracted considerable attention locally, but a complete analysis of its water has never been published. The spring is situated beside a small stream that flows into Rock creek at this point. The surroundings, a natural park of oak and walnut, ash and elm, add much to the attractiveness of the place. The park is connected with the village by a suspension foot bridge over Rock creek. Just below this bridge a dam has been thrown across the stream, to supply the mill near by with water power; and the swift stream below the dam, at the "ford" on the old Pike's Peak trail has washed bare the level limestone rock over a large area. This same stratum of rock that is here exposed, extends north and west under the park and the spring.

The spring has recently been made more accessible by sinking over it a tile twenty-four inches in diameter, down to the bed-rock, through a cleft in which the spring water rises, and the water can be raised to the platform above by means of a pump.

The temperature of the spring, in May was 56° F. On July 7 it was the same. In the winter the temperature changes very little. The amount of water that flows is generally sufficient to fill an inch pipe. Although the water when first drawn is perfectly clear and transparent, in a very short time it becomes yellow and turbid. Boiling the water also causes a heavy precipitate to deposit. The taste of the water is somewhat astringent, and there is sometimes a slight odor of hydrogen sulfide from the spring. The The water when evaporated has a slight alkaline reaction.

The analysis of a sample of the water taken from the spring May 17 shows that 100.000 parts of the water contain the following constituents:

$Si O_2$ and insoluble residue	4.64
$Fe_2 O_3$	2.84
$Ca O$	38.17
$Mg O$	9.32
$Na_2 O$	8.05
$K_2 O$	0.52
$S O_3$	12.89
Cl	3.85
$C O_2$	99.90
$N_2 O_3$	a trace.
Organic matter	a trace.

The most probable combination for the above constituents would be as follows:

Silica and insoluble residue,	$(Si O_2)$	4.64
Iron bicarbonate,	$(Fe H_2 [C O_3]_2)$	6.32
Calcicum bicarbonate,	$(Ca H_2 [C O_3]_2)$	94.65
Magnesium "	$(Mg H_2 [C O_3]_2)$	33.93
Sodium "	$(Na H C O_3)$	1.93
Calcium sulfate,	$(Ca S O_4)$	13.24
Sodium "	$(Na_2 S O_4)$	9.06
Potassium "	$(K_2 S O_4)$	0.96
Sodium chloride,	$(Na Cl)$	6.36
Sodium nitrate,	$(Na N O_3)$	a trace.
Total		171.09

Free carbonic acid gas, 23.91.

This may be express in grains per U. S. gallon of 231 cubic inches, a common method of expression, as follows:

Silica and insoluble residue	2.706 grains
Iron bicarbonate	3.685 grains
Calcicum bicarbonate	55.198 grains
Magnesium bicarbonate	19.787 grains
Sodium bicarbonate	1.125 grains
Calcicum sulfate	7.721 grains
Sodium sulfate	5,284 grains
Potassium sulfate	0.560 grains
Sodium chloride	3.709 grains
Sodium nitrate	a trace.
Total	99.775 grains

Free carbonic acid gas, abundant.

The analysis shows that the water is a chalybeate and also belongs to the class known as alkaline water. From a medicinal standpoint, its most important ingredients are, no doubt, the magnesium bi-carbonate, the iron bi-carbonate and the sodium sulafte. There are numerous waters in the state that contain more magnesium salts than this spring, but very often these are mixed with a large quantity of sodium chloride, so that the water is really a brine and hence cannot be used as a beverage.

Iron is held in solution by the excess of carbonic acid gas, so that soon after the water is drawn this gas has an opportunity to escape and the iron is oxidized and separates out as a yellowish powder, and some of the lime carbonate is frequently deposited with it. The water is therefore not adapted to shipping away from the spring, though possibly, if thoroughly charged with carbonic acid gas and kept under pressure, this might be done.

The quantity of mineral matter is not very large; many of our springs and some rivers contain more. The Saline river, for instance, contains twice as much mineral matter in solution as this spring, but in this river about half of the mineral matter is common salt. The Solomon river contains nearly as much mineral matter as the Louisville spring, but here, too, there is about forty per cent. salt. The water analyzed is decidedly "hard" on account of the large quantity of calcium carbonate (lime) held in solution, but that would be naturally expected where water flows through limestone strata as in this case.

Myology of the Hind Limb of the Raccoon.

(Procyon lotor.)

BY R. C. GOWELL.

With Plates XIV, XV, and XVI.

This paper was suggested on noting how much certain muscles in specimens of the Raccoon dissected by the author differed from the description by Dr. Harrison Allen. (The Muscles of the Limbs of the Raccoon, *Procyon lotor*, by Harrison Allen, M. D., Proc. Acad. Nat. Sci. of Phila., 1882, pp. 115-144.) These variations are of special interest since they occur in a generalized species of low intelligence, whose individuals differ little in habits, and among which we should expect little variation in structure. Dr. Allen's descriptions were based upon dissections of two female raccoons which had probably been in captivity. This may have changed the proportions of certain muscles, but certainly not their attachments. My specimens differed little among themselves and seemed to present a normal structure judging from other carnivorous animals; while in some cases Dr. Allen's arrangement would be very remarkable.

If errors exist in Dr. Allen's work they may safely be attributed to oversight or lack of material. Errors are prone to occur where everything depends upon accurate dissection and observation, and although much care has been taken in the preparation of this paper the author cannot hope that all errors have been avoided.

The material upon which this paper is based consists of an adult female raccoon and two very large males. These specimens were procured through the kindness of Mr. J. C. Saunders of Lawrence. In most instances only such muscles are considered as seem to present variation or other interesting features.

Biceps femoris; Plate XIV, Bic.; Plate XVI, Fig. 7

I found the arrangement of the biceps femoris to be as follows: It arises from the lateral aspect of the tuberosity of the ischium and, spreading over the lateral surface of the thigh, is inserted by aponeurosis from the middle of the thigh half way to the heel; that is, into the fascia lata, lateral margin of patella, ligamentum patellæ, especially into anterior spine of tibia, and below into anterior fascia of the leg. From the deep surface of the biceps near its insertion a strong aponeurosis passes beneath the tenuissimus to join the gastrocnemius at its lower third, but the fibers may be traced to the heel. From Dr. Allen's description it appears that with the exception of the slip to the soleus, he found the insertion entirely on the patella and head of tibia, it being much more restricted than in my specimens. The aponeurosis passing to the gastrocnemius probably corresponds to the "slender fascicle" described by Dr. Allen and, if so, does not differ greatly. The origin by "stout aponeurosis from the spine of the sacrum" was not present in any of my specimens. Sacrum may be a misprint for ischium, for I found no origin from the spine of this bone. The division of the ischial origin into two portions, in Dr. Allen's variation, was evident in all of the specimens examined, but the parts soon joined.

Tenuissimus; Plate XIV, Ten.

The muscle is better developed than in the cat. It arises from the deep surface of the gluteus maximus and passes to the caudal border of the biceps, along the lower fourth of which it descends to be inserted into the fascia of the leg below the biceps. In one of the males the posterior border of the muscle received at the distal third a thin strip from the caudo-tibial division of the semitendinosus. This muscle, owing to its advantageous insertion, materially aids in flexing the leg upon the thigh.

Semitendinosus; Plate XIV, St., Stc.; Plate XV. St.; Plate XVI, Figs. 6 and 8, St.

The semitendinosus arises from the postero-lateral portion of the tuberosity of the ischium and from caudal vertebræ. The ischial origin envelopes the origin of the biceps behind and is slightly joined to that muscle for a short distance. The caudal origin is from the transverse processes of the first two caudal vertebræ. The origin from the first is in common with the caudal origin of the gluteus maximus and is not as extensive as that from the second. This caudal portion passes over the biceps and along the anterior border of the ischial part which it joins at the middle third. In one specimen a delicate fascicle passed from the middle of the semitendinosus to the tenuissimus (see plate XIV). The insertion, which is by flat tendon into the middle of the tibial crest and by fascia into the mesal surface of the tibia, underlies the aponeurotic part of the insertion of the gracilis. Dr. Allen found no vertebral origin of the semitendinosus, nor did I find the origin to be in part by a fleshy slip from the biceps.

Semimembranosus; Plates XIV and XV, Sm.; Plate XVI, Figs. 1, 4, 6 and 8, Sm.

This muscle presents little variation. The "long fusiform slip" uniting the two parts, is so closely joined to the "ischio-pubio-femoral" part throughout that it may be easily overlooked. This slip arises from the ischium between the origin of the other parts.

Sartorius; Plate XV, Sart.; Plate XVI, Figs. 6 and 8, Sar

The sartorius presents a much less extensive insertion than indicated by Dr. Allen. In no case did I find the insertion extending more than an inch below the head of the tibia, that is not more than one-fifth the length of that bone, at which point the insertion of the gracilis began.

Gracilis; Plate XV, Grac.; Plate XVI, Figs. 6 and 8, Gr.

The gracilis is a broad thin muscle covering the posterior half of the mesal surface of the thigh. It arises muscularly from the whole length of the symphysis pubis, from the descending ramus of the pubis and membranously for an inch, in the female half an inch, in front of the symphysis. In one of the males there was no origin from the descending ramus of the pubis. The insertion is coterminous to the insertion of the sartorius and in the same plane, it extends to about the middle of the tibia. The upper part of the insertion is by a strong direct tendon five-eighths of an inch broad, the remainder consists of oblique fibers, from the caudal border of this muscle, which overlie the insertion of the semitendinosus. According to Dr. Allen's description this muscle must have been very different in his specimens. (See p. 135 of his paper.)

Adductor magnus; Plates XIV and XV, A. M.; Plate XVI, Figs. 1, 3 and 4, A. M.

The adductor magnus was entirely free from the gracilis, instead of taking origin in part from the deep surface thereof. The insertion occupies not only the lower half of the posterior surface of the femur, but also a narrow strip extending up to the gluteal ridge.

Pectineus and Adductor brevis; Plate XV, Pect. and A. Br.; Plate XVI, Figs. 1 and 4, P. and A. B.

These muscles, inseparably united, arise from the ilio-pectineal line as stated by Dr. Allen. In all of my specimens, however, the pectineus and adductor brevis were inserted, not upon the adductor longus but upon the femur, by a well defined line *mesal* to the insertion of the adductor longus. This line began at the lesser trochanter just mesal to the insertion of the quadratus femoris and, bowing outward, extended to the middle of the femur; thus the insertion is well separated, especially proximally, from the adductor longus.

Vastus externus; Plate XVI. Figs. 2 and 3, V. E.

This muscle is much larger than the vastus internus. It arises from the upper half of the shaft of the femur from the antero-lateral surface, including the anterior surface of the great trochanter. The muscle is tendinous superficially above, and the deep surface fuses with the crureus. The muscular fibers converge to the lateral margin of the patella and to the lower fourth of the rectus femoris.

Crureus; Plate XVI, Figs. 2, 3 and 4, Cru.

This muscle is much connected with the vasti, but is, perhaps, worthy of individual description. It arises from the anterior surface of the femur; the area of origin is an irregular triangle, whose concave base extends between the supracondylar ridges an inch from the condyles. The origin extends above the middle of the shaft and is coterminous proximally with the vastus internus and laterally with the vastus externus. The insertion is into the capsular ligament of the knee and the summit and sides of the patella. Although this muscle arises from a large surface it is the smallest of the extensor group.

Soleus; Plates XIV and XV, Sol.; Plate XVI, Figs. 5 and 8, Sol

I found the soleus to be of medium size, rather flat and narrow, being a little more than an inch in breadth in the male raccoons and smaller in the female. It was smaller than either head of the gastrocnemius, and, of course, much smaller than the whole muscle. In one of the males the lateral edge of the soleus was fibrous and fused with the tendo-Achillis and slip from the biceps for two inches above the os calcis. In the other specimens this muscle was free to its insertion upon the tendo-Achillis just above the heel.

Flexor longus digitorum; Plate XV, F. L. D.; Plate XVI, Figs. 5 and8, F L. D.

Besides arising from a narrow strip occupying the proximal half or two-thirds of the posterior surface of the tibia, this muscle presents an origin from the head of the fibula. The slip from this origin passes over the tibialis posticus to join the tibial portion.

The *accessory slips* from the long to the short flexors (Plate XV, M. S.) presented a variation. Instead of being inserted upon the short flexor slips to the first, second and third toes they were inserted, one on the slip to the third and two on the slip to the fourth toe. This arrangement was constant, the little slips presenting no variation in number or proportions. The two to the tendon of the fourth toe were inserted about one-fourth of an inch apart.

Tibialis posticus; Plate XVI, Figs. 5 and 8, T. P

The Tibialis posticus arises from the proximal ends of the tibia and fibula, as stated by Dr. Allen, but the origin from the tibia extends over half way down the shaft, lying just laterad to the origin of the flexor longus digitorum with which it is closely connected. This muscle also arises largely from adjoining fascia, especially of the flexor longus hallucis. Its tendon is wholly concealed by the flexor longus digitorum, in company with which it passes through a sheath behind the internal malleolus, but in a separate compartment, and is inserted on the plantar surface of the scaphoid.

Peroneus longus; Plate XIV, Per. lon.; Plate XVI, Figs. 5 and 7, P. l.

The insertion of this muscle, as given by Dr. Allen, is very different from what I found. (See p. 139 of his paper.) In my specimens the carneous fibers converge to a round tendon. This tendon passes through a sheath behind the highest tubercle on the external malleolus, and superficial to the tendons of the other peroneals, to a loop behind the prominent tubercle on the anterior part of the lateral surface of the os calcis. From this point its direction corresponds to the long axis of the foot, until it enters the deep groove in the anterior part of the plantar surface of the cuboid, thence the tendon passes obliquely across the foot to be inserted into the outside of the base of the first metatarsal. This insertion of the peroneus longus is practically the same as is found in man and the cat, and did not vary in the specimens examined by the author.

Peroneus brevis; Plate XIV, Per. Brev.; Plate XVI, Figs. 5, 6 and 7, P. Br.

The origin of this muscle occupies not only the middle third of the fibula but extends nearly to the malleolus. The tendon of insertion appears on the lateral surface of the muscle an inch below the origin, but receives carneous fibers down to the external malleolus, where, thick and strong, it passes through a deep groove on the posterior surface, thence beneath the peroneus longus, to be inserted into the lateral aspect of the base of the fifth metatarsal; and in some cases into the dorsal and plantar fascia.

Peroneus tertius: Plate XIV, Per. Ter.; Plate XVI, Figs. 5 and 7, P. T.

The peroneus tertius was not inserted upon the base of the fifth metatarsal but upon the fifth digit at the bases of the first two phalanges, into the outside of the first and dorsum of the second. In one specimen a small slip passed to the division of the extensor brevis for the fourth toe.

Extensor longus hallucis; Plate XIV, E. L. H.; Plate XVI, Fig. 6, E. L. H.

Dr. Allen says: "This muscle was found in one subject only. It arises from the fibula at its upper third." This muscle was present in all of my specimens. It arose from the fibula for an inch, coterminously with the fibula origin of the tibialis anticus. Passing down behind the tibialis anticus it entered the loop with that muscle, and, becoming tendinous, wound around to the dorsum of the tibialis tendon where it gave a thin slip to be inserted with the same, then passed to the dorsum of the first phalanx of the hallux. In some cases this muscle was inserted entirely with the tibialis anticus and into adjacent fascia, no part going to the hallux.

Extensor brevis digitorum: Plate XIV, E. B. D.

This muscle consisted of five parts, which were distributed to the four inner toes. The slip to the hallux was inserted into the first phalanx, outside the extensor longus hallucis. The second toe received two slips, which were inserted on the dorsum of the second phalanx, in two instances side by side, in the other on each side of the long extensor tendon. The remaining slips were inserted on the third and fourth toes, outside the long extensor. The position of a short extensor to the fifth toe is occupied by the peroneus tertius.

Lumbricales; Plate XV, Lum.

The lumbricales vary in number. In one male Raccoon there were three, as found by Dr. Allen, but instead of being inserted upon the second, third and fourth toes, they went to the third, fourth and fifth toes. The insertion was upon the mesal side near the base of the first phalanx of each. Some of the tendons could be traced to the bone, others were lost on the sheaths of the flexor tendons. In the other specimens lumbricales passed to the four outer toes. These muscles arose at the divergence of the long flexor tendons, each muscle arising principally from the tendon to its toe. The muscle to the second toe was most slender, that to the fifth shortest and thickest.

Abductor minimi digiti; Plates XIV and XV, A. M.

This muscle arises from the plantar and mesal surface of the os calcis, just anterior to the insertion of the tendo-Achillis. The muscle is thin and flat, overlies the musculus accesorius, and tapers to its insertion at the base of the fifth metatarsal. The abdutor minimi digiti is not described by Dr. Allen.

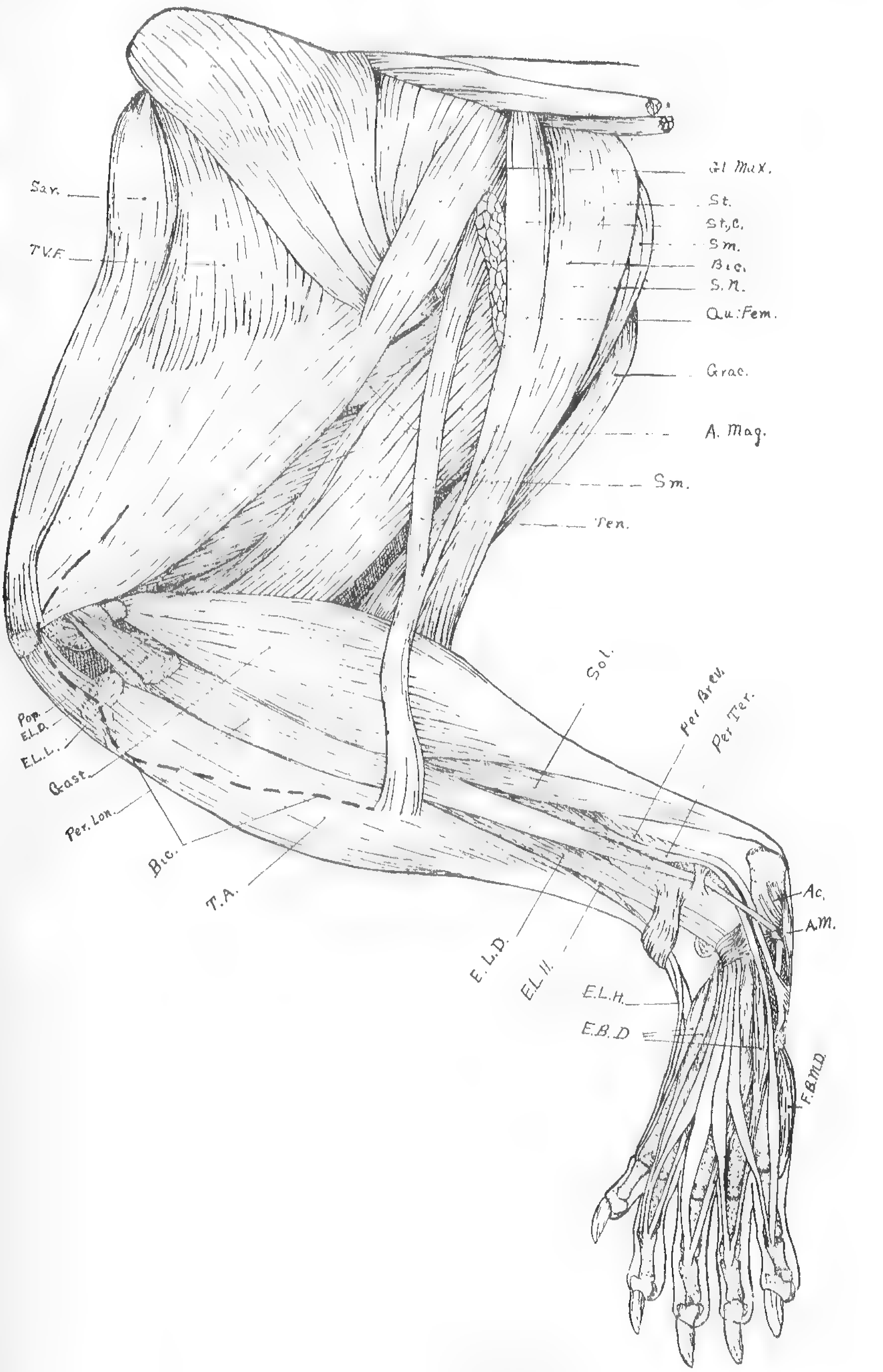
PLATE XIV.

Plate XIV. Hind limb of the Raccoon, lateral aspect, Biceps removed, and dorsum of pes everted.

Thigh. Sar., Sartorius; T. V. F., Tensor vaginæ femoris; Gl. Max., Gluteus maximus; St. Semitendinosus; St. c., Caudal division of same; Sm. Semimembranosus; Bic., cut origin of Biceps femoris; S. n., Sciatic nerve; Ten., Tenuissimus.

Crus. Pop., Popliteus; E. L. D., Extensor longus digitorum; E. L. L., External lateral ligament; Gast., Gastrocnemius; Per. lon., Peroneus longus; Bic., Biceps, line of insertion; T. A., Tibialis anticus; E. L. D., Extensor longus digitorum; E. L. H., Extensor longus hallucis; Sol., Soleus; Per. brev., Peroneus brevis; Per. Ter., Peroneus tertius.

Pes. E. L. H., Extensor longus hallucis; E. B. D., Extensor brevis digitorum; Ac., Accessorius; A. M., Abductor minimi digiti; F. B. M. D., Flexor brevis minimi digiti.



HIND LEG OF RACCOON, LATERAL ASPECT.

R. C. Gowell, del.

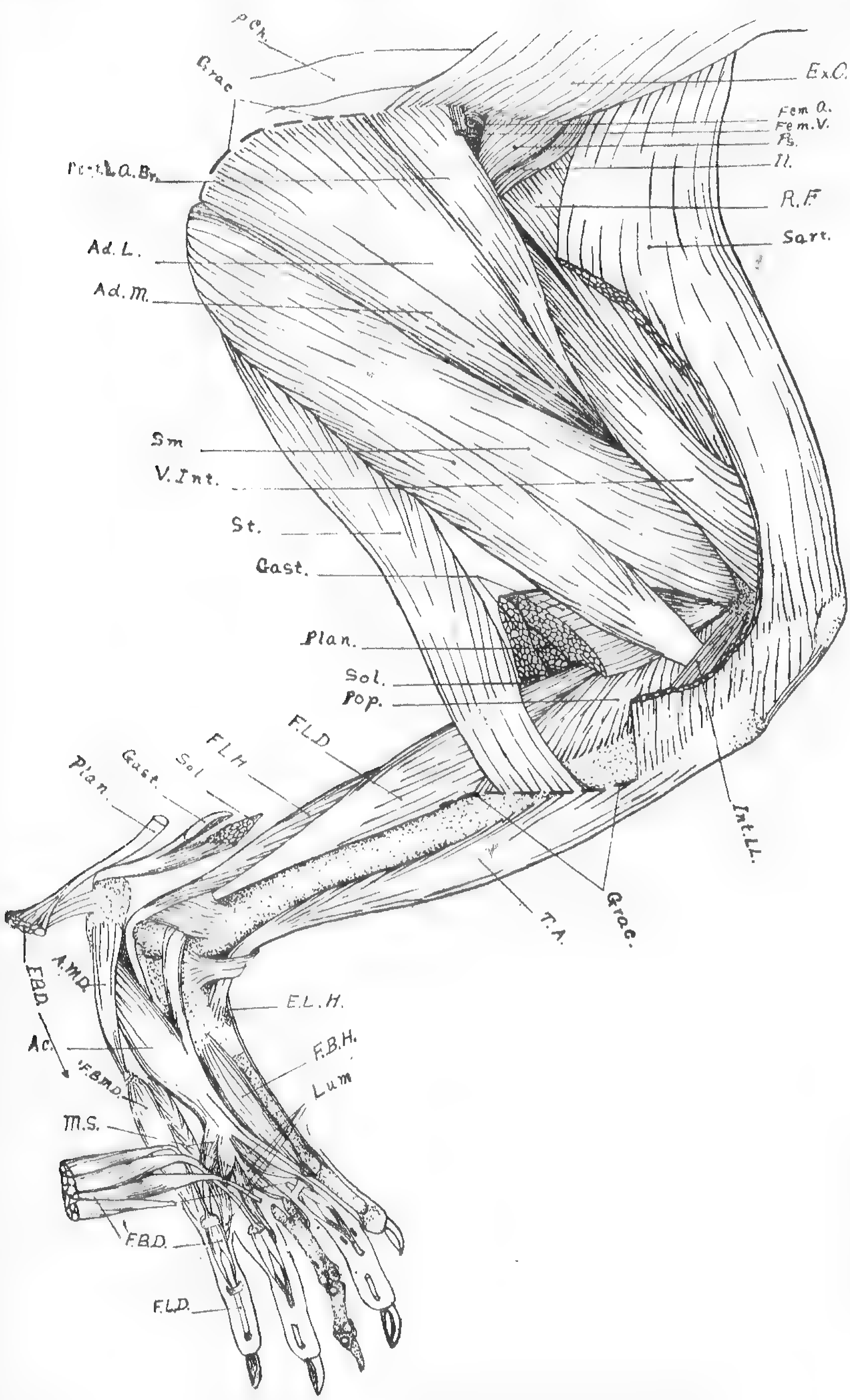
PLATE XV.

Plate XV. Hind limb of Raccoon, mesal aspect, Gracilis and parts of several muscles removed.

Thigh. Grac., Origin of Gracilis; Pect. and A. Br., Pectineus and Adductor brevis; Ad. L., Adductor longus; Ad. M , Adductor magnus; Sm., Semimembranosus; V. Int., Vastus internus; St., Semitendinosus; Sart., Sartorius; R. F., Rectus femoris; Il., Iliacus; Ps., Psoas; Fem. V., Femoral vein; Fem. A., Femoral artery; Ex. O., External oblique; Sp. Ch., Spermatic Chord.

Crus. Gast., Gastrocnemius; Plan., Plantaris; Sol., Soleus; Pop., Popliteus; F. L. D., Flexor longus digitorum; F. L. H., Flexor longus hallucis; T. A., Tibialis anticus; Grac., insertion of Gracilis; Int. L. L., Internal lateral ligament.

Pes. F. B. D., Flexor brevis digitorum, cut and reflected; A. M. D., Abductor minimi digiti; Ac., Accessorius; F. B. M. D., Flexor brevis minimi digiti; M. S., Muscular slips connecting long and short flexor tendons; Lum., Lumbricales, F. B. H., Flexor brevis hallucis; E. L. H., Extensor longus hallucis.



HIND LEG OF RACCOON, MESAL ASPECT.

R. C. Gowell, del.

PLATE XVI.

Plate XVI. Figs. 1 to 4, showing areas of muscular attachment on the Femur:

Fig. 1, Posterior surface of the Femur.

Fig. 2, Anterior surface of the Femur.

Fig. 3, Lateral surface of the Femur.

Fig. 4, Mesal surface of the Femur.

Gl. min., Gluteus minimus; Gl. Med., Gluteus medius; Gl. Max., Gluteus maximus; Ps. and I., Psoas magnus and Iliacus; Qu., Quadratus femoris; P. et A. B., Pectineus and Adductor brevis; A. L., Adductor longus; A. Mag., Adductor magnus; Sm. Semimembranosus, femoral portion; G. Int. and G. Ext., Internal and external heads of Gastrocnemius. The external head arises in common with the Plantarius from a sesamoid.

Figs. 5 to 8, showing areas of muscular attachment to Tibia and Fibula:

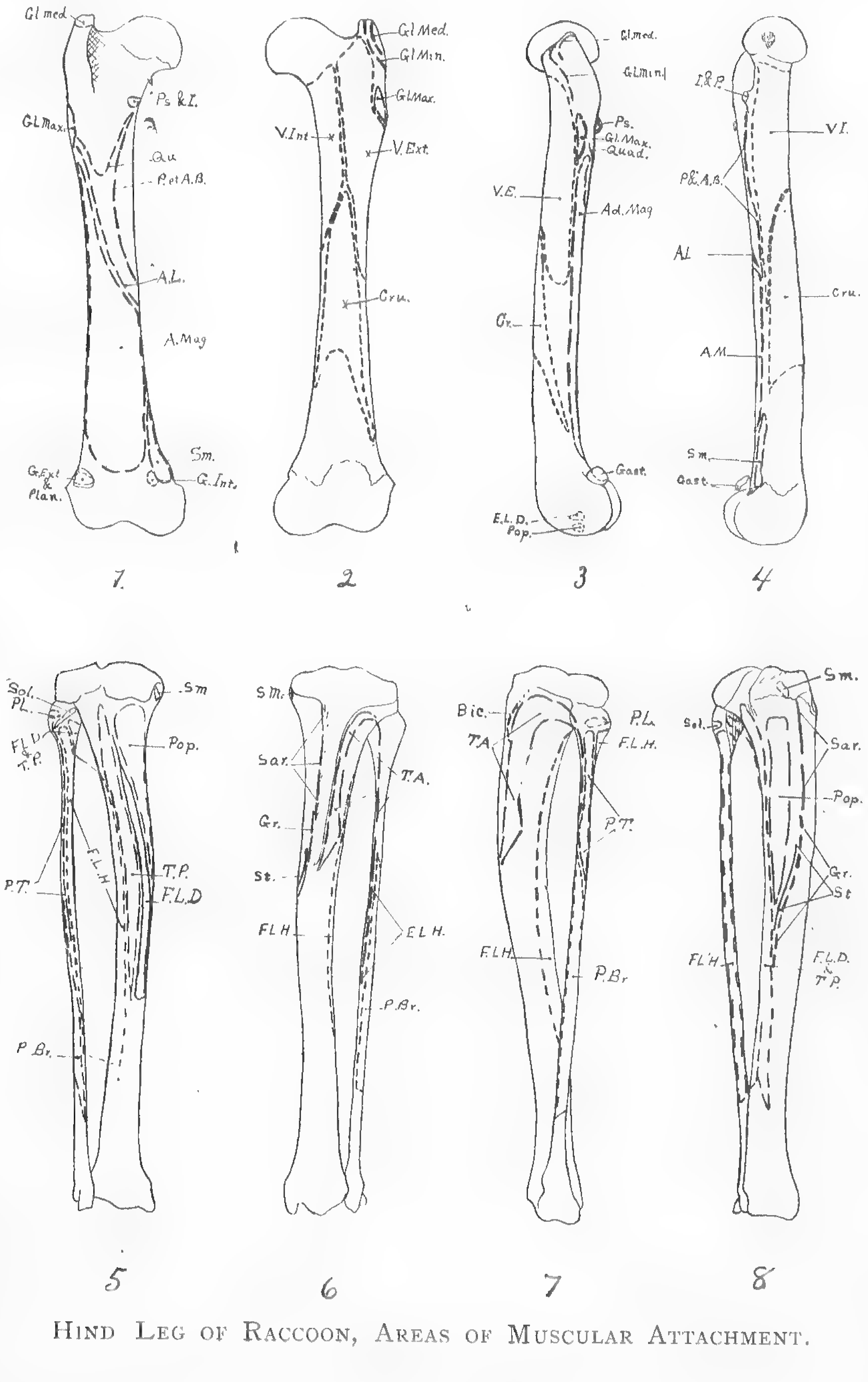
Fig. 5, Posterior surface of Tibia and Fibula.

Fig. 6, Anterior surface of Tibia and Fibula.

Fig. 7, Lateral surface of Tibia and Fibula.

Fig. 8, Mesal surface of Tibia and Fibula.

Sol., Soleus; P. L., Peroneus longus; F. L. D. and T. P., Flexor longus digitorum and Tibialis posticus; P. T. Peroneus tertius; P. Br., Peroneus brevis; F. L. D., Flexor longus digitorum; T. P., Tibialis posticus; F. L. H., Flexor longus hallucis; Pop., Popliteus; Sm., Semimembranosus; Sar., Sartorius; Gr., Gracilis; St., Semitendinosus; E. L. H. Extensor longus hallucis; T. A., Tibialis anticus; Bic., Part of insertion of Biceps.



Hind Leg of Raccoon, Areas of Muscular Attachment.

R. C. Gowell, del.

Notes on the Osteology of Bison Antiquus Leidy.

BY ALBAN STEWART.

With Plate XVII.

Bison antiquus was first made known by Leidy, who described fragmentary remains of a horn core and frontal bone found at Big Bone Lick, Kentucky. His description is as follows: "The specimen is rather too small (a fragment) to determine positively whether or not it is a distinct species from *Bison latifrons*. It did not belong to an aged individual, as the suture is still open between the frontal bone and that portion of the parietal which forms the upper boundry of the temporal fossa. It belongs to a species of Bison, as indicated by the advanced position of the horn-core, and resembles more the corresponding part in *Bison priscus* of Europe, as represented by Cuvier and others, than it does that of *Bison latifrons*. The horn-core is more abruptly conoidal, and relatively more curved than in the latter. It is not improbable, however, that the fragment may have belonged to the female of *Bison latifrons*."

Since the above description was published additional remains have proved conclusively that *Bison antiquus* and *Bison latifrons* are two separate and distinct species. Below are given the cranial measurements of *Bison antiquus*, *Bison latifrons*, and the specimen in the Kansas University Museum, from which the following description is made:

	Bison antiquus.	Bison latifrons.	Kan. Univ. specimen.
*Distance from mesial plane of occiput to tip of either horn-core	360-470		457
Distance between tips of horn-cores	680-920	1932	875
Distance between bases of horn-cores	295-392	407-430	405
Least width of forehead (between orbits and horn-cores)	290-336	380	346
Greatest width of occiput	332	......	270
Circumference of horn-core at base	300-370	510-520	310
Fronto-nasal suture to occipital crest	343	......	269
Distance between edges of orbits	420	......	346

*The measurements of *Bison antiquus* and *Bison latifrons* were taken from The American Bisons, Allen.

Before entering into the description it would be well to give a short resume of the history of this animal as given by Allen.*

The type specimen from Big Bone Lick, Kentucky, seems to have been the only remains of this animal found in that locality, although remains belonging to *Bison americanus* have been found there in abundance—Prof. N. S. Shaler, in 1869, having collected something over a thousand specimens from this locality.

In 1860 Dr. Leidy figured and described a second premolar tooth from South Carolina.†

This specimen may belong to this species or to *Bison latifrons.* The atlas, fragmentary humerus, tibia and metatarsal bone from Darien, Georgia, are hardly sufficient to determine accurately to what species this material may belong, but from the description and measurements it would seem that it belongs to *Bison antiquus.* Below are given the comparative measurements of the two specimens:

ATLAS.

	Darien specimen.	Kas. Univ. specimen.
Transverse axis of brim of articular cup	133	139
Sterno-dorsal axis of cup	70	68
Transverse axis of post articular surface	136	128
Greatest transverse breadth of atlas	240	232
Greatest ventro-dorsal breadth of distal end	100	99
Greatest length near the lateral edge of wing	127	118
Length of centrum, dorsal aspect	84	70
Length of centrum, ventral aspect	59	60

METATARSAL.

	Darien specimen.	Kas. Univ. specimen.
Greatest length	264	270
Greatest transverse diameter of proximal end	65	68
Greatest antero-posterior diameter of proximal end	62	64.5
Transverse diameter of shaft 3.5 in. from proximal end	44	45
Antero-posterior diameter of shaft 3.5 in. from proximal end	44	44.5
Circumference of shaft 3.5 in. from proximal end	145	144

The above remains, with those in the museum here and one skull, now in the possession of a high school in Illinois, and of which a cut of the posterior view is given from a photograph furnished through the kindness of Mr. W. L. Brayton, are all the remains of this species that I know of as having been found east of the Rocky Mountains.‡

Abundance of these remains have been found in Alaska from Eschholtz Bay and the valley and tributaries of the Yukon river,

*The American Bisons. Living and Extinct.
†Holmes' Post-Pliocene Fossils of South Carolina, p. 109, pl. xxii.
‡I have recently examined a portion of a cranium of this species found on the upper part of the Saline river in Kansas.—S. W. Williston.

two collections having been made from the first of these localities and described by Sir John Richardson in the Zoology of the Voyage of the Herald. Some of these remains had not entirely lost their animal matter, the horns still covering the horn-cores in some instances. The second of these localities has furnished fragmentary remains of bison, represented in the collections of the National Museum and the California Academy of Sciences. The remains are more or less abundant in these localities, as miners often bring down horn-cores and other fragments when coming from the interior. In California the remains have been found in various places, associated with the bones of *Mastodon, Elephas, Tapirus*, and *Equus*. In Oregon a specimen of a phalangeal bone was described by Dr. Perkins, which probably belongs to this species.

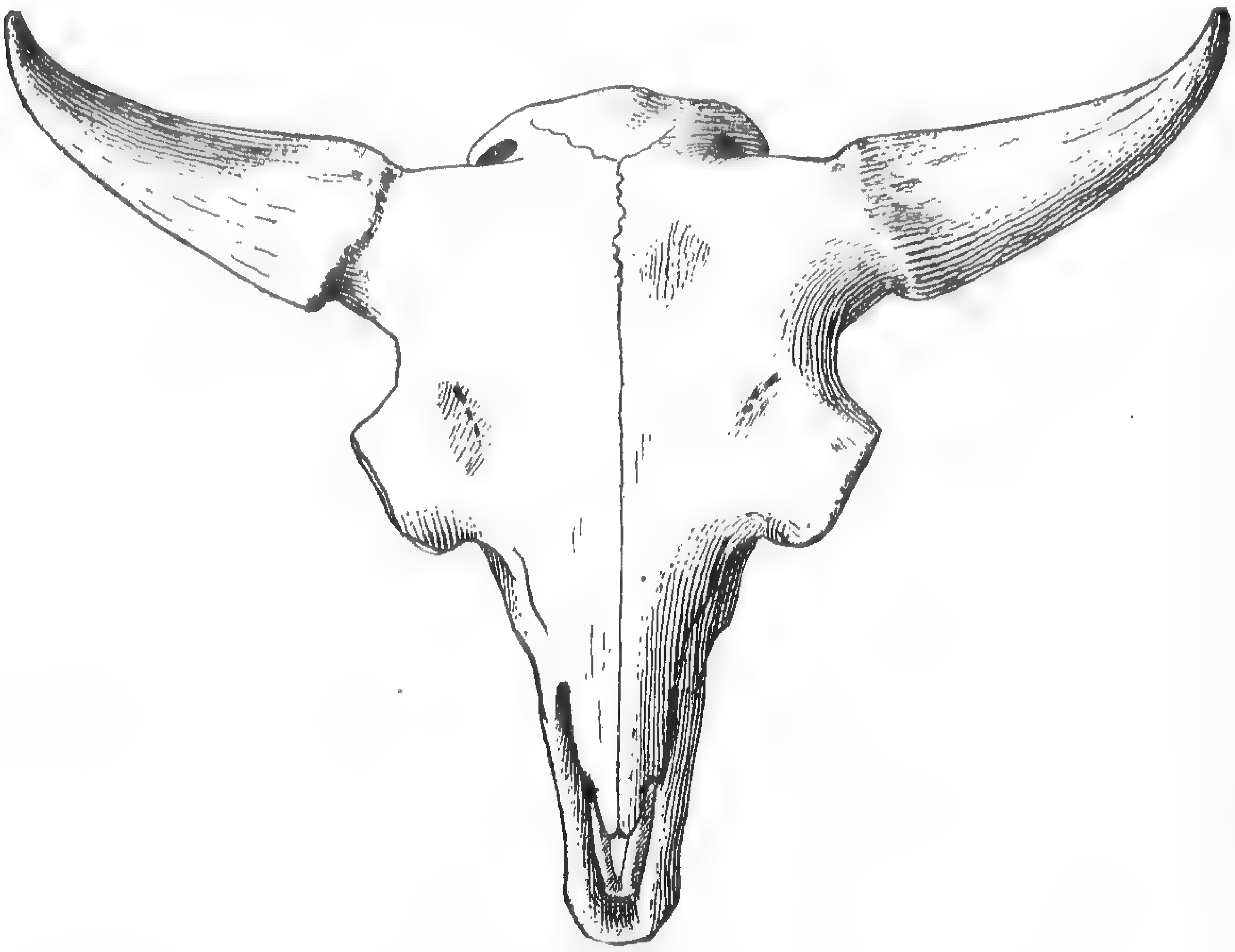
From the above it may be seen that remains of *Bison antiquus* have been found in Georgia, South Carolina,(?) Kentucky, California, Oregon, Kansas, and Alaska, showing that the animal had a range over the greater part of North America. It was cotemporary with the Mammoth, Mastodon, and with man, as a small but well fashioned arrow-head was found by Mr. H. T. Martin, associated with the specimen now in the Kansas University Museum.

Skull.

The skull, when compared with *Bison americanus* and *Bos taurus*, presents numerous points of difference. The skull as a whole is much larger and more tapering toward the extremity, the horn-cores are proportionally longer, larger and less recurved than in *Bison americanus*, the orbits are more protruding and the pre-maxillæ are longer and narrower. Examined in detail the following points of difference are noted:

Occipital.

All of the occipital elements have become united in this specimen, forming one bone. The ex- and supra-occipitals form the back wall of the cranium, and when compared with the two recent forms mentioned above, many points of difference are observed. It is broader and proportionally lower than in either of the recent forms, and the two lateral halves are separated by a median carina which is present in the recent B*os*, but not so well marked as in this species. This carina ends superiorly in a rugose-like swelling, which is much more prominent than in *Bison americanus*, for the attachment of the ligamentum nuchæ. The two lateral halves, instead of being nearly flat as in *Bos taurus*, are quite deeply concave and the lambdoid crest is overhanging the occiput, a character not found in *Bos*. The ex-occipital element is strongly convex just above the condyles. The condyles are more obliquely set than in *Bison americanus*, and although the animal was much larger in every respect, yet the size of the foramen magnum is proportionally less than in the recent bison. The inter-condyloid notch is also proportionally broader in the recent form, the articular portions are regularly convex, the superior and inferior portions of each condyle insensibly grading into each other without being separated by the sharp ridge found at this point in *Bos taurus*. The basilar portion is more horizontally situated, and does not have the rugose knob-like projections just anterior to the condyles, so prominently marked as in *Bison americanus*. The par-occipital processes are firmly co-ossified with the mastoid portion of the periotic, are proportionally more slender and directed more inward than in either of recent forms mentioned above, and the external border is not so sharp as in *Bos taurus*.



Skull of *Bison antiquus*, front view.

Sphenoid.

The basi-sphenoid is shorter and more tapering than the basi-occipital; from the point of junction with this bone it is directed forward, but not so sharply upward as in *Bison americanus*. The pre-sphenoid portion is not so sharply keeled as in *Bos taurus*, nor is the deep sharp groove, just posterior to this portion, so prominent as in the species just mentioned. The orbito- and allisphenoids are not sufficiently well preserved to determine their characters or give comparisons with the recent forms.

Periotic.

The mastoid portion is broad and wedged in between the squamosals and ex-occipitals as in both of the recent forms mentioned. The superior portion, which forms the floor of the temporal fossa, is directed more outward than in *Bison americanus*, and the ridge, which extends along the external border and represents the lower continuation of the lambdoid crest, is not so sharp as in the recent ox, but is more rounded and roughened for ligamentary attachment as in *Bison americanus*. The tubercle, just above the meatus auditorus externus, which is so prominent in *Bos*, has become much less marked and is somewhat roughened as in the recent bison. The anterior portion, just external to the glenoid cavity, is much more concave, but does not project downward so strongly as in *Bos*, nor does the internal portion project outward to form a pit for the hyoid bone.

The tympanic is much inflated from before backward and is more closely applied to the basi-occipital than in *Bos*, causing the external openings of the carotid canal and lacerated foramen to be very much compressed. The anterior styliform process is very short, even more so than in *Bison americanus*.

Squamosal

So far as can be determined the squamosals are very similar to the corresponding portions of the two species with which it was compared, except that the glenoid cavity is not so flat and the post-glenoid foramen is more laterally situated than in *Bos*.

Jugal.

The posterior portions of the jugals are not preserved, but they were probably long and slender and extended almost to the glenoid cavity as in both of the recent forms. The anterior orbital portion is more strongly projected outward and overhanging the face than in either of the forms mentioned, and the rim is much roughened for muscular attachment. The infra-orbital ridge, which is so well marked in both of the recent forms, is not present in this species.

Frontals

The facial portion presents many points of difference when compared with *Bos taurus*, but in most respects it is very similar to the corresponding portion of *Bison americanus.* This portion is more convex and the frontal eminences are more strongly marked than in *Bos.* The orbital portions are much more strongly projected laterally, and more roughened for muscular attachment than in either of the recent forms mentioned; the posterior portions are much broader than in *Bos.* The ridges, connecting the orbits with the bases of the horn-cores and separating the facial from the temporal portion, are not present, the two parts gradually rounding into each other. This ridge is strongly marked in *Bos,* while in *Bison americanus* it is only slightly developed or absent altogether. The horn-cores are proportionally longer and more robust than in the last mentioned species, and are directed less strongly upward and backward. When compared with *Bos* a marked difference in the position of the horn-cores is at once noticed. In this genus the horn-cores are situated far back and occupy the posterior angles of the frontals, while in the bison they are situated just over the root of the zygoma and are separated from the posterior portion of the skull by the anterior wings of the parietals. The anterior surface of the frontals is slightly more convex than in *Bison americanus;* in the ox this portion is slightly concave. The fronto-nasal suture is situated farther forward, and the lateral portions forming the nasal notch are not so sloping as in the ox. The venous foramina, situated above and slightly posterior to the orbits and leading into the frontal sinuses, are present in all of the three forms, but are less numerous in the ox than in the two species of bison under consideration. The supra-orbital notch is not present in *Bison antiquus.*

Nasals.

The nasals are more anteriorly projected than in *Bison americanus,* and are proportionally broader and less arched than in *Bos taurus.* There seems to be no articulation with the maxilla, but on account of the damaged condition of the specimen in this region, this point cannot be accurately determined; in the ox this articulation is very long.

Parietals.

The parietals differ in but few points from the corresponding portion of *Bison americanus.* The parietal eminences are broader and more swollen than in this species, and the swelling invades the frontals somewhat anteriorly. The notch found at the superior portion of the temporal fossa and formed by the anterior wing and the inferior periotic portion of the parietals, is more acute than in *Bison americanus.* In the ox the anterior wings are more vertically placed than in the two species of bison mentioned. In the ox the superior portion does not invade the forehead (as in the bison), but is almost horizontally situated and forms with the frontal a well rounded crest with which it is anchylosed.

Lachrymal.

The lachrymal differs in but two principal points from that of the recent bison. The orbital portion is more projected laterally and roughened on the rim, and there is a large protuberance on the superior border which slightly invades the frontal.

Premaxilla.

The premaxilla are much more narrow throughout their course than in *Bison americanus*, and in this lies one of the strong specific characters of this form. The anterior portion at the symphysis is slightly broader from before backward than in *Bison americanus*. The extremities are well rounded and united at the symphysis, a character which does not occur in any of the recent bison skulls which I have examined. The vomer is not preserved.

Maxilla.

The maxillæ are very similar to the corresponding part of the recent bison. The superior portion is slightly more vertically situated than in the form just mentioned. The facial ridge, separating the anterior part from the zygomatic fossa, is more indistinct and the two portions more blended than in the recent bison, but the anterior portion is more prominent and the posterior portion directed more upward than in this species. The infra-orbital foramen is also slightly more anterior in position, approaching the position of this foramen in the ox. The diameter across the facial ridges is less than in the recent bison, making the face proportionally narrower.

Mandible.

The principal point distinguishing the mandible of this species from that of the recent bison is the long and gently sloping horizontal ramus. This portion is also less closely applied to the last molar than in the two recent forms with which it is compared. The condyles are not bifurcate as in the ox, and the coronoids are more curved backward over the root of the zygoma than in this form. The lower portion of the body is not so rounded, and the ridge along the superior border of the diastema is not so sharply defined as in the ox and recent bison.

Dentition.

The teeth of *Bison antiquus* differ in so few points from those of *Bison americanus* that a detailed description of the dentition is unnecessary.

MEASUREMENTS OF SKULL.

	Bison antiquus.	Bison americanus.
Median plane of occiput to extremity of premaxillaries......	633	54
Median plane of occiput to tip of nasals..................	534	412
Anterior rim of orbit to tip of nasals.....................	248	214
Greatest diameter of orbit..............................	74	72
Anterior rim of orbit to tip of horn-core..................	475	320
Breadth across occipital condyles........................	147	122
Height of foramen magnum............................	40	37
Breadth of foramen magnum...........................	48	51
Distance between tips of paroccipital processes............	114	110
External auditory meatus to posterior rim of orbit..........	200	138
Inter-condylloid notch to base of last molar.....	265	190
Diameter across last molars..............	122	119
Diameter across first premolars..........................	90	108
Length of superior dental series.........................	155	154
First premolar to tip of premaxillaries....................	176	148 5
Diameter across premaxillaries four centimeters from tip....	72	89
Transverse diameter of external nares	97	95
Mandible, condyle to first premolar	325	288
Mandible, condyle to base of last molar...........	184	145
Mandible, diameter across condyles..........	173	155
Mandible, length of inferior dental series.................	157.5	159
Mandible, length of diastema.........	127.5*	117
Mandible, depth of symphysis...........................	75*	69
Mandible, depth of ramus at base of third premolar...	57 5	46

SKELETON.

The differences in the remaining parts of the skeleton of the two species of Bison are not sufficient to warrant description, but to show the difference in size of the two species measurements of some of the principal parts are given below.

	Bison antiquus.	Bison americanus
Humerus, length..	407	272
Humerus, longitudinal diameter of head..................	106	86
Humerus, transverse diameter of head...................	88.5	82.5
Humerus, diameter across condyles, anterior.............	107	85
Ulna-radius, length from posterior tip of olecranon.........	490	412
Ulna-radius, length from sigmoid notch..................	353	316
Ulna-radius, length of sigmoid notch.....................	58	..
Ulna-radius, greatest breadth of olecranon................	99	75
Ulna-radius, transverse diameter of proximal end..........	102	...
Metacarpal, length...........	221	210
Metacarpal, diameter across proximal end................	85	70
Metacarpal, diameter across distal end...................	88*	76

*Estimated.

	Bison antiquus.	Bison americanus.
Second digit, length of proximal phalanx	66.5	61
Second digit, length of second phalanx	41	38
Second digit, length of ungual	73.5	74
Third digit, length of proximal phalanx	69	62.5
Third digit, length of second phalanx	48	38
Third digit, length of ungual	80	61
HIND LIMB.		
Pelvis, antero-inferior spine of ilium to posterior part of ischium	595*	505
Pelvis, greatest transverse diameter of ilium	282	244
Pelvis, center of acetabulum to antero-superior spine of ilium	272*	255
Pelvis, longitudinal diameter of acetabulum	89	78
Femur, length	502	423
Femur, diameter across *trochanter major*	175	153
Femur, greatest diameter of head	67	...
Femur, transverse diameter across condyles	133	116
Tibia, length	461	382
Tibia, transverse diameter of proximal end	141	113
Tibia, transverse diameter of distal end	87	69
Calcaneum, length	175	154
Calcaneum, diameter across sustentaculum	54	44
Astragalus, external length	89	77
Astragalus, internal length	80	72
Astragalus, diameter across proximal condyles	63	50.5
Astragalus, diameter across distal condyles	59	53
Naviculo-cuboid, longitudinal diameter at beak	55	47
Naviculo-cuboid, transverse diameter	77	65.5
Metatarsal, length	270	240
Metatarsal, diameter across proximal end	65	57
Metatarsal, diameter across distal end	78	66
Second digit, length of proximal phalanx	72.5	61
Second digit, length of second phalanx	45	39
Second digit, length of ungual	49	62.5
Second digit, transverse diameter of ungual, posterior	33	26
Third digit, length of proximal phalanx	70	63.5
Third digit, length of second phalanx	48	40
Third digit, length of ungual	65	62
Third digit, transverse diameter of ungual, posterior	30	

*Estimated.

PLATE XVII.

Plate XVII. Fig. 1, posterior view of skull in high school in Illinois. Fig. 2, side view of skull in Kansas University Museum.

Fig. 1.

Fig. 2.

New Species of the Syrphid Genera *Mixogaster* Macq. and *Ceria* Fabr., with Notes.

BY PAUL HUGO ISIDOR KAHL.

Mixogaster breviventris, n. sp.

Black and blackish brown, variegated with yellow bands, black and yellow pubescent; antennæ much elongated, the third joint narrowed in its middle, two and a half times as long as the first one; abdomen narrowed at base, short-pedunculate; wings anteriorly brown, posteriorly greyish hyaline; the fourth vein sends a short vein into the first posterior cell. Length 10 mm., length of wing 8 mm.

Female. Shining, especially conspicuous on pleuræ, sternum and coxæ. Face sparsely covered with yellow pubescence, not projecting more at oral margin than at the antennæ, gently convex, at the insertion of the antennæ not protuberant; yellow with a large, blackish brown, longitudinal median spot, which is gradually dilated from base of antennæ to the lower third of the face, thence contracted to a somewhat acute angle, not quite reaching the oral margin, the spot is black along its middle; across the cheek from the eye to the oral margin a blackish band, behind it a yellow patch, thinly covered with whitish yellow pollen and connected with the yellow of the posterior oral margin; the sides of the lower half of the face with an extremely short, light-yellow pubescence. Front immediately above the antennæ with a broad, almost black, transverse band, reaching the eyes and two-thirds of the distance between base of antennæ and anterior ocellus; above this band there is a yellow, scarcely narrower one, reaching the eyes and encroaching upon the vertex as far as the posterior ocelli; below the yellow band the front is very slightly depressed; on the sides of the black crossband a broad impression, which is continued on the face a short distance as a well marked arcuate line, reaching the eye; the surface of the sides of front uneven, somewhat wrinkled; immediately above the antennæ the surface is smooth, more shining, of brown color, not black like the rest of the crossband.

Vertex behind the yellow frontal crossband black, including the ocellar tubercle, which consists merely of a slightly elevated ring with the space between the ocelli somewhat concave, by no means convex; behind the ocelli a slightly elevated tubercle; front sparsely provided with short, erect fuscous pile on the black band, somewhat lighter on the yellow one; on the vertex the pilosity is fuscous, yellowish at the occiput, more abundant and longer than that of the front. Occiput black, sparsely yellowish pilose above, at the middle with short, at the lower part with longer, sparse whitish yellow pile; superiorly very thinly yellowish pollinose, at the middle of each side a large, distinct, white pollinose patch. Proboscis yellow. Antennæ with the first joint yellowish brown beneath, a little darker above, its length about the same as the distance between its extreme base and the anterior ocellus, its vertical width at apex fully one and a half times greater than that of base, above and beneath with blackish pubescence; the second joint very short, brown, at base darker, scarcely broader than the apex of the first, but at least five times shorter than that joint; third joint thickened, much elongated, fully two and a half times as long as the first one, narrowed in its middle, dark brown; the arista, situated near the base of the third joint, yellowish brown, its extreme base black, not reaching as far as the apex of that joint. Eyes bare; the inner orbits almost parallel and rather broadly separated. Thorax black, the broad lateral border of mesonotum to the scutellum, including humeri, mesopleuræ, upper part of sternopleuræ, upper part of hypopleuræ and most of metapleuræ, pale yellow; the yellow of the pleuræ forms a broad, semicircular band, interrupted only at the posterior side of sternopleuræ by a narrow black stripe connecting the black of pteropleuræ with that of the sternum. Scutellum short, considerably convex, translucent, pale yellow, the extreme base and a dot on lower lateral angle brownish; the furrow between mesonotum and scutellum deep. Abdomen short, a little wider than thorax, blackish brown; first segment rectangular, three times as short as its width, the latter about the same as the distance between the eyes on vertex (not wider), above yellow with a narrow brown, basal band, not quite reaching lateral margin; second segment short, as long as the third, its lateral outline seen from above slightly concave before the middle; first and base of second segments form together a very short peduncle; third and fourth segments of equal width, the fourth hardly longer; fifth as long as the third, its distal end only half as wide as its base; the whole posterior margin of second, third, fourth and fifth dorsal segments broadly bordered with yellow, that of the second of equal width throughout, that of the third, and a little more so of the fourth, slightly widening at sides, that of the fifth considerably dilated laterally as far as the middle of the segment; ventral segments blackish brown, the first one yellow with a brown patch in its middle, the four following segments with posterior margins narrowly yellow, obsolete on the fifth, base of second also with a narrow yellow, transverse band not reaching the lateral margin; ovipositor dark brown, its two oval apendices reddish brown. To the naked eye the whole insect appears almost bare, and its ground color is in no way concealed by the minute pubescence. Mesonotum rather densely, scutellum very sparsely, the whole blackish portion of second and third dorsal, fourth dorsal at base and sides, fifth dorsal at the extreme base only and the blackish portions of ventral segments, provided with minute blackish brown pubescence; the posterior yellow margins of dorsal and ventral segments with yellow pubescence, extending on the fourth dorsal to the middle of the black portion, on the fifth dorsal it extends almost over the whole segment; on the sides of the first segment and on the ovipositor the pubescence is longer and yellowish. Legs rufous, coxæ black, middle and hind trochanters, apical two-thirds of hind femora, dark brown, basal two-thirds of all the tibiæ pale yellow; the pubescence yellow; hind femora not unusually thickened and the hind metatarsi moderately dilated. Halteres brown with yellow knob. Wings brownish anteriorly, greyish hyaline posteriorly; the brownish color is limited behind by the first, by the spurious as far as the anterior crossvein and by the third veins; apex of the sub-marginal cell is, however, greyish; besides a small spot across the greyish hyaline portion at the outer third of the first basal cell, on veins at base of first and last posterior and discal cells, on vein closing the discal cell, and faintly along fifth vein in the second basal cell, brownish; veins dark brown, somewhat reddish brown at base of wing; posterior angle of first posterior cell less than a right one, the vein closing the same cell almost straight and rectangular with the third vein, sending no stump of a vein inwards, but there is merely an indication of a fuscous dot a little above the middle; posterior crossvein bent inwards, making each outer angle of discal cell much less than a right one, and immediately before the same crossvein the fourth vein sends a short stump of a vein into the first posterior cell; from the posterior angles of the first posterior and discal cells a similar stump of a vein outwards; anterior crossvein situated not more than twice its length from base of discal cell; the vein closing the anal cell almost straight; the little crossvein, connecting the auxiliary vein before its apex with the first longitudinal vein, present.

A single female specimen from Lawrence, Kansas, captured by the writer July 4, 1894. It was resting on leaf of *Couvolvulus sepium L.*

Easily distinguished from the previously described species by the short and at distal end broader second abdominal segment, the much elongate, in its middle narrowed, third antennal joint (like that of *Microdon variegatus* Walker, Ins. Saund. Dipt., p. 220, pl. vi, fig. 6; and *Microdnn pachystylum* Williston, Synops. N. Am. Syrph., p. 8), and the venation of the wings. Notwithstanding the shortness of the second abdominal segment, the pedunculate base of abdomen, though short, and the general appearance will place this species in the genus *Mixogaster.* I have before me males and females of *Mixog. conopsoides* Macq. from Brazil (Dr. Williston's collection), in which the second segment of the female abdomen is broader than that of the male, only a little longer than the third and its distal end as broad as base or distal end of that segment. That Macquart (Diptères Exotiques, II, 2, p. 14, tab. 3, fig. 1), when drawing up the generic characters, had before him a male, and not a female as is stated, is unmistakably shown from his description of the fifth abdominal segment: "cinquième court et arrondi à l'extrémité."

PREVIOUSLY DESCRIBED SPECIES.

M. conopsoides Macquart, Diptères Exotiques, II, 2, p. 14, tab. 3, fig. 1 (Extraits des Mémoires...de Lille, 1841);—Rio de Janeiro. Type of the genus. About the sex see remarks above.—Williston, Diptera Brasiliana, Trans. Amer. Entom. Soc., XV, p. 257.

M. mexicanus Macquart, Dipt. Exot., 1er Suppl., p. 123, tab. 10, fig. 15 (Extr. des Mém...de Lille, 1844)—Mexico, female.—Williston, Biol. Centr. Amer., Dipt., Vol. III, Dec., 1891; Omilteme in Guerrero 8,000 feet, Chilpançingo 4,600 feet (H. H. Smith). Two male specimens (Dr. Williston's collection), bearing the labels Omilteme, Guerrero, 8,000 ft., July; H. H. Smith, differ so greatly from Macquart's description and figure, that they would be considered a different species, were it safe to rely upon Macquart. Antennæ not longer than front and vertex together (Macq. fig. with much elongated); face with a large, oblong, blackish brown spot from base of antennæ to oral margin; front and vertex black, upper half of the former yellow (forming a transverse band), the latter in one specimen with an inconspicuous post-ocellar dot yellow (Macquart's female has: "Face jaune, sans bande noire. Front fauve; une tache noire à l'insertion des antennes et une petite protubérance noire au milieu"); scutellum yellow with brown base and a black spot on each lower angle (Macq., "écusson fauve"); coxæ, trochanters, femora (except the rufous knees) and the tibiæ (except the pale almost white basal half of the middle and hind and the basal fourth of the front ones) blackish brown; tarsi dark brown, pulvilli rufous (Macquart's diagnose, "Pedibus rufis").

M. aphritinus Thomson, Kongliga Svenska fregatten Eugenies Resa omkring Jorden, Vetenskapl. Iakttagelser, Diptera, p. 491; 1869.—Sidney (Australia), male.

M. bellula Williston, Biologia Centrali-Americana, Dipt., Vol. III, p. 1, tab. 1, fig. 1, 1a, 1b; 1891.—Mexico, male.

M. dimidiata Giglio-Tos, Diagnosi di nuove specie di Ditteri, VI. Sirfidi del Messico, in Boll. Mus. Zool. Anat. comp. R. Univ. di Torino, Vol. VII, no 123, 1892;—Id., Ditteri del Messico, Parte I, p. 33, tav. I, fig. 9, 9a (Estr. dalle Memorie della Reale Accademia delle Scienze di Torino, Serie II, Tom. XLIII. 1892.)—Tuxpango, female. This species is distinguished by the extraordinary, arcuate impression of the face.

Ceria Willistoni, n. sp.

Syn. *Ceria signifera* Williston (non Loew), Synops. N. Am. Syrph., p. 262.

Black with yellow markings; face with a large, sagittate, black spot; antenniferous process of front almost obsolete; second joint of antennæ about half as long as the third; last section of third longitudinal vein appendiculate and slightly angulate; second abdominal segment much contracted at base; fifth segment black, not at all pollinose. Length about 13.5 mm., length of wing 9.5 mm.

Female. Shining, except the upper three-fourths of front, the black of mesonotum and the sternum, which are opaque; the black of abdomen a little shining only. The perpendicular face, which has a very slight impression at the middle and below a hardly noticeable tubercle, yellow, in the middle with a large black sagittate spot, the broadly rounded apex of which rests on the oral margin and its base narrowly connected with the broad black field below the antennæ; this black field extends transversely to the orbit of the eye, separating the yellow of the face from a small yellow somewhat triangular spot situated at the orbit of the eye and opposite the base of antennæ; from the antenniferous process to the middle of the sagittate spot a yellowish line, very narrow above, widening below. Cheeks broadly black with an abbreviated yellow stripe from the inferior orbit of the eye. Front black, broadly connected with the black below the antennæ; a little below the middle two small, narrowly separated, reddish brown, transverse spots; the opaque portion of the front thinly white pollinose, seen in certain lights only and most conspicuously at the orbit of the eye. Vertex reddish brown, behind the ocelli with two yellow dots placed in a transverse line; the vertex and the sides of front below thinly provided with yellowish pile. Occiput black, thinly white pilose and white pollinose, the latter conspicuous along the orbit of the eye only. Antenniferous process very little projecting above, wholly obsolete below, brownish yellow. Antennæ black, the basal two-thirds of the first joint reddish brown; the first joint slender, scarcely longer than the third and its style together or about as long as the front tibiæ; the second joint scarcely more than half as long as the third. Thorax black with inconspicuous, very minute, brownish pubescence on mesonotum; humeral callus, an oblique, oval spot on presutural depression, an elongate spot on mesopleuræ along the mesopleural suture and below it an oval oblique spot on sternopleuræ along the posterior end of the sternopleural suture, yellowish; on each side of mesonotum a reddish brown, from above seen outwardly arched stripe, beginning a little in front of the scutellar ridge and extending to the transverse suture; along the middle of mesonotum in front two parallel, narrow, yellowish pollinose stripes, not quite reaching the anterior border, but each one terminating in a transverse, yellowish pollinose spot on the transverse suture, behind which the stripes are faintly visible; the black ground color is concealed by the pollen of those stripes; sternum very thinly whitish pollinose. Scutellum reddish brown, towards the sides yellowish brown, the extreme base and lateral angles black, the posterior margin narrowly brown. Abdomen above black, much contracted at the base of the second segment, provided with short, appressed yellowish pubescence, that of the sides of the first segment longer, erect and whitish; the ground color is not at all concealed by the pubescence; second segment as long as the third, with a small yellow basal spot on each side; each one of the second and third segments on the posterior margin with a yellow band of equal width throughout and reaching the lateral margin, the band of the second segment a little broader; on the posterior margin of the fourth segment a narrower yellow band with its anterior outline convex and not reaching the lateral margin; on each side of the third and fourth segments a somewhat V or U-shaped, yellowish pollinose mark, concealing the black ground color, both its branches diverging and not reaching the preceding segment, the inner branch of one mark converging with that of the other; fifth segment wholly black, not at all pollinose, the sparse pubescence, mixed yellowish and blackish, in no way concealing the ground color; the ventral segments black, posteriorly margined with pale yellow on the second, third and fourth segments, very narrowly on the fourth. broadest on the second, thinly provided with whitish pubescence. Legs dark reddish brown; coxæ black, brownish at tip; all trochanters, the extreme base of the front and middle femora, the base of the hind ones broadly, the knees, the base of all the tibiæ, broadly on the middle and hind ones, and the two basal joints of the middle tarsi, yellowish; the color at base of tibiæ pale; the third and fourth joints of the front and middle tarsi, and the four distal joints of the hind ones, blackish; basal half of the front femora black; hind side of middle femora fringed with whitish hairs; the distal half of the femora beneath with two rows of minute black spines, most conspicuous on the hind, least on the front ones; hind femora thickened, but not more so in the middle. Halteres and tegulæ yellowish. Wings with the anterior half brown, the posterior one hyaline; the brown is limited posteriorly by the fourth vein at base, and by the spurious vein to very little beyond the anterior crossvein, wherefrom the brown extends with the outline concave to the third vein, narrowly bordering it posteriorly a short distance before the stump of a vein, which it follows exteriorly, thereafter rather broadly bordering the third vein posteriorly with its outline diverging from that vein; the extreme margin of the wing immediately beyond the apex of the third vein is, however, greyish hyaline, not brown; at base of the wing the color is yellowish; the cells in the brown field are somewhat lighter along their middle. The veins are dark brown, at the base of the wing and the portion of the fifth vein between second basal and anal cells yellowish brown; this portion of the fifth vein is anteriorly and posteriorly bordered with yellowish brown, which encroaches upon the extreme base of the third posterior cell; last section of the third vein forms before its middle a very slight angle, wherefrom a short vein projects into the first posterior cell.

Three female specimens captured by the writer at Lawrence, Kansas. Dedicated to my learned friend, the eminent dipterologist, Dr. S. W. Williston, of Kansas State University.

The specimen, from which the description is drawn, was captured on flowers of *Rubus* May 18, 1895. Of the other two, one was captured May 23, 1896, the other May 16, 1897; the former has the brown color of wings more even throughout; on each side of the second abdominal segment at base between the lateral yellow spot and the black dorsal middle the color is dark reddish brown; the latter with the impression of the face more conspicuous; both are more robust, first joint of antennæ blackened at the extreme apex only, scutellum with disk yellow, not reddish or brownish (the yellow ground color may change after death to yellowish or reddish brown); all three specimens belong, however, to the same species.

To *Ceria Willistoni*, n. sp. I refer *Ceria signifera* described by Williston in his Synopsis of N. Amer. Syrphidæ, 1886, p. 262. Williston writes: "One male specimen from Professor Riley's collection (Florida), and three females in the Loew type collection from Texas (Boll), bearing the label 'signifera?' in Loew's writing. I find discrepancies in the original description which make me doubt that this determination is the correct one." The specimens from Texas, included under *C. signifera* Loew in the Catal. N. Amer. Diptera, 1878, p. 139, by Osten Sacken, are also referred to *C. Willistoni* n. sp., as being the same ones that Professor Williston examined in the Loew type collection of the Mus. Comp. Zool., Cambridge, Mass.

Giglio-Tos (Ditteri del Messico, I, p. 32; 1892) writes about the single female (*C. signifera* Loew) before him: "L'esemplare femmina, che ho esaminato, corrisponde bene alle descrizioni minute del Loew e del Williston." Giglio-Tos was not aware, however, of the differences in the respective descriptions of those dipterologists regarding the antennal joints; whether or not his female from Cordova (Mexico) is the *C. signifera* Loew has still to be ascertained.

Professor Johnson in his list "Diptera of Florida" (in the Proc. Acad. Nat. Sc., Philadelphia, 1895,) records "*Ceria signifera* Loew, Inverness, February 12, 14 (Robertson)," but as his record is not accompanied by other notes, it may be doubtful whether his specimens belong to Loew's *signifera*. The occurrence of *C. signifera* Loew in the U. S. has yet to be confirmed.

Ceria signifera Loew (Neue Beiträge I, p. 18, 19; 1853,) and *Ceria Willistoni* n. sp. differ essentially as follows:

Ceria signifera Loew. Female.

Antennæ—"das 2te Fühlerglied fast noch einmal so lang als das 3te," . . .

Scutellum—"Schildchen ganz gelb; sein Rand an den Seiten rostbräunlich."

Abdomen—"5ter Ring gelbbraun, an der Wurzel, auf der Mittellinie und an der Spitze schwarz, überall mit gelber Bestäubung bedeckt, welche die Grundfarbe schwer erkennen lässt."

The brown of the wing—"am dunkelsten in der Nähe der 3ten Längsader, über welche sie nirgends erheblich hinausreicht."

Ceria Willistoni. n. sp. Female.

Second antennal joint scarcely more than half as long as the third.

Scutellum reddish brown or yellow, the base and lateral angles black, the posterior margin narrowly brown.

Fifth abdominal segment wholly black, nowhere pollinose, the sparse pubescence in no way concealing the ground color.

The brown of the wing reaches the spurious vein in the first basal cell and borders the last section of third vein posteriorly rather broadly, except a short distance before the short vein that projects into first posterior cell.

That there is a typographical error in Loew's statements, "Long. corp. 3½" (p. 18, diagn.) for Long. corp. 5½ as suspected by Giglio-Tos and "die 3te Längsader gelblich," etc., (p. 19, below) for die 5te Längsader gelblich, etc., I judge from the fact that Loew, when pointing out the most conspicuous differences between *C. arietis* male and *C. signifera* female (p. 18), mentions neither the striking differences in the proportion between length of body and wing of the two so closely allied species, nor any difference in the color of and about the 5th (that is, "vorletzte") or 3d vein; he does not mention the fifth ("vorletzte") vein in the description of *signifera*, but does in that of *arietis*. If those differences actually existed, he would certainly have paid some attention to them.

It may not be without importance to here point out that Loew in his descriptions of *Ceria arietis* (p. 18) and *Ceria signifera* (p. 19) writes regarding the antennæ, the former "zweites Glied fast noch einmal so lang als das 3te," the latter "das 2te Fühlerglied fast noch einmal so lang als das 3te;" and on p. 18 below he says, that the two would be considered the different sexes of the same species, but there are differences that cannot be considered sexual, and the most conspicuous of those are, "dass bei *Ceria arietis* die 1ste und 2te Längsader einander viel näher liegen und viel paralleler laufen, als bei *Ceria signifera.*"

Finally I will state, that I have used the genus *Ceria* in the sense of Loew in the "Neue Beiträge I." Bigot's (Ann. Soc. Ent. de France, 1883) separation of the genus into two *distinct* genera I consider hastily done. Though *Ceria* Fabr. (1794) is preoccupied by *Ceria* Scop. (1763), which is *Scatopse* Geoffr. (1764), I have hesitated to substitute for the familiar Fabrician genus that of the "unglücklich gebildeten" (Loew, Neue Beiträge, I, p. 5) *Sphiximorpha* Rondani. I believe, however, that Williston's view (Manual N. Am. Dipt., 1896) will be generally accepted. See Osten Sacken "Priorität oder Continuität" (Wien Ent. Zeit. I (1882). Heft. 8.) and Bergroth "Zur Nomenclatur der Dipteren" (Ent. Nachr. Jahrg. XIII (1887), No. 10).

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PLATE XVIII.

With the article "The Permian and Upper Carboniferous."

Plate XVIII. View of a massive stratum four feet thick of the Strong limestone on the eastern side of the Flint Hills to the west of Reece. Along the edge of the stratum are large numbers of loose, rectangular blocks, which have broken off from its edge on account of the more rapid decomposition of the underlying shales and shaly limestones. These blocks are well shown in the picture.

PLATE XIX.

Plate XIX. View of outcrop of Florence limestone on Spring creek, two and a one-fourth miles south of Rock.

KANSAS UNIVERSITY QUARTERLY.

VOL. VI. OCTOBER, 1897. No. 4.

The Permian and Upper Carboniferous of Southern Kansas.[1]

BY CHARLES S. PROSSER.

SYNOPSIS

Introduction.

In the summer of 1896 the writer rapidly reviewed the fossiliferous Permian and Upper Carboniferous formations of southern Kansas as exposed in parts of Greenwood, Butler, Elk, Cowley and Sumner counties. Although the time at the writer's disposal did not permit a sufficiently thorough study of the region to deter-

1 Published by permission of the director of the Univ. Geol. Survey of Kansas.

mine all the stratigraphic details, it is considered that the observations are sufficiently valuable to be worthy of record. To the north of this region the Permian and Upper Carboniferous rocks of central Kansas have been somewhat fully described by the writer,[1] as well as those along the southern border of the state, from the western part of Cowley county westward.[2] The Upper Carboniferous formations under consideration—the Wabaunsee and Cottonwood—form the upper part of the Missourian series of Keyes; while the Neosho, Chase and Marion comprise all the Permian formations of Kansas in which fossils have been found in that state. For these three Permian formations and the overlying Wellington shales Prof. Cragin has proposed the name Big Blue series from the Big Blue river, in northern Kansas and southern Nebraska.[3] In southern Kansas, succeeding the Wellington shales, is a mass of red sandstones and shales, with a prominent gypsum deposit in the upper part, which is known as the Red-beds, or Cimarron series. These rocks have been recently quite fully described by Prof. Cragin[4] and the writer;[5] but there is uncertainty as to their age. Prof. Cragin in his work correlated the series with the Texas Permian, and this correlation was accepted provisionally by the writer in the Kansas report. In that report a full review of the various published opinions in regard to the age of the Cimarron series was given, but since it was written three papers have been published referring to this question, which may be noticed in this connection. Dr. Williston says: "That these red-beds are not contemporaneous with the Texas Permian would seem assured, and I feel yet more confident that they are, what they were first considered to be, of Triassic age."[6]

In another publication Dr. Williston virtually expresses the same opinion when he says: "I believe yet more strongly, what I always have believed, that the red-beds of Kansas are Triassic in age."[7] It is quite true that their general lithologic appearance is certainly very similar to that of the Triassic rocks in other parts of the United States.

Prof. Grimsley, who has carefully studied the Kansas gypsum deposits, says that the Red-beds "probably mark the transition from Permian to Cretaceous."[8]

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1 Bull. Geol. Soc. Amer., vol. vi, 1894, p. 29. Jour. Geol., vol. iii, 1895, pp. 682, 764. Univ. Geol. Surv. Kan., vol. ii, 1897, p. 58.
2 Univ. Geol. Surv. Kan., vol. ii, p. 64. etc.
3 Col. Coll. Studies, vol. vi, 1896, pp. 3, 5.
4 Col. Coll. Stuies, vol. vi, p. 18.
5 Univ. Geol. Surv. Kan., vol. ii, p. 75.
6 Science, N. S., vol. v, March 5, 1897, p. 395.
7 Kan. Univ. Quar., vol vi, Jan., 1897, Ser. A., p. 56.
8 Bull. Geol. Soc. Amer., vol. viii, March, 1897, p. 236. Kan. Univ. Quar., vol. vi, Jan., 1897, Ser. A, p. 17, for the same statement.

Finally, Mr. Vaughan, of the U. S. Geological Survey, who is studying the Upper Paleozoic and Cretaceous rocks of Oklahoma and Indian Territories and southern Kansas, under the direction of Prof. Robert T. Hill, speaks of the Red-beds as "Permotrias," and states that "no definite line could be drawn between the Carboniferous and the Permian, or between the Permian and the Trias,"[1] in that region.

Mr. C. N. Gould writes me under recent date that he found, in a soft red sandstone not more than 100 feet above the base of the Red-beds or Cimarron series, eight miles west and three miles south of Blackwell, Oklahoma, or about sixteen miles south of Hunnewell, Sumner county, Kansas, a number of invertebrate shells. Mr. Gould states that the lower line of the Red-beds swings around farther to the east in the territory than it does in Kansas.

In this paper no further attention will be given to the rocks above the Marion formation; and if the reader be interested in the higher formations he is referred to the papers already mentioned for fuller details.

Greenwood and Butler Counties.

While engaged in mapping the Cottonwood Falls sheet the Permian formations were followed into the northern part of Butler county, where they were not well exposed on the high prairie which forms the divide between the Cottonwood river valley on the north and the head waters of the Walnut and Whitewater rivers on the south. Consequently a section was sought that would show the stratigraphic details of these formations, and the line of the Missouri Pacific railroad, from Eureka to El Dorado, crossing the prominent ridge of the Flint Hills along the Greenwood–Butler county line[2] seemed to offer such a section, and this was studied. A paper giving a somewhat general account of the geology of this section was published in 1890 by Prof. L. C. Wooster.[3]

The writer was anxious in the first place to find the Cottonwood limestone, which, in his previous work, had been traced into the eastern part of Chase county, some thirty-five miles north of this section, and then to study the overlying Permian formations. It was estimated that the horizon of the Cottonwood limestone would be found somewhere in the vicinity of Reece, Greenwood county,

1 Paper read before the Geol. Soc Washington, March 10, 1897, and reported by W. F. Morsell in Science N. S., vol. v, April 2, 1897, p. 559.

2 A clear idea of this ridge in southern Kansas may be obtained from a "Contour map of southeastern Kansas showing the Flint Hills," by Geo. I. Adams, in Univ. Geol. Surv. Kan., vol. i, pl. ix.

3 Amer. Geol., vol. vi, p. 9, under the title of "The Permo-Carboniferous of Greenwood and Butler Counties, Kansas."

consequently a careful examination of the rocks was begun near this town, nine miles south of west of Eureka. This village is situated on the northern side of the Spring creek valley on the Missouri Pacific railroad, 137 feet above Eureka, to the west of which is the fairly steep eastern slope of the Flint Hills, affording natural exposures of the rocks and in addition the railroad cuts furnish several excellent sections, especially toward the crest of the ridge.

SECTION ALONG THE MISSOURI PACIFIC RAILROAD FROM REECE TO THE CREST OF THE FLINT HILLS.

Crest of Flint Hills on Missouri Pacific railroad:

No.		Feet.
15.	Massive light gray limestone and flint or chert.[1] This forms a conspicuous stratum near the eastern crest of the hills, as shown in the picture. Well exposed in the railroad cut at the eastern crest of the hills.	10=390[2]
14.	Bluish and yellowish shaly limestones with abundant fossils. Lower part maroon, bluish and yellowish calcareous shales.	29=380
13.	Massive stratum of light gray limestone, containing a large amount of flint in layers. (Nos. 13, 14, and 15 are Strong flint.)	11=351
12.	Upper part yellowish shales, containing abundant specimens of *Derbya;* top of the *Neosho* formation. Greater part maroon, calcareous shales, well exposed in the lower part of the railroad cut west of the trestle, where they are capped by the lower part of the flint.	65=340
11.	Grayish to yellowish shaly limestones, in railroad cut 2000 feet east of the trestle, containing *Pseudomonotis.* Lower part of this zone covered.	25=275
10.	Rough, jagged limestone, containing iron concretions 2 to 2½ feet thick.	2=250
9.	Covered	38=248
8.	Massive limestone that weathers to a rough, jagged rock, 4 to 5 feet thick.	5=210
7.	Covered	20=205
6.	Shaly limestones and yellowish shales in railroad cut, about one-half the distance from Reece to the trestle. Lower part of zone covered.	35=185

1 The name "flint" has been so universally used for the silicious deposits of the Kansas Permian that it seems better to use it here rather than the more precise term chert.

2 Prof. Wooster gave the dip as 20 feet per mile to the west, along the line of this railroad (*Op. cit.*, p. 10), and if this estimate be correct it will add 100 feet or more to the thickness of the rocks in the above section. In a letter Prof. Wooster states that the average dip at Eureka is about 12 feet per mile to the southwest.

No.		Feet.
5.	Bluish, shaly limestone at top, containing *Aviculopecten.* The greater part of the zone covered.	50=150
4.	Massive limestone, containing flint and abundant specimens of *Fusulina,* 3 inches in thickness.	3=100
3.	Yellowish shales and thin limestones, containing *Spirifer cameratus.*	10±97[1]
2.	Massive limestone, containing abundant specimens of *Fusulina,* about 2 feet thick. Nos. 2 to 4 exposed in the railroad cut 1½ miles west of Reece.	2=87
1.	Mostly covered, but just west of Reece are thin, shaly limestones, which weather to a brownish red color.	85=85

Reece railroad station.

CORRELATION AND PALEONTOLOGY.— Nos. 13, 14, and 15, of the above section, which are well shown in the three railroad cuts between the trestle and the summit, the western one being about one-half mile east of Summit station, are correlated with the Strong flint which forms the lower part of the Chase formation. The similarity of these zones to those of the Strong flint is very marked when this part of the section is compared with a complete one of the Strong flint as exposed in the Cottonwood or Neosho valleys to the north. In the section near Council Grove the lower layer of limestone and flint has a thickness of seven and a half feet, then there are twenty-one and a half feet of light gray limestones and rather coarse yellowish shales, in the upper part of which are abundant fossils; above these is a heavy limestone containing an abundance of coarse flint, ten feet in thickness, which is capped by a massive gray limestone three feet thick.[2] This gives a thickness of forty-two feet for the Strong limestones and flint near Council Grove, while in the Reece section the thickness is fifty feet. In places the upper layer of flinty limestone contains only a small quantity of flint and constitutes a massive ledge of light gray limestone. This stratum frequently forms a prominent outcrop near

1 At the time of my visit these shales were hastily measured; but since then Prof. Wooster has sent me a section of the cut in which the thickness for the shaly zone foots up 17 feet. The section is as follows:

No.		Ft.	In.
10.	Buff limestone, four layers; a few fossils, mostly *Fusulina*	3	
9.	Buff shale	5	
8.	Carbonaceous shale	2	
7.	Buff, shaly limestone; fossils	1	6
6.	Blue shale, full of fossils	8	4
5	Buff limestone, one layer	1	9
4.	Buff calcareous shale		9
3.	Buff *Fusulina* limestone	1	8
2.	Dark shale, buff on weathered surface; no fossils	3	
1.	Buff limestone, top layer is blue and full of *Fusulina*	2	

In this section Nos. 1 and 10 correspond to Nos. 2 and 4 of my section, while Nos. 2 to 9 are included in my No. 3.

2 Jour. Geol., vol. iii, p. 773.

the crest of the Flint Hills, as is shown in the picture of the massive ledge four feet thick south of the railroad at the western cut. The upper part of the shaly limestones—No. 14—are of bluish and yellowish color and contain great numbers of fossils, as does the similar zone described on Elm creek west of Council Grove,[1] and in the railroad cut east of Grand Summit, Cowley county. The upper layer of the limestone and flint with the fossiliferous zone of the shaly limestones is nicely shown in the western railroad cut, about a half mile east of Summit station; the base of the lower limestone and flint in the cut immediately west of the trestle, and the middle part of the sub-formation in the intervening cuts.

In the railroad cut, just west of the trestle, the upper part of the Neosho formation is admirably shown, the top of the cut being in the base of the Strong flint. The upper part of the Neosho is composed of a zone of yellowish shales containing specimens of *Derbya*, which are apparently nearer *D. multistriata* (M. and H.) Pros. than *D. crassa* (M. and H.) H. and C., and a few other species similar to the zone of yellowish shales exposed at the top of the Neosho formation on the Crusher Hill west of Strong City.[2]

In the railroad cut 2,000 feet east of the trestle are grayish to yellowish shaly limestones—No. 11—in which specimens of *Pseudomonotis Hawni* (M. and H.) are common. The following species were collected in this cut:

1. *Productus nebrascensis*, Owen .... (c)
   Part of the specimens have larger and longer spines than is generally the case for this species. Possibly not larger than on fig. 3, b. and c., pl. XXVII, Pt. II, Pal. Missouri.
2. *Pseudomonotis Hawni* (M and H.) .... (c)
3. *Aviculopecten occidentalis* (Shum.) M. and W. .... (c)
4. *Spirorbis* sp .... (c)
   This zone is probably near the middle of the Neosho formation.

East of this cut the greater part of the surface is covered by soil, and most of the railroad cuts are shallow so that the base of the Neosho formation was not accurately determined. Again, apparently, the Cottonwood limestone which forms such striking massive outcrops to the north, in Chase and Lyon counties, has lost its massive structure and does not form conspicuous outcrops in the western central part of Greenwood county.

1 Ibid., p. 774.
2 Ibid., p 767, No. 16.

The massive limestone of No. 8, which weathers to a rough, jagged rock, is somewhat similar to a stratum twenty-six feet above the base of the Neosho formation in the Cottonwood valley,[1] and it is referred to the Neosho formation. It seems probable that the base of the Neosho formation is either in No. 7 or 6, and the horizon of the Cottonwood limestone is also either in No. 7 or 6 of the Reece section. This would agree fairly well with the Cottonwood river section, where the Neosho formation has a thickness of 130 feet and it is 144 feet from the top of the Cottonwood limestone to the base of the Strong flint.

If the above correlation be correct then the massive limestones forming Nos. 2 and 4 of the Reece section are in the Wabaunsee formation, possibly ninety feet or more below its top. The thickness of the rocks between the top of No. 4 and the supposed horizon of the Cottonwood limestone in this section agrees quite closely with the upper part of the Wabaunsee formation as exposed in the bluff of the Cottonwood river east of Elmdale. The Elmdale section is as follows:

No.		Feet.
6.	Cottonwood limestone, light gray, containing large numbers of *Fusulina*, near top of bluff.	
5.	Mostly covered..................................	30=165
4.	A ledge of conspicuous limestone which weathers to a very rough surface. "Dry bone limestone" of Swallow.	5=135
3.	Partly covered	60=130
2.	A buff to light gray limestone containing *Fusulina*, from 3½ to 4 feet thick. At the base greenish shales containing fossils in fair abundance as, *Spirifer cameratus* Mort , *Athyris subtilita* (Hall) Newb., *Chonetes granulifera* Owen, *Productus semireticulatus* (Martin) de Koninck and others.	4=70
1.	Mostly covered to level of the Cottonwood river....	66–66

Another reason for referring the limestones of Nos. 2 and 4 of the Reece section to the Wabaunsee formation is the occurrence of *Spirifer cameratus* Mort. in the shales between them, which species has not been found above the Cottonwood limestone in the region where it is well shown. From the shales of No. 3 the following species were obtained:

1. *Productus cora* d'Orbigny.............................. (a)
2. *Productus semireticulatus* (Martin) de Kon.............. (r)

[1] Ibid., p. 765, No 8.

3. *Productus nebrascensis* Owen .... (rr)
4. *Productus longispinus* Sowb .... (rr)
5. *Spirifer cameratus* Mort. .... (c)
6. *Spirifer* (*Martinia*) *planoconvexus* Shum .... (r)
7. *Derbya crassa* (M. and H.) H. and C. .... (c)
8. *Athyris* (*Seminula*) *subtilita* (Hall) Newb .... (rr)
9. *Hustedia mormonii* (Marcou) H. and C. .... (rr)
10. *Chonetes granulifera* Owen .... (rr)
11. *Meekella striato-costata* (Cox) White and St. John .... (c)
12. *Fusulina cylindrica* Fisher .... (a)
13. *Septopora biserialis* (Swallow) Waagen .... (rr)

In addition to the above list Prof. Wooster has identified the following species from this cut:

Aviculopecten occidentalis (Shum.) Meek and Worth.
Rhynchonella uta (Marcou) Meek.
Spiriferina Kentuckensis Shum.
Dielasma bovidens (Morton) H. and C.
Bellerophon carbonarius Cox.
Pseudomonotis Hawni (M. and H.) var, *sinuata* M. and W.
Phillipsia sp.
Archæocidaris sp.
Eocidaris sp.

The bluish shaly limestone of No. 5 contains fossils, *Aviculopecten occidentalis* (Shum.) Meek and Worth, *Myalina* sp. and a few other species having been noticed. From this cut Prof. Wooster reports exfoliated specimens of *Spirifer* sp.

SECTION ALONG THE WHITEWATER AND WALNUT RIVERS FROM TOWANDA TO WINFIELD.

There is a decrease in altitude of about 325 feet in the sixteen miles from the Summit to El Dorado in the Walnut river valley; but the country is comparatively smooth with but few exposures of rocks. From Towanda, eight miles south of west of El Dorado, in the Whitewater valley, a section was followed in the direction of the strike along the valleys of the Whitewater and Walnut rivers to Winfield, Cowley county. Four miles northwest of Towanda, on the south bank of the West Whitewater river, west side section I, Benton township, is the following section:

No.		Feet.
3.	Yellowish shales, which are 40 feet above river level	1=12
2.	Buff limestone containing gypsum concretions, some flint and specimens of *Bakevellia parva* M. and H.	1=11
1.	Yellowish argillaceous shales in the upper part and shaly limestones at the base.	10=10

The section just described, as well as the rocks between the two Whitewater rivers and to the west of Towanda and the main Whitewater river, belong in the Marion formation. On the eastern side of the river, in the vicinity of Towanda, are occasional exposures of buff limestone, but no fossils were found.

On the divide between the Whitewater and Walnut rivers, four miles north of Augusta and one-half mile west, is a small quarry in a buff, massive limestone, nine feet of which is exposed. It contains a layer of flint one inch in thickness and some fossils as: *Athyris subtilita* (Hall) Newb., *Productus semireticulatus* (Mart.) de Koninck, *Pleurotomaria* sp., *Archæocidaris* sp., and crinoid segments. The dip is southerly, and this zone seems to belong in that of the Winfield limestone.[1]

On the south bank of the Walnut river, at the highway bridge south of Augusta, is an excellent exposure of the Florence flint and limestone. The section is as follows:

No.		Feet.	
4.	Shaly buff limestones, fossiliferous...............		
3.	Argillaceous shales..........................		
2.	Massive, buff limestone, thick bedding, and 13 feet thick in the quarry east of the highway.	35	50
1.	Thin layers of flint, alternating with thin limestones which are somewhat fossiliferous.	15	15

River level.

From this outcrop the following species were collected:

1. *Athyris* (*Seminula*) *subtilita* (Hall) Newb............. (r)
2. *Derbya multistriata* (M. and H.) Pros............... (r)
3. *Meekella* (?) *Shumardiana* (Swal.)(?)................. (rr)
4. *Productus semireticulatus* (Mart.) de Kon., var. *Calhounianus* Swal. (c)
5. *Productus semireticulatus* (Mart.) de Kon.............. (rr)
6. *Pinna peracuta* Shum.............................. (rr)
7. *Aviculopecten occidentalis* (Shum.) Meek............... (rr)
8. (?) *Allorisma* sp.................................. (rr)
   Poorly preserved.
9. *Bellerophon* sp.................................. (r)
   Imperfectly preserved.
10. *Campophyllum* sp................................ (a)
11. *Chætetes* sp.................................... (r)
12. *Archæocidaris* spines.

For the purpose of assistance in correlation and in tracing the various limestones across the state it is important to remember that

[1] For the definition of this name see Univ. Geol. Surv. Kans., vol. II, p. 61.

the Florence limestone, so well exposed on the Cottonwood river at the city of that name, is the same as the Fort Riley limestone on the Kansas river at Fort Riley and Junction City.

On the bank of the Little Walnut creek, two miles northeast of Douglass, are shaly buff limestones, apparently in the Florence, which contain the following fossils:

1. *Athyris (Seminula) subtilita* (Hall) Newb. . . . . (c)
2. *Derbya crassa* (M. and H.) H. and C. . . . . (r)
3. *Derbya multistriata* (M. and H.) Pros. . . . . (c)
4. *Aviculopecten occidentalis* (Shum.) M. and W. . . . . (rr)
5. *Septopora biserialis* (Swallow) Waagen . . . . (rr)
6. *Phillipsia major* Shumard. . . . . (rr)

From Douglass along the valley of the Walnut river to Winfield there are frequent outcrops of the Florence limestone, and near the summit of the bluffs the Winfield limestone. In a railroad cut, two and one-half miles south of Douglass, is a good exposure of the Winfield limestone and forty feet of lower shales. There are numerous small rolls shown in the cut, both anticlinal and synclinal. The section is:

No.		Feet	
3.	Massive limestone which weathers rather rough and contains some fossils. No concretions at this locality. *Winfield* limestone.	11	51
2.	Yellowish argillaceous shales	20	40
1.	Variously colored argillaceous shales, greenish, maroon, yellowish, etc. Some of the maroon layers 2 feet thick. No fossils found in the shales. Railroad level.	20	20

These colored shales below the Winfield limestone correspond to similar shales described by the author in the Cottonwood valley below the Marion limestone, as the Winfield limestone was first called.[1] The Winfield limestone above the railroad cut, at this locality, contains the following species:

1. *Productus semireticulatus* (Martin) de Kon. . . . . (rr)
2. *Derbya crassa* (M. and H.) H. and C. . . . . (c)
   Some of the specimens are near *D. multistriata* (M. and H.) Pros.
3. *Schizodus Wheeleri* (Swallow) Meek.(?) . . . . (rr)
4. *Archæocidaris* sp. . . . . (rr)
   Spines and plates.

In a small run on the south side of Rock creek, six miles south

1 Jour. Geol., vol. III, p. 773.

of Douglass and one mile south of Rock, is a ledge of massive, soft buff limestone, four feet of which is shown. This stratum is only three or four feet above the level of Rock creek, and by the barometer seventy feet below the Winfield limestone on the bluff to the north, and is in the Florence sub-formation; the difference of seventy feet between the two limestones being about the average thickness for the intervening shales.

About one and one-fourth miles farther south, on Spring creek, at the W. H. Grove farm, is an outcrop of ten feet of the Florence buff, massive limestone. The ledge shows plenty of "sand holes" and fragments of fossils.

Around the head of a draw on the highway, five miles north of Winfield, is an excellent outcrop of the Winfield concretionary limestone. It is a typical ledge, for it contains abundant concretions; but they are not of constant occurrence as may be readily seen by following the outcrop of this limestone from Douglass to Winfield. The limestone is coarse and rough, weathering in large, angular, whitish blocks. Below are yellowish and colored argillaceous shales; while in the upper part of the limestone, and in great numbers loose on the ground, are large iron-stained concretions containing fossils. These are known locally as "sand bricks," and they are flatter than those to the north in the Cottonwood valley, which are oblong or rounded. From this concretionary limestone the following species were collected:

1. *Productus semireticulatus* (Mart.) de Kon................ (rr)
2. *Rhombopora lepidodendroides* Meek...................... (rr)
3. *Septopora biserialis* (Swallow) Waagen................. (rr)
4. *Chætetes* sp.. (rr)

A little higher on the highway may be seen plenty of loose flint, probably from the decomposition of limestone at that locality.

As nearly as can be determined from the topographic sheets and other data at command there is a dip of one hundred feet in the Florence limestone from the quarry on the Walnut river south of Augusta to the one in the eastern part of Winfield. The distance between the two localities is twenty-eight miles, which would give a south dip of about three and a half feet per mile.

Elk and Cowley Counties.

To the south of Greenwood and Butler counties are Elk and Cowley counties, Cowley extending south to the state line while to the east of its southern half and south of Elk is Chautauqua county. The eastern half of Cowley and the western part of Chautauqua and Elk counties are in the Flint Hills, the crest of which is near the Cowley-Chautauqua and Elk county line.

For the purpose of studying the stratigraphy of the southern Flint Hills and determining their geological formations, two sections were followed from the east across them. The northern section is along the line of the Atchison, Topeka & Santa Fe railroad from Moline, Elk county, through Grenola, Grand Summit and Cambridge to Grouse creek, Cowley county. The southern one is along the Missouri Pacific railroad from the vicinity of Cedar Vale, Chautauqua county, through Hooser, Dexter and Eaton to Winfield, Cowley county.

SECTION FROM GRENOLA TO GRAND SUMMIT.

The Grand Summit section is, perhaps, the best known Permian section of southern Kansas. This is due in part to the abundant fossils found in the railroad cut east of Grand Summit station. A section of the eastern side of the Flint Hills, in this region, was described by Prof. Broadhead in 1882,[1] and the writer's attention was first directed to the locality by the fine collection of Permian and Carboniferous fossils from it in the Geological Museum in the University of Kansas. Mr. Geo. I. Adams has also described in a somewhat general way the section along the line of this railroad through Moline, Grenola and Cambridge to Winfield.[2]

In the northern part of Moline, on the bank of the Wild Cat creek, are iron-brown shaly limestones containing large numbers of *Fusulina cylindrica* Fischer and other fossils. On the hill to the northwest of the city is quite a thickness of drab to buff sandy shales, that contain but few fossils. These are capped by a thin, brownish to yellowish limestone. The rocks in the vicinity of Moline probably belong in the Wabaunsee formation.

Grenola is situated in the valley of Big Caney creek, Greenfield township, in the western part of Elk county. The railroad cut, immediately east of Grand Summit station, is five miles north of west from the bluish shales on the bank of the Big Caney creek just west of Grenola which form the base of the following section from the creek to the cut east of Grand Summit:

No.		Feet.
28.	Top of railroad cut, east of Grand Summit, yellowish to bluish shales and shaly limestones in which fossils are very abundant. An excellent locality for collecting.	15=407

1 Trans. St. Louis Acad Science, vol. iv, pt. iii, published in 1883 or '84, pp. 486, 487.
2 Univ. Geol. Surv. Kans., vol. i, pp. 26-29, and pl. i.

No.		Feet.	
27.	Massive, light gray limestone, which forms a conspicuous bench on the hillside. Lower part of the *Strong* limestone.	10	=392
26.	Rather coarse, yellowish shales, about 15 feet.......	15	382
25.	Fine argillaceous maroon shales at top, and lower variously colored shales.	30	367
24.	Rather shaly limestone, which, in places, is very hard, 3 to 4 feet thick.	4	337
23.	Shales alternating with thin limestones; at base maroon shale.	26	=333
22.	Heavy limestone at top, below shaly limestone and shales. One layer contains plenty of fossils.	20	=307
	(Nos. 22 to 28=No. 1 of Broadhead, which, in his section, is 134 feet thick.)		
21.	Limestone of bluish-drab color....................	5	=287
	(No. 2 of Breadhead's section, which he gave as 5 feet thick.)		
20.	Shales, lower part bright maroon color.............	10	=282
	(No. 3 of Broadhead.)		
19.	Limestone, 10 feet thick, according to Broadhead and No. 4 of his section.	10	=272
18.	Shales to shaly limestones containing fossils........	25	=262
17.	Light buff-colored *Fusulina* limestone, with layer of flint.	$1\frac{1}{2}$	237
	(Nos. 17 and 18=No. 5 of Broadhead, which he gave as 27 feet of shales with thin shaly limestone beds.)		
16.	Somewhat shaly *Fusulina* limestone. (No. 6 of Broadhead, which he called "a flag-like limestone bed; a good building rock.") Perhaps Nos. 16 and 17 represent the *Cottonwood* limestone.	4	$235\frac{1}{2}$
15.	Yellowish shales; *Fusulinas* very thick in top of shales.	5	$=231\frac{1}{2}$
14.	Drab. Very hard limestone.....................	$1\frac{3}{4}$	$=226\frac{1}{2}$
	(Nos. 14 and 15, with probably the top of No. 13=No. 7 of Broadhead, which he gave as 8 feet shelly buff limestone.)		
13.	Yellowish soft shales; *Spirifer cameratus* and numerous other fossils.	5	$224\frac{3}{4}$
	(No. 8 of Broadhead.)		
12.	Massive limestone with abundant *Fusulina*, and six inch layer of flint at top and bottom.	2	$219\frac{3}{4}$
11.	*Fusulina* light gray limestone.....................	$1\frac{3}{4}$	$217\frac{3}{4}$
	(Nos. 11 and 12=No. 9 of Broadhead.)		

No.		Feet.
10.	Yellowish shales, *Spirifer cameratus*, *Fusulina* and plenty of fossils.	$1\frac{3}{4} = 216$
9.	Light gray, massive *Fusulina* limestone, with layer of flint at top.	$1\frac{3}{4} = 214\frac{1}{4}$
8.	Yellowish fossiliferous shaly limestone, $2\frac{1}{2}$ to 3 feet.	$3 = 212\frac{1}{2}$
7.	Shales and shaly limestone........................	$2\frac{1}{2}$ $209\frac{1}{2}$
6.	Covered, 10 to 11 feet...........................	10 207
	(Nos. 6 to 11 = No. 10 of Broadhead.)	
5.	Massive, drab limestone..........................	2 197
	(No. 11 of Broadhead, and base of his Permian.)	
4.	Covered, except at base, where it is a cellular, shaly, yellow limestone, in front of O'Connell's house.	25 = 195
	(The limestone = No. 13 of Broadhead, which he gives as 4 feet thick and capped by 28 feet of shaly sandstone.)	
3.	Arenaceous yellowish shales in upper part; yellowish iron-stained limestone alternating with drab shales in lower part; in first railroad cut west of Grenola. *Spirifer cameratus.*	15 = 170
	(No. 14 of Broadhead, which he referred to the "true Upper Coal Measures.")	
2.	Covered, with shaly bluish limestone and shales in lower part; at first large railroad fill west of Grenola.	55 = 155
	(Probably Nos. 15 to 18 of Broadhead, which he gave as 52 feet in thickness.)	
1.	Covered. Bluish shales at base containing *Spirifer cameratus* and other fossils; on the western bank of Big Caney creek. (No. 19 of Broadhead; 20 feet of sandy shales in the upper part of this zone.)	100 = 100

Level of Big Caney creek, at highway bridge west of Grenola.

The thickness of this section agrees closely with the difference in altitude obtained from the Atchison, Topeka & Santa Fe railroad levels, which give 400 feet, although the topographic sheets give barely 300 feet. No allowance has been made for the dip, which will probably increase somewhat the total thickness of the rocks in this section, since Prof. Broadhead obtained a dip of twenty-six feet per mile to the southwest in the eastern part of Cowley county,[1] while Adams gave the dip along the line of this section as "about ten feet per mile" to the west,[2] and as stated later, the writer obtained a dip to the southwest of sixteen feet per mile.

1 Ibid., p. 488.
2 Op. cit., p. 28

CORRELATION AND PALEONTOLOGY.—For the purpose of classification it is more convenient to begin with the upper part of this section, which is readily correlated. The massive limestone—No. 27—in the railroad cut east of Grand Summit, forms the lower part of the Strong limestone at the base of the Chase formation. Above the limestone are the yellowish and bluish shales—No. 28—which contain abundant fossils. Here the larger number of fossils have been collected that are credited to Grand Summit, Cowley county. These shales correspond to the fossiliferous shales—No. 14—of the section west of Reece. The most abundant species are *Productus nebrascensis* Owen, many very perfect and beautiful specimens of which occur in great numbers; *Meekella striato-costata* (Cox) White and St. John; *Myalina Kansasensis* Shum.; and *M. Swallovi* McChesney. The following is the complete list collected in about one hour:

1. *Productus nebrascensis* Owen .... (aa)
2. *Productus semireticulatus* (Mart.) de Kon .... (r)
3. *Derbya multistriata* (M. and H.) Pros .... (rr)
4. *Derbya crassa* (M. and H.) H. and C .... (rr)
5. *Meekella striato-costata* (Cox) White and St. John .... (a)
6. *Athyris* (*Seminula*) *subtilita* (Hall) Newb ....
7. *Myalina Kansasensis* Shum .... (a)
8. *Myalina perattenuata* M. and H .... (rr)
9. *Myalina*(?) *Swallovi* McChesney .... (a)
10. *Gervillia longa* Geinitz .... (rr)
11. *Aviculopecten occidentalis* (Shum.) M. and W .... (r)
12. *Aviculopecten* sp.

    Small specimens, apparently adult, with some smaller plications between the coarser.
13. *Pinna peracuta* Shum .... (c)

    Part of the specimens are unusually large and possibly belong to a different species.
14. *Pseudomonotis Hawni* M. and H .... (rr)

    Small specimens.
15. *Aviculopecten* cf. *neglectus* (Geinitz) Meek .... (rr)
16. *Aviculopecten neglectus* (Geinitz) Meek .... (rr)
17. *Allorisma* sp .... (rr)
18. *Schizodus* sp .... (a)

    Large form, in outline somewhat like *S. curtus* M. and W.
19. *Schizodus Wheeleri* (Swal.) Meek .... (rr)
20. *Schizodus curtus* M. and W .... (r)

21. *Straparollus* (*Euomphalus*) *subrugosus* M. and W. . . . . (rr)
22. (?)*Nuculana bellistriata* Stevens, var. *attenuata* Meek. . . . (rr)
Very imperfectly preserved.
23. *Discina nitida* (Phillips) M. and W. (?) . . . . (rr)
24. *Discina* cf. *convexa* Shum. . . . . (rr)
25. *Bellerophon* sp . . . . (rr)
Imperfectly preserved.
26. *Aclis* cf. *Swalloviana* (Geinitz) Meek . . . . (c)
27. *Rhombopora lepidodendroides* Meek. (?) . . . . (rr)
28. *Archæocidaris* spines . . . . (c)
29. *Bryozoa* sp . . . . (r)
30. *Septopora biserialis* (Swallow) Waagen . . . . (r)
31. *Entolium aviculatum* (Swal.) Meek. (?) . . . . (rr)
32. *Orthoceras* cf. *rushensis* McChes. . . . . (rr)
33. *Crinoid* segments. . . . . (r)
34. *Macrodon* cf. *obsoletus* Meek . . . . (rr)

The yellowish shales—No. 26—at the bottom of the massive limestone are referred to the Neosho formation, which, in the Cottonwood valley, has a zone of similar shales at its top.[1] The base of the Neosho formation, however, is not determined as easily, since the position of the Cottonwood limestone is somewhat in doubt. Ninety-five feet below the base of the Strong limestone is the top of the bluish drab limestone—No. 21 of this section and No. 2 of Broadhead's—which he described as "persistent wherever its associated strata are found," and "containing many good characteristic fossils, including *Eumicrotis* [*Pseudomonotis*] *Hawni*, *Myalina perattenuata*, *Aviculopecten occidentalis*, *etc.*" A similar limestone and fauna are in the Neosho formation in the Cottonwood valley 94 feet below the base of the Strong limestone, and a lower one 110 feet below it, so it seems probable that No. 21 is in the Neosho formation. In the Cottonwood and Kansas valleys it is 144 feet from the bottom of the Strong limestone to the top of the Cottonwood limestone. In the Grand Summit section, without a complete allowance for dip, it is 145 feet from the bottom of the Strong limestone—No. 27—to the top of No. 17, the light buff colored Fusulina limestone. In the railroad cut this limestone does not resemble the Cottonwood limestone in texture, for it consists of a layer one and a half feet thick at the top, with a shaly Fusulina limestone four feet thick at the base; but there is an agreement in color and the great abundance of Fusulinas. When this zone was first studied it was referred to the horizon of the Cot-

[1] Jour. Geol., vol. III, p. 765. No. 16 of the section.

tonwood limestone, although it does not closely resemble it as shown in its typical region, and furthermore the underlying rocks do not agree with those below the Cottonwood limestone in the Cottonwood valley. However, after a consideration of all the data at hand, it appears to correspond more nearly with the Cottonwood than with any of the other limestones in that part of this section where we may expect to find its horizon. The limestone is light gray to whitish in color, unless stained, and contains myriads of Fusulina with a few fragments of shells. The flint is more abundant than in the Cottonwood limestone farther north, and in this are abundant specimens of Fusulina.

The shales and shaly limestones—No. 18—overlying this limestone are somewhat fossiliferous, the following species having been obtained:

1. *Productus cora* d'Orbigny............................ (c)
2. *Productus nebrascensis* Owen........................ (rr)
3. *Allorisma subcuneatum* M. and H.................... (rr)
4. *Aviculopecten occidentalis* (Shum.) M. and W........... (rr)

These shales do not agree in reference to the fauna with the yellowish, very fossiliferous shales which overlie the Cottonwood limestone in the central and northern parts of Kansas. Perhaps they represent the Cottonwood shales and with the subjacent limestone constitute the Cottonwood formation which will then have a thickness of 30½ feet in this section.

If the correlation of Nos. 16 and 17 of the above section, with the Cottonwood limestone, be correct, then the remaining 231 feet of the section commencing with No. 15 belong in the Wabaunsee formation. Nos. 12 and 9 are massive, light gray limestones, which also contain large numbers of Fusulina and great quantities of flint, especially No. 12 in which there is a conspicuous six inch layer of flint at the top and bottom of the stratum. In fact these limestones contain the greatest amount of flint seen in any part of the section, for in the Strong limestone or flint but a comparatively small amount of flint was seen.

The yellowish shales alternating with these Fusulina limestones contain plenty of fossils, *Spirifer cameratus* Mort. occurring frequently in them; but it was not noticed above the limestone which is referred to the Cottonwood. The shales of No. 13 furnished the following species:

1. *Spirifer cameratus* Mort............................ (r)
2. *Spirifer* (*Martinia*) *planoconvexus* Shum............... (r)
3. *Athyris* (*Seminula*) *subtilita* (Hall) Newb.............. (r)

4. *Productus cora* d'Orbigny .... (r)
5. *Derbya robusta* (Hall) H. and C.(?) .... (rr)
Similar to fig. 17, pl. X, Pal. N. Y., Vol. VIII, Pt. II.
6. *Derbya crassa* (M. and H.) H. and C. .... (rr)
7. *Septopora biserialis* (Swallow) Waagen .... (c)
8. *Meekella striato-costata* (Cox) White and St. John ...... (rr)
9. *Rhombopora lepidodendroides* Meek .... (rr)
10. *Fistulipora nodulifera* Meek .... (rr)
A flat specimen which apparently belongs to this species.
11. *Crinoid* segments .... (c)

In No. 10 the seven species of the succeeding list were obtained:

1. *Spirifer cameratus* Morton .... (c)
2. *Athyris* (*Seminula*) *subtilita* (Hall) Newb. .... (rr)
3. *Productus cora* d'Orbigny .... (rr)
4. *Chonetes granulifera* Owen .... (c)
5. *Fusulina cylindrica* Fischer ....
Abundant in layers.
6. (?)*Fistulipora nodulifera* Meek .... (rr)
7. *Meekopora Prosseri* Ulrich .... (c)
Identified by Ulrich and described in MS.

From the bluish shales at the base of No. 1, on the bank of Big Caney creek, the following species were collected after a hasty search:

1. *Spirifer cameratus* Mort. .... (c)
2. *Productus cora* d'Orbigny .... (rr)
3. *Productus nebrascensis* Owen .... (rr)
4. *Aviculopecten carboniferus* (Stevens) Meek .... (rr)

Prof. Broadhead regarded No. 11 of his section—No. 5 of mine as "undoubtedly of *Permian* type and the strata may be considered Permian,"[1] while I would locate provisionally the base of the Permian some sixty feet higher, perhaps at the top of No. 18, which equals No. 5 of Broadhead.

CAMBRIDGE SECTION.

The Strong limestone may be readily followed from Grand Summit to the southwest along the Cedar creek valley to Cambridge and the Grouse creek valley. At various places along the Cedar creek valley or its bluffs it forms a prominent ledge, and about one-fourth mile west of Cambridge is an extensive quarry in the lower part of the Strong limestone. In the Grand Summit cut the base

1 Op. cit., p. 487.

of the Strong limestone is 1429 feet A. T., while in the Cambridge quarry, nine miles to the southwest, it is approximately 1284 feet A. T., giving a dip to the southwest of 16 feet per mile.

Section of the Cambridge quarry:

No.		Feet.	
4.	Yellowish and bluish shales which contain some fossils.	4	$52\frac{1}{4}$
3.	Hard limestone, containing numerous fossils, especially *Pleurophorus*.	$\frac{3}{4}$	$48\frac{1}{4}$
2.	Massive, hard limestone, used for building stone, which, in the eastern part of the quarry, contains a considerable amount of flint. There is also quite a large amount of loose flint on the surface near the quarry.	$2\frac{1}{2}$	$47\frac{1}{2}$
1.	Covered.	45	45

Level of Grouse creek.

From Nos. 3 and 4—the larger number from No. 3—the following species were obtained:

1. *Pleurophorus subcostatus* M. and W. (?) . . . . (c)

   These specimens are not so large as the figures in the Illinois report and are probably the form mentioned as a variety of *P. subcuneatus* M. and H. (Geol. Surv. Ill., Vol. II, Palæontology, p. 348).

2. *Pleurophorus* (?) *Calhouni* M. and H. (?) . . . . (aa)

   A considerable number of gibbuns specimens, which agree fairly well with the figures and description of this species. In some of the specimens there is a longitudinal depression posterior of the umbones, which probably represents the lateral tooth.

3. *Yoldia* (?) *subscitula* M. and H. . . . . (rr)
4. *Pleurophorus* (?) *subcuneatus* M. and H. . . . . (c)
5. *Pseudomonotis Hawni* (M. and H.) . . . . (c)
6. *Pseudomonotis Hawni* (M. and H.) cf. var. *ovata* M. and H. and perhaps var. *sinuata* M. and W. (c)

   Small and imperfect specimens.

7. (?) *Nautilus eccentricus* M. and H. . . . . (aa)

   These specimens are apparently this species, though it is possible they may belong to the genus *Bellerophon*, as they are all internal impressions.

8. *Myalina permiana* (Swal.) M. and H. . . . . (c)

SECTION ACROSS THE SOUTHERN FLINT HILLS.

The section across the Flint Hills of the southern and central part of Cowley county, along the line of the Missouri Pacific railroad, from Taussig at their eastern foot to Winfield in the Walnut river valley, was hastily examined. The author regrets that on account of the limited time at his disposal he was unable to determine the limits of all the formations shown in this section; but submits the following partial correlation. Mr. C. N. Gould has published a section along the line of this railroad in which the lithologic character and thickness of the rocks composing it are given;[1] but the total thickness of limestones reported in it seems to be too great.

SECTION FROM TAUSSIG TO HOOSER.

No.		Feet.
13.	Massive limestone weathering whitish and containing an abundance of flint, about 40 feet thick. Probably the *Strong limestone.*	40=435
12.	Red and blue shales, according to Gould..........	10=395
11.	Brownish sandstone, given by Gould as 10 feet thick.	10=385
10.	Mainly red shales	20=375
9.	Limestone, with abundant *Fusulina* in lower part...	5½=355
8.	Covered; about 4½ feet.........................	4½=349½
7.	Light gray, rather massive limestone, containing some *Fusulina.*	5=345
6.	Mainly covered along the railroad. At base a massive limestone with a metallic ring. The central and upper part of the stratum weathers to a very rough surface. It contains a considerable amount of flint.	150=340
5.	Mainly covered; the shales at the top below the massive limestone of No. 6 contain numerous specimens of *Spirifer cameratus* and *Athyris subtilita.*	85=190
4.	Brownish limestone in which there are large numbers of *Fusulina.*	10=105
3.	Yellowish shales in which *Spirifer cameratus* and *Athyris subtilita* are common.	12=95
2.	Covered, with brownish-red *Fusulina* limestone at the base.	23=83
1.	Covered to Taussig railroad station...............	60=60

The measurements in the above section are nearly all barometric and it deserves more careful study. If the correlation of the massive limestone—No. 13—near Hooser with the Strong limestone be correct, then the horizon of the Cottonwood limestone is in the covered part of No. 6, below which all the remaining rocks belong

1 Univ. Geol. Surv. Kans., vol. 1, pp. 31 to 35, and see pl. 1.

in the Wabaunsee formation. The yellowish shales of No. 3 contain the species listed below:

1. *Productus cora* d'Orbigny .... (c)
2. *Productus nebrascensis* Owen .... (rr)
3. *Athyris* (*Seminula*) *subtilita* (Hall) Newb .... (c)
4. *Spirifer cameratus* Mort .... (c)
5. *Aviculopecten occidentalis* (Shum.) M. and W .... (rr)
6. *Aviculopecten* sp .... (rr)
7. *Fusulina cylindrica* Fisher .... (c)
   Abundant in shales and brownish *Fusulina* limestone.
8. *Meekopora Prosseri* Ulrich .... (rr)

DEXTER SECTIONS.

Along the railroad track from a short distance north of Dexter to the third railroad cut, one and a fourth miles south of Dexter, is the following section. The altitudes were obtained by means of a barometer and the difference between them is less than the actual thickness of the rocks, on account of the strong east dip at this locality:

No.		Feet.
5.	Heavy limestone with plenty of flint and nodules, in third railroad cut south of Dexter. The limestone contains large numbers of flat to irregular shaped concretions which are quite similar to those in the Strong limestone south of Cottonwood Falls. In the fold in the cut the dip is 5° east. Base of *Strong limestone.*	
4.	Yellowish shales with abundant fossils, then covered; below which, in the second railroad cut, are shaly limestones containing *Pseudomonotis Hawni* and three species of *Myalina.*	30=100
3.	Red and yellowish shales	15=70
2.	Yellowish to grayish shales and thin limestones containing abundant fossils, in first railroad cut half mile south of Dexter. Below is a rough limestone, and then covered to north of the Dexter station.	55=55
1.	In railroad ditch north of Dexter is shown the upper part of a massive light gray to whitish limestone, which contains great numbers of *Fusulina,* with some *Crinoid* segments and spines of *Archæocidaris.* This resembles the Cottonwood limestone considerably.	

From the yellowish shales in the third railroad cut, at the top of No. 4, the following fossils were collected:

1. *Derbya multistriata* (M. and H.) Pros. . . . . (rr)
2. *Productus nebrascensis* Owen. . . . . (rr)
3. *Pinna peracuta* Shum. . . . . (rr)
4. *Aviculopecten* sp. . . . . (rr)

In the shaly limestones at the base of No. 4, in the second railroad cut, and in the yellowish to grayish shales at the top of No. 2, in the first railroad cut, is an abundant fauna of the Neosho formation. The list is as follows:

1. *Productus nebrascensis* Owen. . . . . (aa)
2. *Productus cora* d'Orbigny. . . . . (rr)
3. *Aviculopecten occidentalis* (Shum.) M. and W. . . . . (a)
4. *Pseudomonotis Hawni* (M. and H.). (c)
5. *Pseudomonotis*(?) sp. . . . . (rr)
   Large pustules on the surface differing from any of the figures seen.
6. *Myalina Kansasensis* Shum. . . . . (c)
7. *Myalina perattenuata* M. and H. . . . . (c)
8. *Myalina*(?) *Swallovi* McChes. . . . . (rr)
9. *Pinna peracuta* Shum. . . . . (rr)
10. (?)*Astartella vera* Hall. . . . . (rr)
11. *Macrochilina angulifera* White(?). (rr)
12. *Bellerophon* sp . . . . (rr)
    Too imperfectly preserved for identification.
13. *Lamellibranch* . . . . (rr)
    Undetermined species.

The massive flint and concretionary limestone—No. 5—at the top of the above section is the base of the Stong limestone, below which is the Neosho formation; while possibly the light gray *Fusulina* limestone of No. 1 represents the Cottonwood limestone. On the western side of Grouse creek, at Dexter, the base of the Strong flint is 135 feet above the creek level; but the creek banks are covered by alluvial deposits, so that we were unable to find any exposures of rocks near the horizon of the Cottonwood limestone. In a railroad cut at Sliding Bluffs, on the western side of Grouse creek, two and one-half miles west of north of Dexter, is an excellent exposure of the lower part of the Strong limestone and subjacent shales. The flint shows prominently in the limestone and below it are yellowish shales and shaly limestones in which fossils are abundant, especially *Derbya multistriata* (M. and H.) Pros. The other species are:

1. *Derbya crassa* (M. and H.) H. and C.
2. *Productus nebrascensis* Owen.

3. *Aviculopecten occidentalis* (Shum.) Meek.
4. *Myalina Kansasensis* Shum.
5. *Pinna* sp.
   Curved and markings differing from *P. peracuta* Shum.
6. *Allorisma* (*Sedgwickia*) cf. *granosum* (Shum.) Meek...... (rr)
   Does not show granules, but outline and other markings like this species.

Below these rocks are red shales. Farther west, in the railroad cut not far east of Eaton, is a massive, buff limestone, the thick layers considerably shattered, which underlies the plateau of this region. One and one-half miles east of Eaton is the base of a massive flint limestone. This flint and the superjacent limestone are referred to the Florence flint and limestone of the Chase formation.

WINFIELD SECTIONS.

The Florence limestone can probably be followed west across the country from Eaton to the valley of the Walnut river at Winfield, as stated by Mr. Gould.[1] To the east of the Southern Kansas railroad, in the eastern part of Winfield, is a quarry in massive, buff, soft limestone which has been worked quite extensively. The lower part of the limestone is laminated; in the upper part are many "sand holes," and portions of the rock are bluish to lead color. It resembles closely the Jones quarry at Florence, and it is clearly the Florence limestone. The following section was measured from the base of this quarry, which is about on a level with the Missouri Pacific railroad station to the top of the hill just east of the Southwest Kansas College:

No.		Feet.	
5.	Loose on the top of the hill just east of the Southwest Kansas College. Rough blocks of the Winfield limestone.		
4.	Massive limestone immediately east of the college. *Winfield limestone.*		
3.	Mainly covered..............................	88	100
2.	Shaly yellowish limestone in upper part of quarry with *Athyris subtilita.*	2+	=12
1.	Massive, buff limestone of quarry, 9½ feet exposed. *Florence limestone.*	9½	=9½

The Winfield limestone, which caps the college hill to the east of Winfield, also forms the top of asylum hill to the north and reservoir hill to the south. The dip of the Florence limestone in

1 Ibid., p. 34.

the Winfield quarry is ½° south, 80° west. According to the Burden sheet, of the United States Topographic Map, the altitude of the Florence limestone at Eaton is approximately 1,375 feet A. T., while at Winfield it is 1,117 feet, and the distance between the two localities eleven miles, which will give a dip to the west of twenty-three feet per mile. In the Winfield section it is ninety feet from the base of the Winfield limestone to the top of the massive Florence limestone; while in the typical region of the Cottonwood valley it is eighty-four feet.

On the western bank of the Walnut river, to the west of Winfield, is a massive limestone which forms in places a marked escarpment along the bluff with a vertical wall of rock ten feet in thickness. Along the highway, directly west of Winfield, the ledge is thirteen feet thick, the base of which is about forty-five feet above the river level. The lower part of the ledge, when weathered, is very rough with some concretions; near the middle are yellowish shales containing numerous specimens of *Athyris subtilita* and *Derbya crassa*, with a few other species; then comes massive limestone again, above which are yellowish shales. It is a clear exposure of the Winfield limestone, except that at this locality the concretions which are so prominent at many places as, for example, five miles north of the city are inconspicuous. The following species were collected in this highway cut:

1. *Athyris* (*Seminula*) *subtilita* (Hall) Newb. . . . . (a)
   One specimen shows the spire very nicely.
2. *Productus semireticulatus* (Mart.) de Kon . . . . (r)
3. *Productus semireticulatus* (Martin) de Kon. var. *Calhounianus* Swallow. (rr)
4. *Derbya crassa* (M. and H.) H. and C. . . . . (c)
5. *Pseudomonotis Hawni* (M. and H.). . . . . (rr)
6. *Aviculopecten occidentalis* (Shum.) Meek . . . . (r)

The difference in altitude between the base of the Winfield limestone on college hill and on the bluff west of the Walnut river is approximately seventy-five feet, while the distance is about two and a half miles, which gives a dip to the west across the Walnut valley of thirty feet per mile.[1]

ARKANSAS CITY SECTIONS.

Twelve miles south of Winfield in the valley, between the Arkansas and Walnut rivers, is Arkansas City. To the east of the Walnut river, at the middle bridge, is a quarry in massive lime-

1 In vol. II, p. 65, of the Univ. Geol. Surv. of Kansas, the writer gave the dip as forty feet per mile across this valley; but that estimate was too great.

stone twelve feet thick which has been quarried to a considerable extent for local use. This bluff affords the best section in the vicinity of Arkansas City.

SECTIONS OF THE BLUFF EAST OF ARKANSAS CITY.

Near top of hill.

No.		Feet.
11.	Thin bedded limestones, quarried to some extent...	12=107
10.	Shales, 3 to 4 feet............................	3=95
9.	Limestone stratum............................	1=92
8.	Covered, slope................................	20—91
7.	Massive limestone, containing large numbess of clay pebbles, giving the stone a mottled appearance.	3=71
6.	Shales, about 7 feet..........................	7=68
5.	Yellowish shales, exposed on bluff above quarry....	3=61
4.	Buff to blue thin limestones.....................	5=58
3.	Shaly light gray limestone, in which fossils are abundant from 1 to 1½ feet thick.	1=53
2.	Massive limestone of quarry....................	12 52
1.	Covered to level of the Walnut river.............	40—40

Nos. 1 to 5, inclusive, of the above section are exposed in the bluff at the quarry and were measrued by Mr. J. W. Beede; while the remaining part of the section is on the hill a short distance to the southeast, for part of the details of which I am indebted to Mr. C. N. Gould. In the shaly limestone of No. 3 Mr. Beede collected the following fauna:

1. *Myalina aviculoides* M. and H........................ (c)
2. *Myalina* sp.. (c)

   Perhaps *M. recurvirostris* M. and W. Too poorly preserved for specific identification.
3. *Athyris* (*Seminula*) *subtilita* (Hall) Newb.............. (aa)
4. *Productus semireticulatus* (Mart.) de Kon.............. (a)
5. *Productus semireticulatus* (Mart.) de Kon., var. *Calhounianus* Swallow. (r)
6. *Productus nebrascensis* Owen(?)...................... (rr)

   A large specimen possibly belonging to this species, though it is wider on the hinge line and in this respect more closely resembles *P. semireticulatus*.
7. *Derbya crassa* (M. and H.) H. and C.................. (aa)
8. *Derbya multistriata* (M. and H.) Pros.................. (c)

   Perhaps some of the preceding species should be listed as this one. They are rather larger than the ordinary *D. crassa*.

9. *Aviculopecten occidentalis* (Shum.) Meek .... (rr)
10. *Rhombopora lepidodendroides* Meek .... (r)
11. *Septopora biserialis* (Swallow) Waagen .... (rr)
12. *Pinna peracuta* Shum .... (rr)
13. *Edmondia subtruncata* Meek.(?) .... (rr)
14. *Chænomya Cooperi* M. and H.(?) .... (rr)
    Broken specimen, impossible to identify specifically.
15. *Crinoid*, calyx and numerous segments of the stem......
16. *Archæocidaris*, plates and spines .... (c)
17. *Metacoceras dubium* Hyatt(?) .... (rr)
    Specimen identified by Prof. Hyatt.

It seems probable that No. 2 of this section is the Winfield limestone, though it was not traced by the writer from Winfield to Arkansas City, and scarcely any flint or concretions were found at this locality.

SECTIONS NORTH AND NORTHWEST OF ARKANSAS CITY.

On the hill, two miles north of the city, Mr. Beede measured the following section belonging in the Marion formation:

No.		Feet.	
3.	Shaly and hard limestones	8	40½
2.	Limestones containing fossils	7½	32½
1.	Blue shales	25	25

In the limestone of No. 2 Mr. Beede collected the following fossils:

1. *Myalina aviculoides* M. and H. .... (c)
2. *Aviculopecten occidentalis* (Shum.) Meek .... (r)
3. *Bakevellia parva* M. and H. .... (c)
4. *Schizodus curtus* M. and W. (?) .... (rr)
5. Gastropod cf. *Murchisonia* sp. or *Loxonema* sp. .... (rr)
   Internal impression showing at least ten whorls. The largest Gastropod seen in the Marion.
6. *Bryozoan* sp. .... (r)
   Poorly preserved.

On the eastern side of the Arkansas river, about two and a half miles northwest of Arkansas City, is a buff, soft limestone which has been quarried to some extent. This outcrop of the Marion formation is near the "head gates" of the canal where the following section was measured:

No.		Feet.	
3.	Yellowish shales	7	42

No.		Feet.
2.	Buff, fairly massive limestone, which has a cellular layer near the center of the stratum that contains numerous specimens of *Bakevellia parva* M. and H. and an occasional specimen of *Myalina aviculoides* M. and H. (?), and *Nautilus eccentricus* M. and H. (?), both of the latter imperfectly preserved.	15=35
1.	Covered to level of Arkansas river................	20 20

Conclusion.

It is thought that the above sections will give some idea of the interesting Upper Carboniferous and Permian formations in southern Kansas which are worthy of careful study. On correlating them with the typical Permian and Upper Carboniferous formations of central Kansas it is found that in general there is a close agreement between the different zones of the several formations, except in the case of the Cottonwood formation. The abundant fauna of the lower Cottonwood shales was not found in these sections, and the horizon of the Cottonwood limestone is in some doubt. However, a more careful study of the region where the Cottonwood formation is to be expected may remove this apparent difference, since in two of the general sections studied its horizon seems to have been covered.

To the south, in Oklahoma, scarcely anything has been published about the geology of the Upper Carboniferous and Lower Permian, and it is a region which will probably afford us most interesting information when it is thoroughly studied. This investigation should be continued across Oklahoma to northern Texas at the earliest opportunity, in order to make it possible to correlate precisely the Kansas with the Texas Permian. Also, as the writer has stated elsewhere,[1] this work is necessary before a decision can be reached as to whether the Red-beds or Cimarron series of southern Kansas and northern Oklahoma should be correlated with the Permian or the Triassic.

1 Univ. Geol. Surv. Kans., vol. ii, p. 9.

Range and Distribution of the Mosasaurs, With Remarks on Synonymy.

BY S. W. WILLISTON.

With Plate XX.

The Mosasaurs are at present known from four remote regions of the world—North and South America, Europe and New Zealand. Doubtless they lived over the greater part of the earth and may be expected to be found wherever the deposits in which they occur are found. Their geological range is confined exclusively to the Upper Cretaceous, from the time corresponding to the upper part of the Dakota to that of the lower part of the Laramie, or from Upper Cenomanian to the Lower Danian. The correlation of the American Cretaceous deposits with those of Europe, or even with each other is by no means exact, or even approximately exact. Nevertheless the equivalency of the different strata and epochs is sufficiently well determined to admit of approximate results, and it is one of the purposes of this paper to bring what evidence the Mosasaurs - typical Cretaceous reptiles—may present, bearing upon the subject.

The oldest Mosasaurs are apparently those described by Hector from New Zealand, which he referred to the genera Liodon and *Taniwhasaurus* Hector.* The genus *Liodon* Owen, Dollo has recently shown to be a synonym of *Mosasaurus.*† Whether or not Hector's species is congeneric with those placed under *Liodon* by Cope is not certain, though it is evident that it is closely allied. *Taniwhasaurus* is as clearly of the *Platecarpus* type, and may possibly belong to that genus.

The most recent form is the historical *Mosasaurus giganteus* Soemmering (*M. Camperi, M. Hoffmani*) from the Mæstricht beds in the Lower Danian. These three forms, *Tylosaurus*, *Platecarpus* and *Mosasaurus* represent three distinct and divergent types, which I will call the Tylosaurinæ, Platecarpinæ, and Mosasaurinæ, cor-

*On the Fossil Reptilia of New Zealand, Trans and Proc., New Zealand Institute, vi, 338, 1873.
†Bull. Soc. Belg. Geol., vii, 79, 1892.

responding to the megarhynchous, microrhynchous and mesorhynchous types of Dollo.*

The Tylosaurinæ begin with *Liodon* (*Tylosaurus?*) *Haumurensis* Hector in the Cenomanian of New Zealand and continue to the Upper Senonian of Belgium as found in the genus *Hainosaurus* Dollo, from the Brown Phosphatic Chalk of Mesvin Cipley. In the interior of North America the type, so far as known, begins near the lower part of the Niobrara and terminates at its close or in the beginning of the Ft. Pierre, that is, to use the European time periods, with the close of the Turonian or the beginning of the Senonian. Forms ascribed to this genus, the *Liodon* of Cope, are from the Lower Greensand or Lower Marl of New Jersey, but their positive identification is yet uncertain, if not doubtful, since the only characteristic parts, the rostrum, quadrate and limb bones have never yet been found. There is nothing improbable in its occurrence in these beds, but hitherto nothing decisively characteristic of *Tylosaurus* has been found there. The genus *Hainosaurus* is clearly of the *Tylosaurus* type. In fact the two genera are so nearly related that decisive distinctional characters are not yet forthcoming, unless they be found in the paddles.

The Platecarpinæ have a very similar distribution. Beginning in the Cenomanian of New Zealand, in *Taniwhasaurus*, if the deposits of New Zealand are really cotemporaneous with this epoch in Europe, they terminate in the closely allied *Plioplatecarpus* Dollo from the Lower Mæstrichtian of Belgium. In North America the species upon which the genus *Platecarpus* has been chiefly based are known nowhere outside of Kansas and Colorado, and are here restricted exclusively to the Niobrara. The type species of this genus, *P. tympaniticus* Cope, is from Mississippi and is in all probability congeneric with the Kansas species, but this has not yet been satisfactorily proven, though it certainly belongs in the Platecarpinæ.

From the Ft. Pierre only one species can be referred to this group, and this with doubt. *Brachysaurus* described by myself in the last number of this QUARTERLY may belong here, but I believe that its affinities are more close with the Mosasaurinæ. It is certainly closely related to *Prognathosaurus* Dollo,† from the Upper Senonian of Belgium, and I should have had little hesitancy in identifying it with that genus had not Dollo stated that the chevrons are free in *Prognathosaurus*.‡

*Mem. Soc. Belg. de Geol., iv, 163, 1890.
†Mem. Soc. Belg. de Geol., iii, 193, 1889.
‡Mem. Soc. Belg. de Geol., iv, 163, 1890.

Of the Mosasaurinæ, including the two genera *Mosasaurus* and *Clidastes*, the lowest horizon is the upper part of the Niobrara in Kansas. *Clidastes* ranges into the Ft. Pierre, as previously stated by myself. In the eastern Atlantic region his genus is represented by forms closely allied to those from Kansas. Its range then, is from the upper part of the Turonian through the larger part of the Senonian.

The typical *Mosasaurus* is confined exclusively to the Senonian and Danian. Its distribution in North America is reputed to be from New Jersey, Alabama and Dakota, but some of the determinations may be incorrect. The species from the Ft. Pierre are, however, clearly congeneric with one or more from New Jersey. In Europe *Mosasaurus* is known only from the Upper Senonian and the Danian (Upper Chalk and Mæstrichtian), that is, apparently, from later horizons than those in which the genus occurs in America.

The two genera *Mosasaurus* and *Clidastes* are nearly related, though sufficiently different to justify their independent existence.

From the known distribution of the Mosasaurs, Dollo has concluded, "Que la Nouvelle-Zéland (ou, mieux, les terres australes) est le centre d'irradiation des Mosasauriens, qui en seraient partis à la fin de l'époque cénomanienne, auraient vécu uniquement en Amérique durant l'époque turonienne, auraient émigré en Europe à l'époque sénonienne et s'y seraient éteints avec l'époque mæstrichtienne." The fact that Mosasaurs are reported from the Amazonian Purus, corresponding to the Mæstrichtian, would certainly indicate that they had not become at all restricted in distribution in the latter part of their existence.

The distribution of the Mosasaurs, so far as now known, seems to be of little value in the correlation of the Cretaceous epochs. Only a single genus seems to be of wide distribution, and the nearly related ones may be widely separated in geological range. Two, perhaps three distinct types appear suddenly in the Cenomanian and have continued side by side in the same waters throughout the greater part of the time during which the group has been in existence. Some minor divergent forms have appeared, such as the singular *Phosphorosaurus* Dollo, *Prognathosaurus* and *Brachysaurus* and, perhaps, *Baptosaurus* Marsh, which, by the way, is one of the latest American forms, from the Upper Greensand or Marl of New Jersey, and occurring also, if Merriam's determination is correct, in the Niobrara of Kansas.

The common aquatic ancestor of the three types must be sought for in a much earlier period, certainly in the Lower Cretaceous.

The rudimentary or possibly functional zygosphene among the Platecarpinæ, or some members of it and the complete zygosphene in *Clidastes*; together with the shortened muzzle and more fully ossified paddles, indicates a much closer relationship between the Platecarpinæ and Mosasaurinæ than between either and the Tylosaurinæ. In the last we find, in some forms at least, that the fifth finger is actually longer than the fourth, with as many phalanges, and that the carpus and tarsus are almost wholly unossified. If we assume with Dollo that the zygosphene is a primitive character, and it must be unless it had an independent origin among the Mosasaurs, then *Clidastes* would be the most generalized and *Tylosaurus* the most specialized of the Mosasaurs. In the paddles and skull, *Tylosaurus* is with hardly a doubt, more specialized than any other genus. However, although *Clidastes* may retain some of its primitive characters, it certainly shows in many other respects a high degree of specialization.

In the accompanying plate are shown the side views of skulls of two of these types, the Tylosaurinæ and Platecarpinæ. The third type, the Mosasaurinæ, may be seen by reference to plate XV, in Vol. III, of this QUARTERLY.

I give below a tabular review of the known genera of the Mosasaurinæ arranged in systematic sequence, using the European time-epochs for comparison's sake. Of course it is understood that the exact equivalency of these time-periods is yet a matter of uncertainty.

TYLOSAURINÆ.

Hind feet functionally pentadactylate. Trunk short, the tail proportionally long, not dilated distally. Tarsus and carpus almost wholly unossified, the phalanges numerous. Vertebræ wholly without zygosphene. Premaxillary projecting into a long rostrum in front of the teeth. Quadrate with a short suprastapedial process.

Tylosaurus Marsh

Cenomanian of New Zealand (*Liodon Haamuriensis* Hector).
Upper Turonian of Kansas and New Mexico (Niobrara).
? Senonian of New Jersey (Greensand).

Hainsosaurus Dollo

Upper Senonian of Belgium (Brown Phosphatic Chalk of Cipley).

*Mem. Soc. Belg. Geol., iv, 168.
†Ueber the Pythonomorphen der Kansas Kreide, Paleontographica, xli, 36.

PLATECARPINÆ.

Hind feet functionally pentadactylate. Trunk short, the tail proportionally long, not dilated distally. Carpus and tarsus imperfectly ossified. Vertebræ with rudimentary or functional zygosphene. Premaxillary not projecting beyond the teeth, very obtuse. Quadrate large, with long suprastapedial process.

Platecarpus Cope

Upper Turonian of Kansas and Colorado (Niobrara).

? Senonian of Mississippi.

Plioplatecarpus Dollo.

Lower Mæstrichtian of Belgium (Danian).

Prognathosaurus Dollo.

Upper Senonian of Belgium (Brown Phosphate of Cipley).

? **Brachysaurus** Williston

Senonian of Dakota (Ft. Pierre).

Sironectes Cope and Holosaurus Marsh

Upper Turonian of Kansas (Niobrara).

Taniwhasaurus Hector

Upper Cenomanian of New Zealand.

MOSASAURINÆ.

Hind feet tetradactylate. Carpus and tarsus fully ossified, and with not more than six phalanges in any digit. Trunk relatively long, the thorax short, the tail much compressed distally, the chevrons co-ossified with the centra. Zygosphenes rudimentary or functional. Humerus with a strong radial process at distal end. Prefrontal more or less dilated into a horizontal plate posteriorly. Coronoid large. Rostrum short, obtusely conical. Quadrate small, with a suprastapedial process of moderate length.

Mosasaurus Conybeare

Lower Danian of Belgium and England (Upper and Lower Mæstrichtian and Upper Chalk).

Upper Senonian of Belgium (Brown Phosphate of Cipley).

Senonian of New Jersey and Dakota (Greensand and Ft. Pierre).

? Senonian of Alabama and North Carolina.

Clidastes Cope.

Uppermost Turonian or Lowermost Senonian of Kansas and Colorado (Niobrara and Ft. Pierre).

Senonian of New Jersey, Alabama and Mississippi.

INCERTÆ SEDIS.

Baptosaurus Marsh.

Upper Senonian of New Jersey (Upper Greensand).
Upper Turonian of Kansas (Niobrara).

Phosphorosaurus Dollo.

Upper Senonian of Belgium (Brown Phosphatic Chalk of Cipley).

TYLOSAURUS.

? *Macrosaurus* Owen, Journ. Geol. Soc. Lond., 1859, 380.

? *Lesticodus* Leidy, Proc. Amer. Phil. Soc., 1859, vii, 10.

? *Nectoportheus* Cope, Proc. Amer. Phil. Soc., 1868, 181.

Liodon Cope et alia, nec Owen.

Rhinosaurus Marsh, Amer. Journ. Sci., June, iii, 461, 1872 (preoc.).

Rhamphosaurus Cope, Proc. Acad. Nat. Sci. Phil., 1872, 141 (preoc.).

Tylosaurus Marsh, Amer. Journ. Sci., iv, 1872, 147.

Moderate to very large sized species. Rostrum much produced, the nares situated far back. Facial surface of the parietal produced to the posterior part in the middle, the sides nearly parallel. Postfrontal and prefrontal meeting on the superior orbital border. Prefrontal not expanded on the facial plane over the orbit. Quadrate with a short suprastapedial process. Humerus slender, the proximal end angular, the distal end without radial process. Ulna and radius slender. A single carpal or tarsal bone present, not articulating with adjacent bones. Phalanges very numerous, the fifth finger not reduced. Hind limb as large as the anterior. Spines of caudal vertebræ not elongated. Thoracic vertebræ twelve to fourteen in number, the lumbo-dorsals about ten, the pygal caudals five; whole number of vertebræ not exceeding one hundred and twenty; no zygosphene. Coracoid not emarginate.

As in *Platecarpus* the rightful name of this genus can not be determined until more is known about the forms described from incomplete material from New Jersey. It seems very probable that the name *Tylosaurus* will eventually have to be abandoned. It is altogether likely that *Nectoportheus* is the same, while *Macrosaurus* and *Lesticodus* possibly are. In this uncertainty *Tylosaurus* may be retained for the present.

Macrosaurus lævis Owen, the type of the genus, was proposed for a species represented by two dorsal vertebræ from the Greensand of New Jersey. Leidy (Cretaceous Reptilia, 75) referred other remains to the same species, but with the remark, "I cannot avoid the suspicion that both the specimens in question and those described by the high authority just mentioned (Owen) really appertain to the dorsal series of *Mosasaurus*." The vertebræ figured by Leidy seem to be congeneric with the Kansas forms referred to *Tylosaurus*, but, inasmuch the genus is distinguished with difficulty by the vertebræ alone, it would be hazardous to say with any degree of certainty that they are really the same. Cope, in 1870 (Extinct Batrachia, etc.), referred certain bones to this same species under the name *Liodon*. In the plates of the same work he figured two or three vertebræ over the name of *L. validus*, referred to *L. lævis* in the text, and to *Clidastes antivalidus* in the explanation of the plates! The bone figured in the text certainly does not belong with *Tylosaurus*, and, if Cope is correct in his determination, *Macrosaurus* is not the same as *Tylosaurus*. The different names that he used, however, are sufficient evidence of his uncertainty.

Lesticodus was given by Leidy to a species (*L. impar*) represented by teeth and portions of the jaws, and was afterwards abandoned by him. Cope apparently believed that the genus was the same as *Liodon* Cope.

Nectoportheus Cope was based upon *Liodon validus* (olim *Macrosaurus*) and was characterized by him as follows: (Extinct Batrachia, etc., 208) "The posterior dorsals are so much more depressed than in *Liodon lævis*, that future discovery may justify the generic separation of the genus *Nectoportheus*, which I originally applied to this animal." In his "Cretaceous Vertebrata" (p. 160) he says: "The typical species of this genus (*Liodon anceps* Owen) is very little known, but few remains having been obtained from the English chalk, its locality and horizon. Numerous North American species resemble it in the forms of the crown of the teeth, and it is probable, though uncertain, that they agree in other respects also. Several names have been proposed for our species, the earliest of which is *Macrosaurus* Owen. This name applies to species with compressed dorsal vertebræ, as *L. lævis* and *L. Mitchelli*, both from the New Jersey Greensand. For species with the depressed dorsal vertebræ, as *L. validus* from New Jersey, *L. perlatus* from New Jersey, and *L. proriger* from Kansas, the name *Nectoportheus* was proposed and briefly characterized."

The definition of *Tylosaurus* (*Rhinosaurus*) was explicit and exact, leaving no doubt of the genus to which it was intended to apply.

PLATECARPUS.

? *Holcodus* Gibbes, Smithsonian Contributions, ii, p. 9, 1850.
Platecarpus Cope, Boston Soc. Nat. Hist., 1869, p. 164.

Lestosaurus Marsh, Amer. Journ. Sci., June, 1872.

Medium sized Mosasaurs. Premaxillary short and obtuse, projecting very slightly beyond the teeth. Teeth slender, and recurved, faceted upon the outer side and striate on the inner. Nares much dilated anteriorly, situated forward. Frontal emarginated in the middle behind; pineal foramen large, situated near the frontal suture. Facial surface of parietal small, triangular in shape, the apex not extending beyond the middle of the bone. Prosplenial with a dilated wing-like process above. Quadrate large with a large suprastapedial process, reaching below the middle of the bone. Expanded portion of palatine short. Coronoid short and not prominent. Zygosphenes of vertebræ rudimentary. Cervical vertebræ seven in number. Thoracic vertebræ not more than fifteen in number, lumbo-dorsals nine or ten; pygial caudals five or six; chevrons large, articulated, spines of caudals regular in length, Limbs relatively large; arm and leg bones short and expanded; three or four carpal or tarsal bones present, closely articulating; pollex and hallux shorter than the fourth digit, divaricated. Coracoid with a deep emargination. Pelvic bones large; ischium much expanded distally; pubis without antero-proximal process.

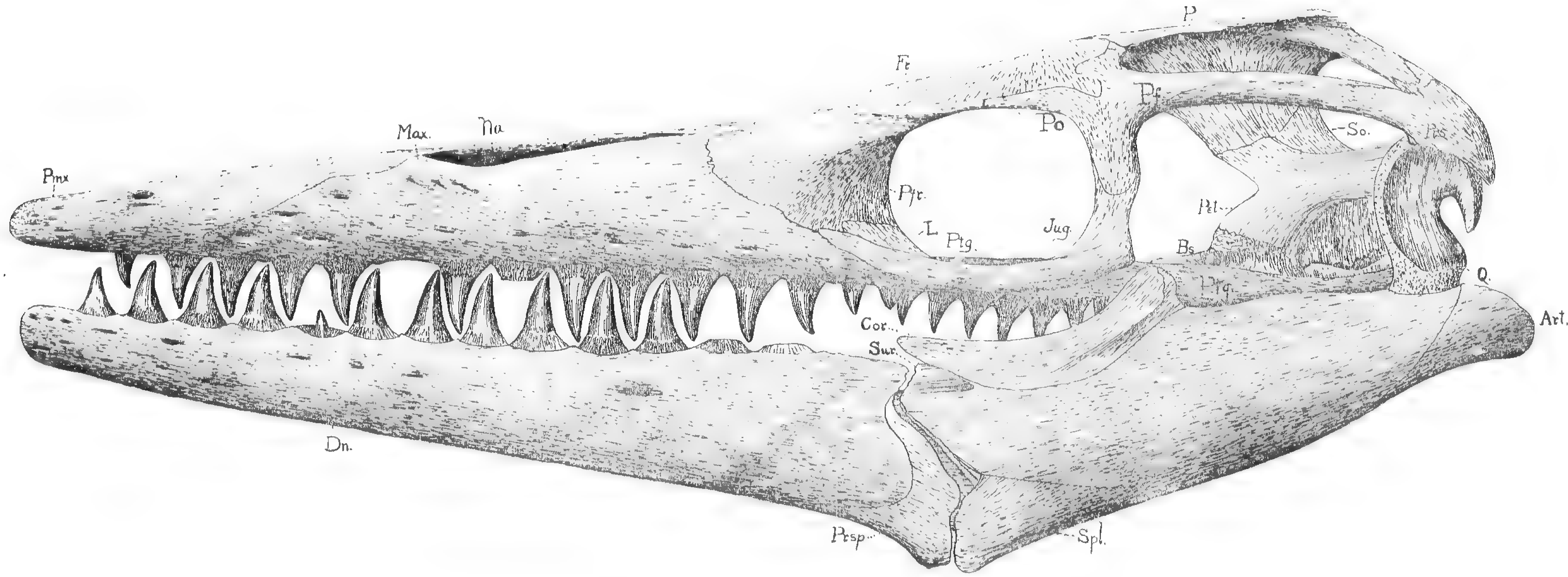
The genus *Holcodus* Gibbes was proposed for the reception of a species supposed by him to be represented by three teeth from Alabama, South Carolina and New Jersey. Two of these were figured in his work cited (pl. iii, ff. 6-9), with the following description: "They are solid, and resemble in their pyramidal form those of *Mosasaurus hoffmani* antero-posteriorly, the dividing ridges making the anterior and posterior surfaces equal, and they are both convex. They are also acutely pointed. In *Mosasaurus* the outer surface is plane or nearly so, and both have longitudinal narrow planes near the base. * * In the teeth under notice, on the outer half are many planes, almost grooves, and also on the inner face, which is peculiarly striated toward the base. As the striated character is a structural distinction, the name *Holcodus* is given to the genus, and that of *acutidens* to the species." Professor Leidy afterward* showed that only those teeth from Alabama belonged to a Mosasauroid, the ones from New Jersey being those of a crocodile (*Hyposaurus*). He describes Gibbes' type as follows: (op. cit.) "The specimen has the enameled crown three-fourths of an inch in length. The base is elliptical in transverse section, and measures five lines antero-posteriorly, and four lines transversely The crown is nearly equally divided by acute ridges, which are im-

*Cret. Reptiles of the United States, p. 32, foot note.

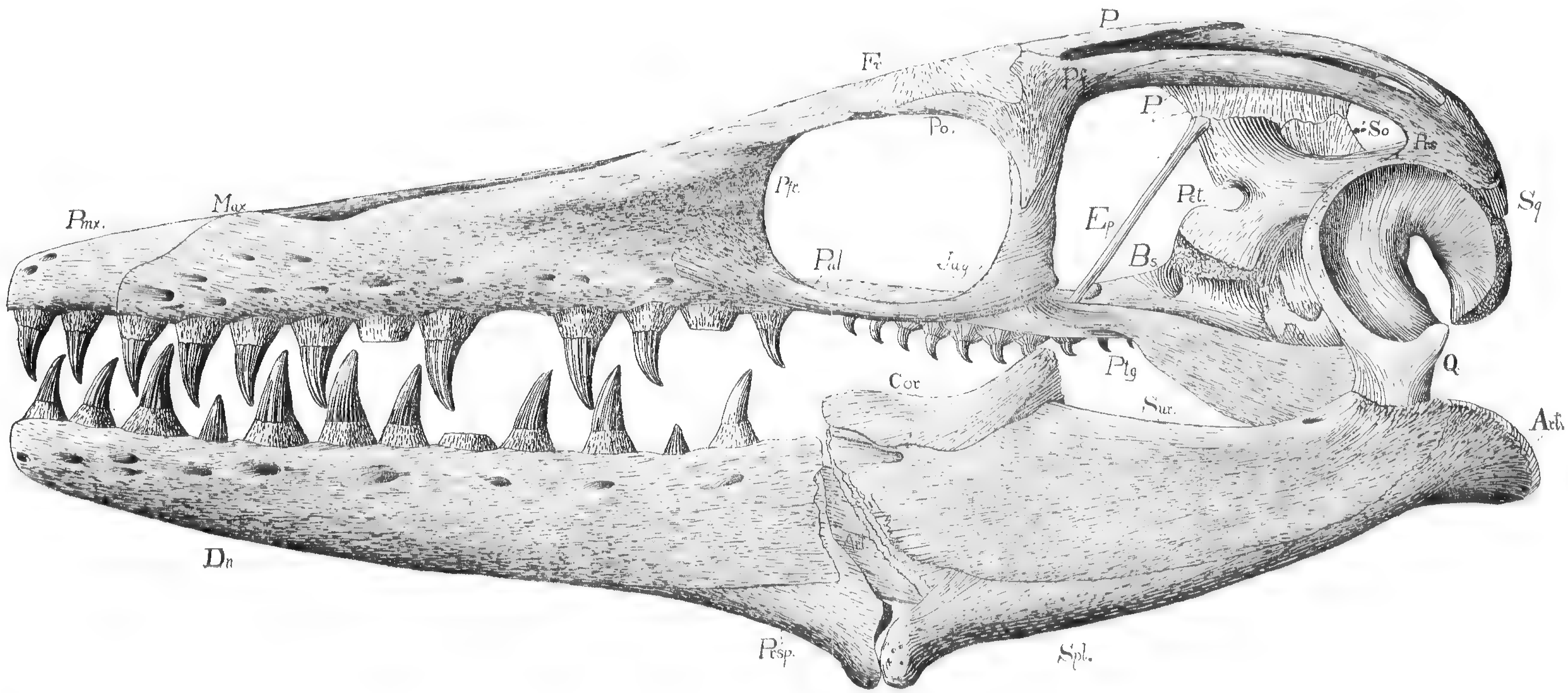
perfect in the specimen, but appear not to have been denticulated. The surfaces are subdivided into narrow, slightly depressed planes, and the inner one is strongly striate at the base." He is inclined to refer the tooth to *Mosasaurus*, a view in which Marsh coincides after examination of the type.*

I cannot agree with these authors. Whatever the tooth may be it is not that of a Mosasaurus. Professor Cope erected the genus *Platecarpus* for a species which Leidy had previously referred to *Holcodus*, under the name *tympaniticus*. The specimen which he described was from Mississippi. Later Cope applied the name *Holcodus* to two species from Kansas (*H. coryphæus and H. ictericus*), but which he later placed in *Platecarpus* after the name *Lestosaurus* had been given to the genus represented by them. Cope in his Cretaceous Vertebrata (p. 141) says: "The teeth of the Kansas species referred to it are somewhat similar in character to those described by Gibbes; but it is evident that the latter belonged to a different animal more nearly allied to the true *Mosasaurus*." Of *Platecarpus tympaniticus* very little of the skeleton has been described, and the tail is not yet known. At one time, Cope stated that the tail vertebræ of *Platecarpus* had co-ossified chevrons, upon what authority I can not learn. Marsh based the distinction of *Lestosaurus* largely upon that character, apparently following Cope. The quadrate of *P. tympaniticus*, as figured by Cope certainly looks very much like that bone of the Kansas species, and the quadrate in this genus is a very characteristic bone. These questions then, are to be settled before the name *Platecarpus* can be finally accepted for the Kansas forms: First, Is the typical *Platecarpus* identical with *Holcodus?* I believe that it is. The teeth of the Kansas forms agree perfectly with Leidy's description and figure of the type specimen of *Holcodus*. Second, Is *Platecarpus tympaniticus* congeneric with the Kansas species placed in this genus. This also appears to be true, but it is by no means yet proven. If both propositions are true, our species must be known as *Holcodus*. If the latter only is true, *Platecarpus* will be retained; while if the former is alone true, the name *Lestosaurus* will take precedence. It is a pity that little or nothing has been added to our knowledge of the southern and eastern species of this group within the last twenty years. Perhaps we may expect more definite knowledge concerning them in the immediate future. There is no inherent improbability that the Alabama or Mississippi species are not congeneric with the western ones, inasmuch as we know positively that one genus at least, *Clidastes*, does occur in all these regions, and it does not seem at all unlikely that all of them are common to the different horizons.

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



Skull of Tylosaurus proriger Cope.



S. Prentice, del.

Skull of Platecarpus coryphæus Cope.

Some New Cirriped Crustaceans From the Niobrara Cretaceous of Kansas.

BY W. N. LOGAN.

Hitherto but very little has been made known concerning the Crustacea of the American Cretaceous. In the following communication are given the descriptions of several forms of Cirripeds, specimens of which have been collected during the past year or two in the western part of Kansas. Their horizon is from the lower-most part of the Ornithostoma Beds, and from the Yellow Chalk. Figures and further descriptions will be given in Vol. I, of the Paleontology of the University Geological Survey, now in preparation.

Squama Gen. Nov.

Capitulum composed of from nine to twelve plates of medium size and sub-triangular; peduncle short, composed of seven rows of plates, tapering gradually, to near the extremity, and ending in a rapidly, almost abruptly diminishing reflex area of smaller plates; form adhering to Inoceramus by its entire length.

Squama spissa n. sp.

Capitulum composed of twelve plates, viz.; carina, terga, (2), scuta (2), rostrum, subrostrum, subcarina, superior laterals (2), and carino-laterals (2). Height of capitulum from base to tip 19 mm.; width (lateral) from carina to subrostrum 17 mm. Carina long, narrow, somewhat shield shaped, and slightly convex; length 5 mm.; maximum breadth 2 mm., overlapping lateral in one specimen. Torga, triangular, with apex pointing toward base of capitulum, and base somewhat rounded; very slightly convex smooth; length 10 mm.; breadth (maximum) 15 mm., joined closely with laterals in one specimen. Scuta large, convex, in general shape triangular; superior border almost straight; rostral border convex, base smooth, slightly concave, length (10) mm.; maximum breadth 7 mm., adhering closely to superior lateral and overlapped by rostrum. Rostrum clubshaped, slightly convex; length 6 mm., breadth 2 mm. Subrostrum with the same characteristics as rostrum, except that it is smaller. Carino-laterals long, triangular, with apex distal, smooth, length 10 mm. Maximum breadth 4 mm. Superior laterals shorter 3 mm.; otherwise much the same as carino lateral. Peduncle short, composed of seven rows of plates; plates oblong, narrow, overlapping, short; maximum breadth 6 mm.

The type specimen was collected from the base of the Ornithostoma Beds by the writer, in Jewell county.

Squama lata, n. sp.

Capitulum composed of ten plates, viz.; carina, targa (2), scuta (2), subcarina, superior laterals (2), carino-laterals (2): height 8 mm.; width 16 mm. Carina long, narrow, rounded, slightly convex, the surface marked by parallel striæ; height 4 mm., breadth 2 mm. Terge triangular, with the base rounded; slightly convex, the surface smooth; length 8 mm., maximum breadth 4 mm. Scuta large, convex, quadrangular, its superior lateral border somewhat rounded; rostral border straight, surface marked; length 8 mm., breadth 5 mm. Carino-laterals long, triangular, the surface marked by transverse lines; length 8 mm., breadth 3 mm. Superior laterals shorter, resembling the carino-laterals in general shape. Peduncle short, its maximum breadth 6 mm.; composed of seven rows of plates; plates quadrangular, with the upper border curved; six or seven larger plates in the upper part of a row, succeeded below by about ten very much smaller ones.

Type specimen adhering to Inoceramus shell by its entire length. The type specimen was presented by Mr. M. R. Watson, of Trego county, and had evidently come from the lowermost beds of the upper Niobrara.

Stramentum, Gen. Nov.

Capitulum composed of eight or nine plates; plates of the peduncle narrow, with the ends turned down, presenting a thatched appearance; plates each with a groove running longitudinally. The two known species of this genus are evidently from a higher horizon than those previously described, coming from the yellow chalk, or the same beds that contain the toothed birds.

Stramentum Haworthi.

Pollicipes Haworthi Williston. University Geol. Surv., Vol. II, p. 243, pl. XXXVI.

Capitulum small, composed of nine plates, viz.; carina, scuta (2) terga (2), latralia (4); height 10 mm., breadth 8 mm. Terga triangular, with the apex pointing toward the base of the capitulum;

surface marked by striations, moderately indented in the type specimen; height 10 mm.; greatest breadth 4 mm. Superior laterals triangular, with the apex rounded; convex overlapping scuta in the single specimen; height 9 mm., breadth at base 13 mm. Scuta shorter than the superior laterals, their edges slightly rounded; moderately convex; triangular with the apex truncated; height 8 mm., breadth at base 3 mm. Carino-lateral in position, its general shape triangular, with the apex truncated by a line parallel with the base, which is inclined at an angle of thirty degrees towards the base of the capitulum; height 10 mm.; breadth at base 2 mm. Carina long, narrow, rounded; height 10 mm.; breadth at base, 2 mm. Peduncle composed of nine rows of plates; plates narrow, 1 mm. in breadth and 4 mm. in length, with about thirty plates in each row; plates turned downward at end, grooved along central line. Height of specimen 27 mm.; height of capitulum 10 mm. Weight of peduncle 17 mm.

The type specimen attached to an *ostrea congesta* by the extremity of its peduncle. It was discovered by Professor Haworth and placed provisionally in the genus Pollicipes by Professor Williston in the work cited. Its horizon is the Yellow Chalk from the vicinity of Gove City in Gove county.

Stramentum tabulatum, n. sp.

Capitulum composed of eight plates, viz.; terga (2), scuta (2), lateralia (4); height 5 mm., breadth 7 mm. The plates are flat and marked by lines and the whole capitulum is short and pointed. Terga triangular, the longest side of the triangle adjoining the carino-lateral, the shortest side adjacent to the superior lateral; breadth at base 2 mm., height 5 mm. Scuta small, but one half the size of the terga; triangular, almost equilateral. Carino-lateral long, moderately narrow, triangular, the most acute angle at the apex, height and breadth about the same as those of the targa. Superior laterals small, in the form of an isosceles triangle and of about the size of the scuta. Peduncle short, rounded, composed of six, or possibly seven rows of plates, with about sixteen plates in each row; plates less than 1 mm., in width, their length more than 2 mm.; turned downward at the ends and overlapping in rows. Type specimen collected by Mr. H. T. Martin from the Upper Niobrara Chalk of the Smoky Hill River.

Power of a Twelve Foot "Power" Windmill.

BY E. C. MURPHY.

In Vol. VI, No. 2, Series A, of the KANSAS UNIVERSITY QUARTERLY the writer gave the results of some windmill tests made during the summer of 1896 for the U. S. Geological Survey. The results of one of these tests, namely, that of a twelve foot power Aermotor we wish to discuss more fully, especially from a mathematical standpoint.

This mill is on a thirty foot steel tower. The wind wheel has eighteen curved fans, each $44 \times 18\frac{3}{4} \times 7\frac{3}{4}$ inches, set at an angle of 31^{0} to the plane of wheel. The shaft is geared forward 6 to 1, so that the brake pulley makes six revolutions to one of wind wheel. The method of measuring the wind velocity and the power of the mill are fully described in the article referred to above, and need not be repeated here.

The curves CR, FS, and HT, Fig. 1, show the relation between wind velocity and horse power for brake loads of 2 lbs., 4 lbs. and 6 lbs. respectively on an arm of $35\frac{1}{4}$ inches. The curve AK is tangent to these curves and is the envelop of them.

MATHEMATICAL RELATIONS DERIVED FROM THESE LOAD CURVES.

Curve AK. This curve crosses the axis x, of wind velocity at about $x=5$, and is seen to resemble a parabola whose axis is vertical and coincides with that of axis y (horse power). We may assume for it the form

$$x^2=a+by \qquad (1)$$

in which a and b are constants whose values are to be determined. We see that for $x=5$, $y=0$ and for $x=15$, $y=.58$, hence $a=25$ and $b=345$ and equation (1) becomes

$$x^2=25+345y \qquad (2)$$

x being wind velocity in miles per hour.

If any other value of x, as 21, be substituted in (2) and the value of y computed it is seen to agree very closely with the ordinate of the curve.

It is seen that the curve AK is tangent to the 2 lb. curve at 9 to 10; to the 4 lb. curve at $x=15$, and to the 6 lb. curve at $x=20$ to

21, hence the envelop curve is tangent to the load curves for loads and velocities as follows—

Loads......	0	1	2	3	4	5	6
Velocities (x)	5	$7\frac{1}{2}$	10	$12\frac{1}{2}$	15	$17\frac{1}{2}$	20

that is, for each increase of velocity of about $2\frac{1}{2}$ miles per hour, starting with 5 miles, there is an addition of one pound of load.

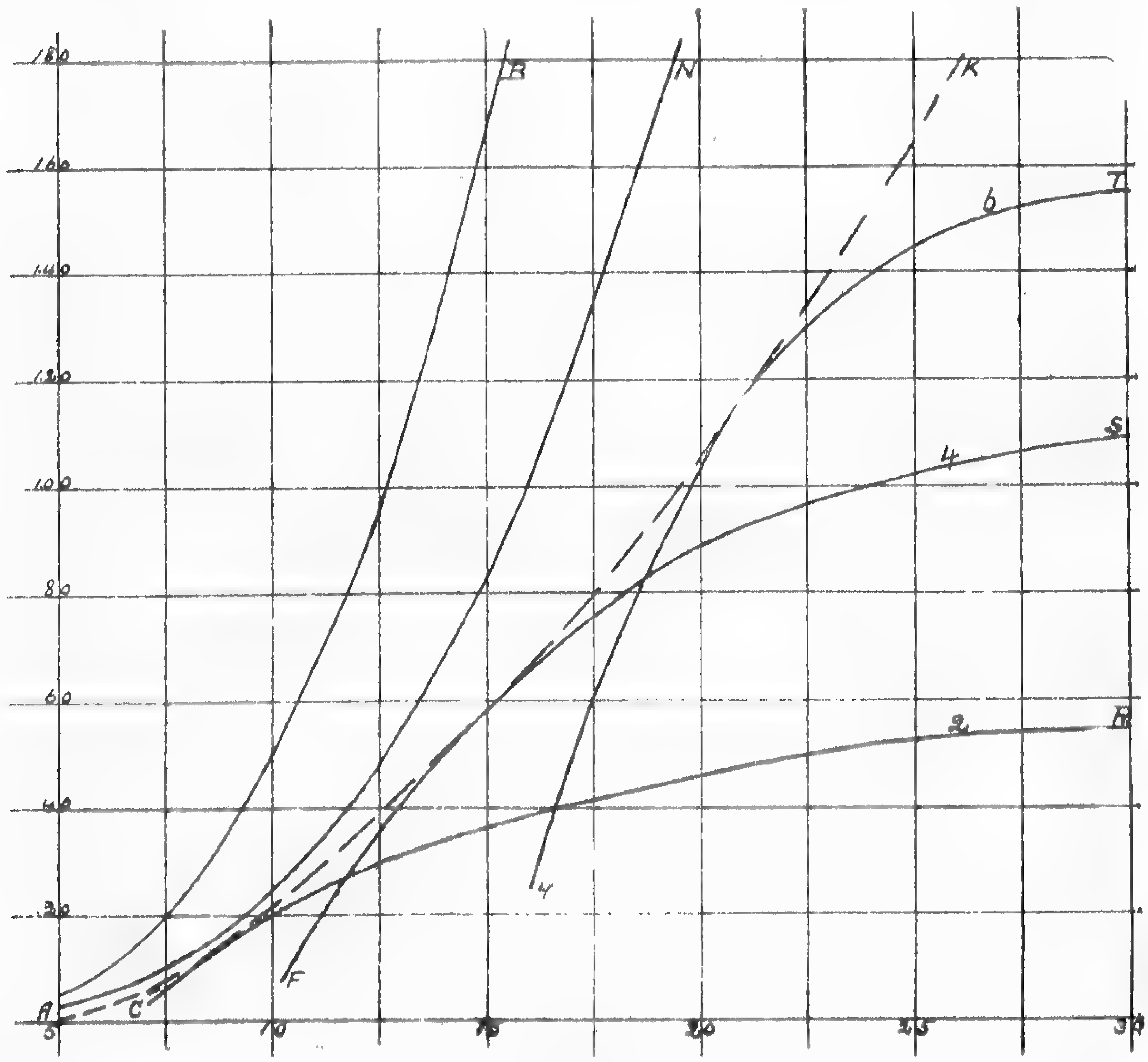


Fig. 1.

Hence for this curve AK the relation between load and wind velocity is,

$$\text{load } z = -2 + \tfrac{2}{5}x \qquad (3)$$

x being in miles per hour and z in pounds.

To find the relation between wind and velocity and velocity of wind wheel, v, for this curve we notice that y in (2) being, horse power is proportional to the product of the brake load and the velocity of the wind wheel or $y = kvz$, k being a constant. Substituting for y this value in (2) we have

$$x^2 = 25 + 345(k.v.z) \qquad (5)$$

Substituting for z its value from (3) in (5) and reducing we have

$$x^2 - 138kxv + 690kv - 25 = 0 \qquad (6)$$

Ideal curve AK.

The relation between load and wind velocity in (3) is for the useful load only. The mill also carries a useless friction load, to be considered further on. Now, if this useless load could be made to decrease as x decreases and become zero when x is zero, that is, the mill start in the lightest breeze then the curve AK would pass through the origin where x is zero and y is zero and be of the form

$$x^2 = b'y \tag{7}$$

Most of this curve would differ little from the actual curve AK. Equation (3) would then be of the form

$$z = b''x \tag{8}$$

and (6) of the form $x^2 = k'vx$ or $x = k'v$ (9)

that is, for the curve AK of the ideal mill the velocity of the wind wheel and also the useful load on the mill increases uniformly as the wind velocity increases. This curve shows the maximum power of the mill for any wind velocity, and in order for the mill to furnish it, it is necessary to increase the load on the mill at a rate equivalent to one pound on an arm of $35\frac{1}{4}$ inches, or an amount such as to yield 111 feet pounds per revolution. It will then be found that the velocity of any part of the wind wheel is increasing at a rate given by the equation $v = \frac{2}{10}Rx$ (10)

R being the distance in feet from the part to center of wheel, and v and x being in feet per second.

THE LOAD CURVES CR, FS AND HT.

These curves are seen to resemble parabolas whose axis is parallel to axis x. The equation of such a curve is of the general form

$$x = a + by^2 \tag{11}$$

a and b are constants for either curve.

For the curve CR we have y = .2 when x = 10, and y = .37 when x = 15. Hence a = 8 and y = 52 approximately and (11) becomes

$$x = 8 + 52y^2 \tag{12}$$

x being in miles per hour and y in horse power.

If this equation be plotted it will be seen that it coincides with CR very nearly to about x = 20, beyond this it is above CR, and the distance between them increases with x. The reason why CR falls below the parabola is due to the reduction of wind area or governing of the mill. The wind is constantly changing its direction and the wind wheel does not respond quickly to those changes of direction. It is pulled into the wind by a spring fastened to the tail, and the quickness of its response to changes of direction depends on the tension of this spring. The greater the wind velocity the longer it is in coming full in the wind and the greater the reduction of effective wind area and consequent loss of power. If the wheel would stay full in the wind up to, say thirty miles per hour, the curve CR would probably coincide with the parabola up to this value.

The curves FS and HT are approximately parabolas, but the departure from the parabolic form increases as the load on the mill and wind velocity increases.

MATHEMATICAL RELATIONS BASED ON THEORY AND EXPERIMENT.

Sir Isaac Newton, in his "Principia," gave the first practical formula for finding the resistance of plates to the motion of a fluid against them. His general theoretical formula for the pressure when the plane of plate is at right angles to direction of motion of the fluid is

$$P = \gamma A \frac{c^2}{2g} \tag{12}$$

P is the total pressure in pounds on the area, A the greatest area of plate, γ the heaviness of fluid (pounds per unit volume), c the wind velocity and g the acceleration of gravity.

This formula when modified to give air pressure takes the form

$$P_1 = \frac{0.0027, B.A.}{(1+.003665t)B_1} c^2 \tag{14}$$

t is the temperature in centigrade degrees, B the reading of barometer at place of observation, B_1 the barometer reading at sea level and zero centigrade and c the velocity of the air in miles per hour.

This purely theoretical formula has been tested by quite a number of scientists and engineers and found to have a correct form, but to need a coefficient in order to give the measured pressure. The value of this coefficient, as found by these experimenters, varies in value from 1.3 to 1.8. One of the latest and best of these values is 1.44, derived from Prof. S. P. Langley's experiments.

Introducing this value in (14) we have the formula

$$P_2 = \frac{0.00389BA}{(1+.0036651)B_1} c^2 \tag{15}$$

The wind velocity c is in miles per hour.

For $t = 8^0$ Cent., $B = 28.9$ ins., the standard conditions of the atmosphere when the test was made (15) reduces to

$$P_3 = 0.00364Ac^2 \tag{16}$$

P_3 is in pounds per sq. ft., A in sq. ft. and c in miles per hour. If c is in ft. per second (16) takes the form

$$P_3 = 0.00169Ac^2 \tag{17}$$

PRESSURE ON AN INCLINED PLATE.

Newton's formula for fluid pressure on a plate inclined at an angle β with the direction of motion of the fluid is

$$P_4 = \gamma A \sin^2 \alpha \frac{c^2}{2g} \tag{18}$$

Measurements of this pressure on inclined plates show that this formula has not the correct form. Prof. S. P. Langley's experiments show that wind pressure on an inclined surface is normal to the surface, varies with the shape of surface and the direction of the longest edge, whether at right angles to direction of wind or parallel to it, and that the pressure is much larger than that given by Newton's formla. Fig. 2 shows curves given the relation be-

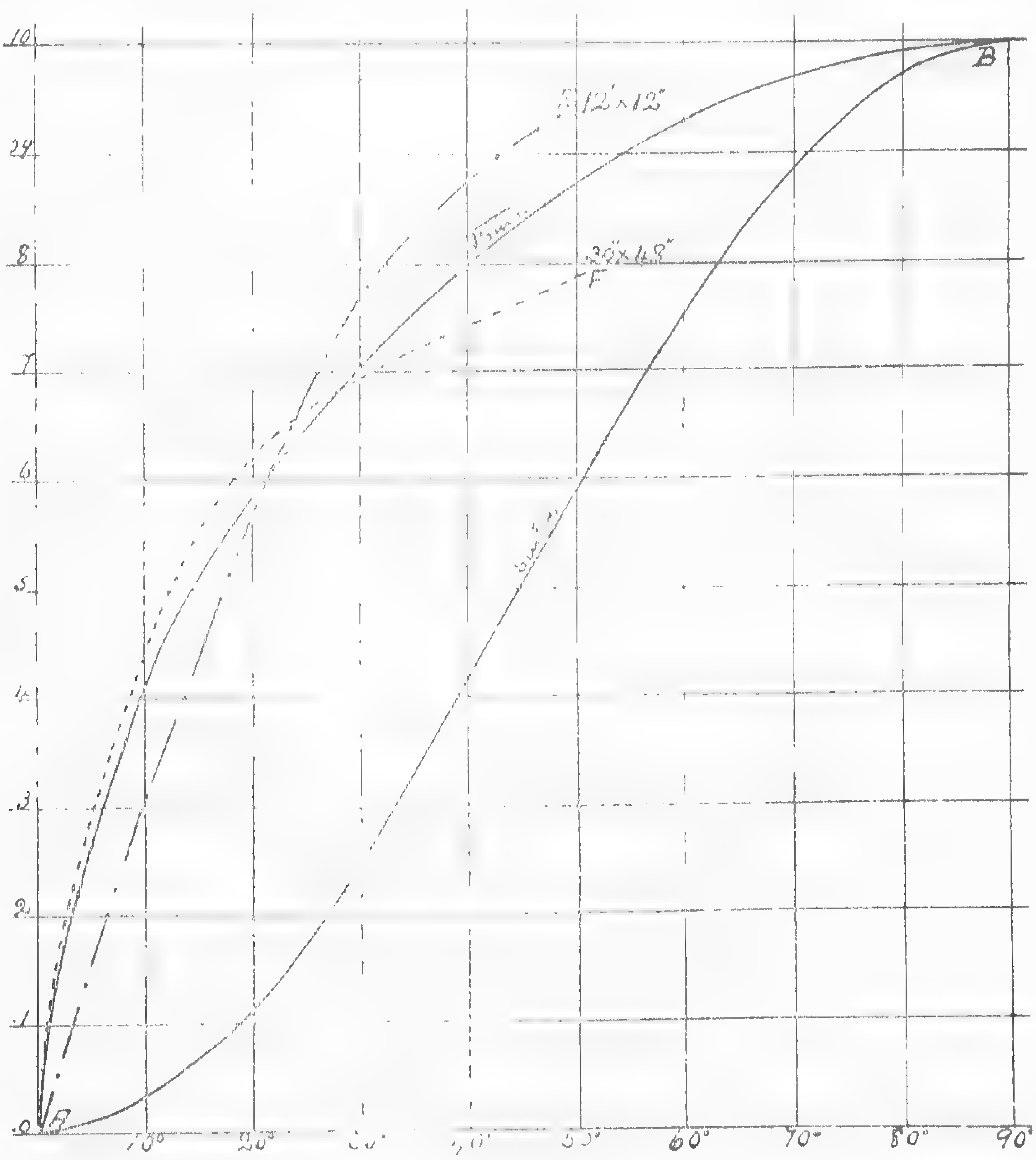


Fig. 2.

tween the ratio $\frac{P\alpha}{P_{90}}$ for value of α, $P\alpha$ being the normal pressure on a plane making an angle α with the direction of motion of the wind, P_{90} being the pressure when $\alpha = 90^0$. The curve AE is one given by Prof. Langley for a 12x12 in. plane, AF another by Prof. Langley for a 30x4-8 in. plane (ratio 6.2) the longer edge being at right angles to direction of wind. The curves for $\sin^2\alpha$ and $\sqrt{\sin\alpha}$ are also shown.

The fans of our wind mill have a mean width of 13¼″ and a length of 44 ins. The ratio of length to mean width is 3.1. The fans are slightly curved. We do not know the value of $\frac{P\alpha}{P_{90}}$ for the fans of this mill but these values lie somewhere between the values given by the curves AE and AF and they cannot differ much from those of $\sqrt{\sin\alpha}$.

It is easily seen from the curves $\sin^2\alpha$ and $\sqrt{\sin\alpha}$ that any formula for the power of a wind mill based on the assumption that the normal pressure varies as $\sin^2\alpha$ is very much in error. The formula then for the normal pressure on an inclined surface like the fan of a wind mill when not moving is from equation (18)

$$P_5 = 0.00169A\sqrt{\sin\alpha}\,c^2. \qquad (19)$$

P_5 is lbs. per sq. ft., A is sq. ft. c in ft. per second.

PRESSURE ON MOVING FAN OF WIND MILL.

In the formula (19) the surface A is stationary and the wind is striking it with a velocity c. The fans of a wind mill are moving in a plane at right angles to the direction of the wind. Let v be the volocity of a strip of a fan at a distance R from the axis of wind wheel.

In Fig. 3*, AB is this strip making an angle β with the direction of the wind. Completing the parallelogram on v and c we have v_1 the relative velocity, or velocity of wind with respect to moving fan. v_1 makes an angle α with the direction of the wind.

The normal pressure on this strip would be that due to v_1 if the strip did not move away from the wind, but the strip being inclined to v_1 is moving away from it, and the velocity producing pressure is v_1 minus the amount that the surface moves away from v_1 in the direction of v_1.

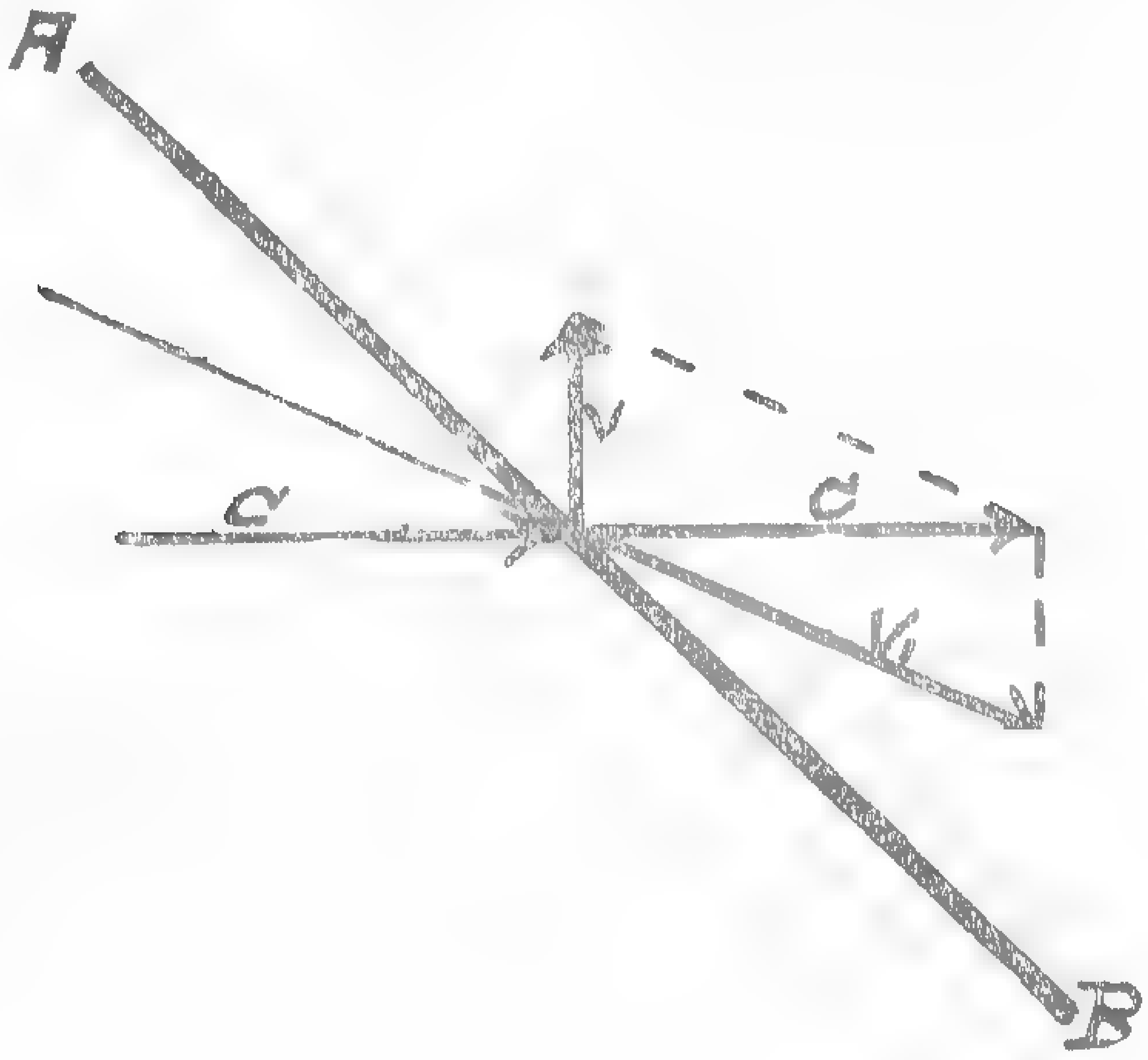


Fig. 3.

In Fig. 4, AB represents the position of the strip at the beginning of a second and A_1B_1 that at the end of the second. The wind at the beginning of second meets strip at A at the end of second it meets it at D, that is, while the strip has moved a distance

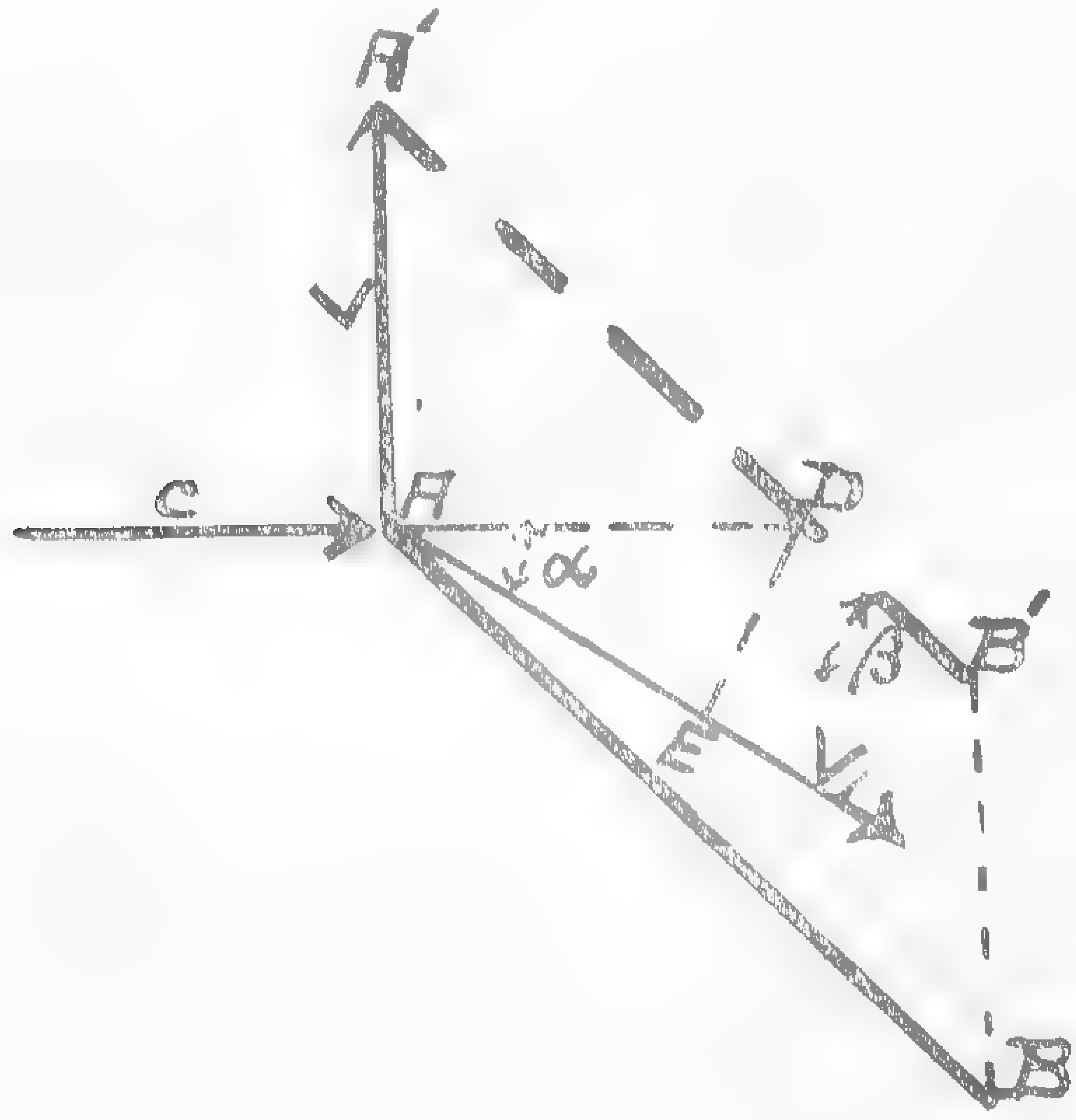


Fig. 4.

v it has moved in the direction of c a distance AD = $v\cot\beta$. While it has moved this distance in direction c it has moved AE in the direction of $v_1 = v\cot\beta\cos\alpha$. Hence the velocity producing pressure is

$$v = v_1 - v\cot\beta\cos\alpha = \sqrt{c^2 + v^2} - v\cot\beta\cos\alpha \qquad (20)$$

Substituting this value for c and A^1 for A in (19) we have for the normal pressure on a moving strip of mill

$$P_n^1=0.00169A^1(\sqrt{c^2+v^2}-v\cot\beta\cos\alpha^2)\sqrt{\sin\alpha} \qquad (21)$$

From Fig. 3 $\tan\alpha=\frac{v}{c}$. $\therefore$ $\sin\alpha=\frac{v}{\sqrt{c^2+v^2}}$ and $\cos\alpha=\frac{c}{\sqrt{c^2+v^2}}$

Substituting these in (21) we have

$$P_n^1=0.00169A^1\frac{(c^2+v^2-cv\cot\beta)^2}{\sqrt{c^2+v^2}}\frac{\sqrt{v}}{(c^2+v^2)^{\frac{1}{4}}} \qquad (22)$$

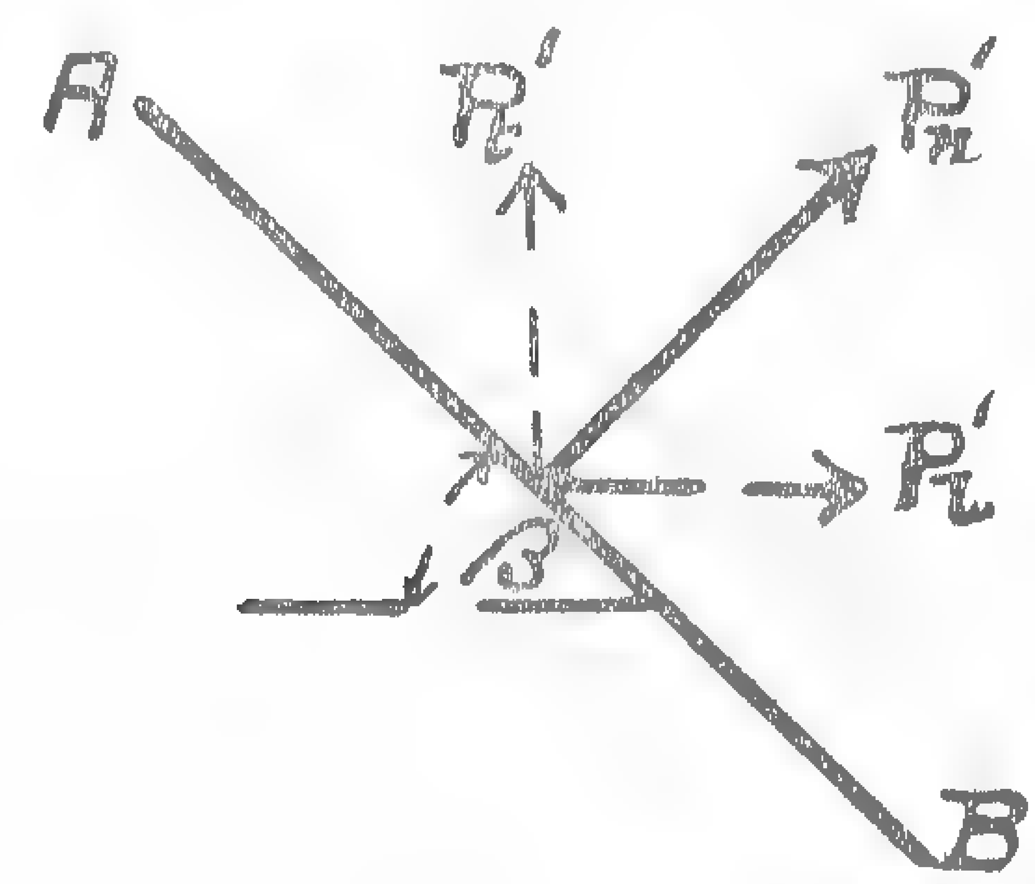


Fig. 5.

This normal pressure P_n^1 on a strip is shown in Fig. 5. Resolving it into two components, one in the plane of the wheel, the other at right angles to it, we have for P_t^1 the component which produces rotation $P_t^1=P_n^1\cos\beta$. This tangential pressure multiplied by v and divided by 550 the number of ft. lbs. per sec. in a horse power.

$$(HP)^1=\frac{0.00169A^1\cos\beta}{550}(c^2+v^2-cv\cot\beta)^2\frac{v^{\frac{3}{2}}}{(c^2+v^2)^{\frac{5}{4}}} \qquad (23)$$

Equation (23) gives the horse power of a strip of one fan. To find the horse power of the mill we must divide a fan into such a number of strips that v may be considered the same for all points of it, apply (23) to each one of these, add these and multiply the result by the number of fans in the wheel.

Equation (23) contains three variables, horse power, wind velocity and velocity of strip. If any relation between v and c be known by substituting this in (23) the resulting equation is a relation between horse power and wind velocity. This general equation then includes all the equations that can be gottten by varying the load on the mill. The two lb. curve, CR, for example, since the load is constant for it, is the relation between v and c, as well as the horse power for the useful load. By substituting this relation in (23) we get the relation between total horse power (useful and useless) and wind velocity for one strip. The relation between v and c for the curve AK is given in equation (10) namely $v = .2Rc$. Substituting this value in (23) we have

$$(HP^1)_1 = \frac{0.00169A^1\cos\beta}{550} \frac{(1 + (.2R)^2 - .2R\cot\beta)^2}{[1 + (.2R)^2]^{\frac{5}{4}}} (.2R)^{\frac{3}{2}} c^3 \quad (24)$$

Fig. 6 shows one fan of this mill divided into four strips. The

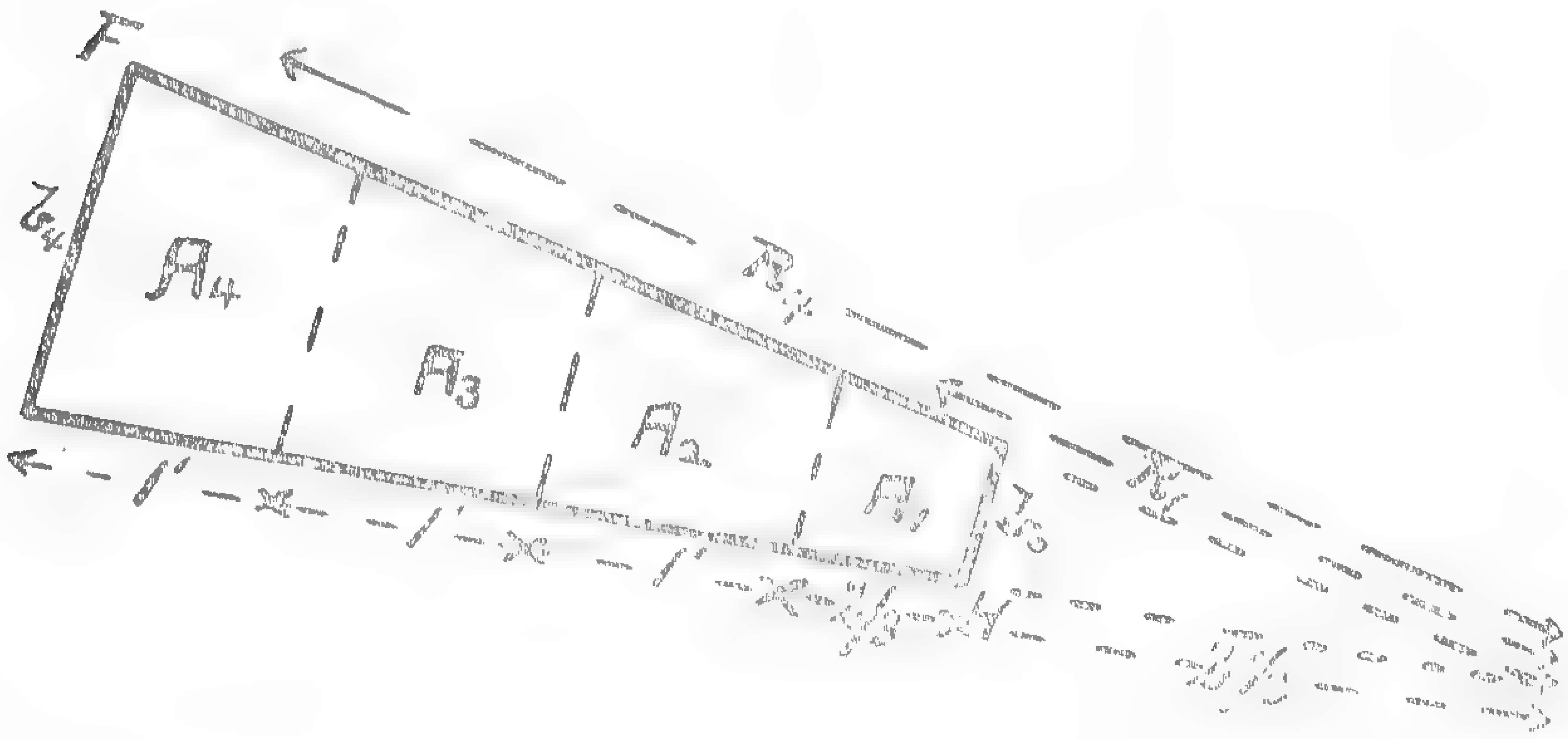


Fig. 6.

values of b, R, v, A and α for each strip are given in table I. Since $\tan\alpha = \frac{v}{c}$ and $v = .2Rc$, $\tan\alpha = .2R$, that is α is constant for any strip for all values of c.

For one of the constant load curves as CR, $v = \sqrt{\frac{c-a}{b}}$, see equation (11) $\therefore \tan\alpha = \frac{\sqrt{\frac{c-a}{b}}}{c} = \sqrt{\frac{c-a}{bc^2}}$, hence α must decrease as c increases. From (21) it is seen that as α decreases P_n' decreases, and consequently the power of the mill.

Table I.

b	R	v	A	α^0
.647				
.801	2.7	.53c	.483	$47^0—30'$
1.062	3.5	.7c	.922	41 —45
1.312	4.5	.9c	1.177	34 —47
1.563	5.5	1.1c	1.441	27 —53

Substituting for A^1 and R the different values shown in table I and for $\cos\beta$ its value, and multiplying by 18, the number of fans, we have for the total horse power of this 12 foot mill

$$(H.P.) = \frac{0.00169 \times .515}{550}(1.481 + .773 + .376 - .128)c^3$$
$$= .0000787c^3 \qquad (25)$$

c being in feet per second.

Equation (25) is a cubical parabola and is the curve AN shown in Fig. 1.

TOTAL POWER OF WIND.

The total energy of the wind which strikes the fans of this mill is kinetic energy, $KE = \frac{1}{2}Mc^2$, M being the mass of air striking the fans per second and c the wind velocity in feet per second. M = volume multiplied by heaviness and divided by acceleration of gravity, and volume = area A multiplied by c, hence we have

$$KE = \frac{\gamma A c^3}{2g} \qquad (26)$$

Dividing (26) by 550 to reduce to horse power we have

$$(H.P.) = \frac{\gamma A c^2}{2g550} \qquad (27)$$

Substituting for γ, A and g their values for the atmospheric conditions we have $(H.P.) = .000156c^3$ (28)

Equation (28) is a cubical parabola. It differs from (25) only in the value of the coefficient, which is about twice that of (25). This equation is represented by the curve AB, Fig. 1.

It appears then from (25) and (28) that this mill when loaded with a uniformly increasing useful load is using at all wind velocities about half the energy of the air which strikes its fans. From (25) and (2) it appears that the total power that this mill takes from the wind varies as the cube of the wind velocity, but that the useful power yielded varies only as the square of the velocity.

On New Canonical Forms of the Binary Quintic and Sextic.

BY BESSIE E. GROWE.

INTRODUCTORY NOTE.

The reduction of the non-singular binary cubic and quartic by linear transformation to their canonical forms $(a,0,0,d)(xy)^3$ and $(a,0,d,0,e)(xy)^4$, was achieved by Cayley early in the development of the Invariant theory. In the year 1882, Brill (Math. Annalen, XX., p. 330,) and Stephanos, in the "Mémoire sur les faisceaux de formes binaires ayant une même Jacobienne," (Tome XXVII, of the *Savants Étrangers* of the Académie des Sciences, 1883) showed that the sextic was reducible by linear transformation to the form $(a,0,c,d,e.0,g)(xy)^6$. In Elliott's Algebra of Quantics, 1895, Chap. XIII, is to be found a discussion of Hammond's canonical form of the quintic $(a,b,0,0,e,f)(xy)^5$. (See last paragraph of the preface).

In a paper on Hessians and Steinerians of Higher Orders in the Geometry of One Dimension, published in the Annals of Mathematics, Vol. XI, page 121, I gave the following theorem: *Every non-singular quantic of odd degree may be linearly transformed so that its two middle terms shall vanish; this may be done in* $\left(\frac{n-1}{2}\right)^2$ *distinct ways.* I was in possession of this result at least a year before the appearance of Elliott's book.

Miss Growe undertook, at my suggestion, to find the two new canonical forms of the quintic and sextic, which theory showed must necessarily exist.

There is still lacking a general theory of these canonical forms for higher quantics. Such a theory must involve the notion of Jacobians and Cremonians of higher orders in some way analogous to my theory of Hessians and Steinerians of higher orders.

H. B. NEWSON.

A binary $n$ic may be interpreted geometrically as a system of points on a line. When the $n$ic is written in full, the ground points (see Clebsch, Algebräische Formen, Chap. II,) are in no special way related to the points of the $n$ic; but, in order to simplify the form of the $n$ic, we may, without any loss of generality, choose any two points on the line as ground points.

Since changing the ground points is equivalent to a linear transformation, canonical forms of the $n$ic may be obtained by choosing the ground points of the system of binary coordinates on certain covariants of the $n$ic.

I Problem: To find the covariant C upon which to take the ground points in order to reduce the quintic $(a,b,c,d,e,f)(xy)^5$, to the form where b and e are zero.

$xy=0$ is the equation of the ground points.

If the ground points are to be on C, then x and y must divide out, or the coefficients of the first and last terms of C are zero. The problem then becomes:

To find the covariant C, the coefficient of whose first (and necessarily last) term is zero, when b and e are made zero.

(a) is the first coefficient of the quintic (a);

$(ac-b^2)$ is the first coefficient of the Hession (H);

$(ae-4bd+3c^2)$ is the first coefficient of a quadratic covariant (I);

$$a^2(ae-4bd+3c^2)-3(a^2c^2-2ab^2c+b^4)=0$$

when b and e are zero.

$\therefore$ the first (and last) term of the 12ic $(a^2\mathrm{I}-3\mathrm{H}^2)$ disappears when b and e are zero.

$$\therefore\ C=(a^2\mathrm{I}-3\mathrm{H}^2).$$

This covariant is of order 4 in the coefficients, and 12 in the variables. Since theory shows that the points of this covariant are associated in pairs, we have six different pairs of points which may be chosen as ground points.

Thus we have six different pairs of linear factors of the covariant C which may be used to transform the quintic to this canonical form. Hence we have

Theorem 1: *A non-singular binary quintic may be brought by linear transformation to the canonical form* $(ax^5+10cx^3y^2+10dx^2y^3+fy^5)$ *in six different ways.*

It may be interesting to know that C, in turn, is found to be the Jacobian of the quintic and another covariant S, whose second term disappears when b and e are zero, and is of the ninth degree.

Using Bruno's tables:

$$S = \mathrm{I}_4\ \phi_{3.9} + 3(\phi_{3.3}\ \phi_{4.6} + \phi_{2.2}\ \phi_{5.7}) - \phi_{3.5}\ \phi_{4.4} + \phi_{2.6}\ \phi_{5.3}.$$

II PROBLEM: To find the covariant C_1 upon which to take the ground points in order to reduce the sextic $(a,b,c,d,e,f,g)(xy)^6$ to the form where b and f are zero.

$(a^2d-3abc+2b^3)$ is the first coefficient of the Jacobian (J).

$(ac-b^2)$ is the first coefficient of the Hessian (H).

(a) is the first coefficient of the sextic (a).

$(a^2f-5abe+2acd-6bc^2+8b^2d)$ is an octavic covariant (L).

$$2(a^2d-3abc+2b^3)(ac-b^2)-a^2(a^2f-5abe+2acd-6bc^2+8b^2d)=0$$

when b and f are zero.

$\therefore$ the first and last term of $(2\mathrm{HJ}-a^2\mathrm{L})$ disappears when b and f are zero.

$$\therefore C=(2\mathrm{HJ}-a^2\mathrm{L}).$$

This is the form of Brill and Stephanos.

This covariant is of order 5 in the coefficients and 20 in the variables.

Theorem 2: *A non-singular sextic may be brought by linear transformation to the canonical form* $(a,0,c,d,e,0,g)(xy)^6$ *in ten different ways.*

This 20th degree covariant is further found to be the Jacobian of the sextic (a) and a covariant S_1 of the 16th degree, whose second term disappears when b and f are zero.

(a) is the first coefficient of the sextic (a).

$(ae-4bd+3c^2)$ is the first coefficient of a quartic covariant (K).

$(ac-b^2)$ is the first coefficient of the Hessian (H).

Forming the combination $(2a^2\mathrm{K}-\mathrm{H}^2)$:

$$2a^2(ac-4bd+3c^2)-(a^2c^2-2ab^2c+b^4)=$$
$$2a^3c-8a^2bd+5a^2c^2+2ab^2c-b^4$$

Using the operator D,

$$\left(g\frac{d}{df}+2f\frac{d}{de}+3e\frac{d}{dd}+4d\frac{d}{dc}+5c\frac{d}{db}+6b\frac{d}{da}\right)$$

To obtain the second coefficient, we have:

$$(4a^3f-24a^2be+40a^2cd+8ab^2d-40a^2cd$$
$$+20abc^2-20b^3c+6b(- - - - - - -)=0$$

when b and f are zero.

$$\therefore \mathrm{S}_1=(2a^2\mathrm{K}-\mathrm{H})^2.$$

III PROBLEM: To find the covariant C_2 upon which to take the ground points in order to obtain the canonical form of the sextic in which c and e are zero.

The following are first coefficients of covariants of the sextic in which c and e are made zero.

$a = C_{1.6}$ the sextic
$ag - 6bf - 10d^2 = I_2$
$-4bd = C_{2.4}$
$-b^2 = C_{2.8}$
$-b^2g + 3adf = C_{3.2}$
$-ad^2 = C_{3.6}$
$a^2d + 3b^3 = C_{3.12}$
$16abd^2 - 2ab^2f = C_{4.10}$

(Notated according to E. B. Elliott in *Algebra of Quantics.*)

Forming the covariant C_2, the coefficient of whose first term vanishes when c and e are zero, we have:

$$C_2 = 12C_{3.12}\,C_{4.10} - 48C^2_{1.6}\,C_{2.4}\,C_{3.6} - 8C^2_{1.6}\,C_{2.8}\,C_{3.2}$$
$$-8C_{1.6}\,C^2_{2.8}\,I_2 - 29C^2_{2.4}\,C_{2.8}\,C_{1.6}.$$

This covariant is of order 7 in the coefficients and 22 in the variables.

Theorem 3: *The non-singular sextic may be brought by linear transformation to the canonical form* $(a,b,0,d,0,f,g)(xy)^6$ *in eleven different ways.*

The covariant upon which the ground points are taken in order to drop the second, and next to the last terms of the—

cubic is of order 2 in coefficients, degree 2 in variables;
quartic is of order 3 in coefficients, degree 6 in variables;
quintic is of order 4 in coefficients, degree 12 in variables;
sextic is of order 5 in coefficients, degree 20 in variables;
$n$ic is of order $(n-1)$ in coefficients, degree $(n-1)(n-2)$ in variables.

From the consideration of the above relation between the order and degree of the covariant and that of the quantic itself, we may conclude that, in all probability the order of the covariant is given in general by $(n-1)$ and the degree by $(n-1)(n-2)$, where n is the degree of the quantic whose canonical form is required.

On the Action of Sulphuric Acid upon Strychnine, in the Separation of this Alkaloid from Organic Matter.

BY E. H. S. BAILEY AND WM. LANGE.

In the separation of the alkaloids from organic matter in the ordinary toxicological examinations, it has been found convenient to purify the alkaloid from the last portions of organic matter by evaporation of the partially purified material with a drop or two of strong sulphuric acid, and the question has arisen, to what extent does this operation destroy the alkaloid. The concentrated acid destroys the organic matter, and it would be strange if it did not, under these conditions, partially destroy the alkaloid or by hydrolysis or in some other way so change it that its presence could not be discovered by ordinary reagents. The object of these investigations was to determine if possible, to what extent this process affected the delicacy of the tests for the detection of strychnine.

The method employed for separation of an alkaloid from organic matter is usually that of Stas', modified by later investigators as the conditions of the case may suggest. For the separation of strychnine, the best method has been found to be to acidulate with acetic acid, and digest at a moderate temperature with diluted alcohol. This alcoholic solution is then evaporated and an aqueous solution is obtained, which is made alkaline with caustic potash and shaken with chloroform several times; the chloroform solution is separated, and evaporated to dryness, and the residue, dissolved in a drop of dilute acetic acid, is tested for strychnine by the appropriate reagents. If this residue is still impure, it will become colored when the sulphuric acid is added to it, on account of the decomposition of organic matter, for pure strychnine salts and sulphuric acid give no coloration, or only the very faintest trace of color.

The color tests for strychnine are considered very satisfactory if carefully performed, and in connection with the precipitation by alkaloid reagents and the examination of the crystals by the microscope, and with the physiological test also, they can be depended upon to identify the alkaloid. Our experience has been that the most delicate tests could be made by the use of sulphuric acid and potassium bichromate. In this case the succession of colors, blue, purple and red is very characteristic. The color with some other oxidizing agent, as manganese dioxide, is frequently of value as a confirmatory test, especially in the presence of other substances such as caffein. With this latter reagant the color reactions appear more slowly, but are just as definite finally.

In these experiments the delicacy of the color reaction with sulphuric acid and potassium bichromate was first established. In order to do this, solutions of strychnine of various strengths were prepared by dissolving a known weight of the alkaloid in acetic acid and water. The strength of these solutions varied from one grain of strychnine dissolved in 1000 cc. of water to one part in 1,000,000. One tenth of a cubic centimeter of the solution, corresponding to one-tenth the weight of strychnine in one cubic centimeter, was evaporated to dryness on a porcelain crucible cover, over a water bath, taking care to have all the strychnine deposited at one point on the cover. This residue was then moistened with one drop of concentrated sulphuric acid and a minute particle of potassium dichromate was drawn through the droplet with a fine glass rod. This gave the characteristic color reaction. Beginning with a concentrated solution of strychnine, the tests were made in solutions of greater dilution till a point was reached at which it was not possible to detect the alkaloid by this test. The microscope was not used in the examination of the color test.

In the second series of tests, after evaporating the solution to dryness on the porcelain cover, it was treated with a drop of concentrated sulphuric acid, and heated for fifteen minutes on the water bath, then the test was made in the usual manner.

In the third series of tests the conditions were such as would prevail in the ordinary course of analysis, when organic matter is present. To each portion, before testing, a measured quantity of extract of beef was added, twenty-five cc. of alcohol and a few drops of acetic acid and the whole was digested for an hour on a water bath. The mixture was then diluted, filtered, and evaporated to dryness on a water bath, allowed to cool and dissolved in water acidulated with a drop of acetic acid. The solution was made alkaline with potassium hydrate and shaken out twice with chloroform, about ten cc. of this solvent being used each time. The mixed chloroform solutions were then evaporated to dryness at 100° and the residue was moistened with a drop of sulphuric acid. This was warmed for fifteen minutes, then dissolved in water made alkaline with potassium hydrate and shaken out three times with chloroform. The mixed chloroform solutions were evaporated to dryness on a water bath, concentrating the residue to a small point on the porcelain surface, and the test was applied as in the preceding cases.

The results of these tests were as follows:

DELICACY OF THE CHEMICAL TESTS.

Fractions of a milligram present in the solution (x=limit, t=test).

	0.1	0.05	0.033	0.025	0.020	0.016	0.011	0.005	0.003	0.0025	0.0020	0.0016	0.0014	0.00125	0.0011	0.001	0.0005	0.00033	0.00025	0.00020
Series I. Tests with the plain solution:	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	x
Series II. Tests with strychnine and sulphuric acid.	t	t	t	t	t	t	t	t	t	t	t	t	t	t	t	x				
Series III. Tests with strychnine, sulphuric acid and organic matter.	t	t	t	t	t	x														

These experiments show that, though great care was exercised in the treatment of the residue, the action of the sulphuric acid decreases the delicacy of the reaction, so that although 25-100,000 of a milligram was detected in the original solution, after heating with sulphuric acid only 11-10,000 of a milligram was detected. After the treatment with sulphuric acid and the shaking out with chloroform, it was not possible to find the strychnine except in a solution that contained 2-100 of a milligram. It is evident that the treatment with sulphuric acid does diminish the delicacy, but that is not so large a diminution probably as the process of shaking out with chloroform. Although chloroform is an excellent solvent for strychnine, one part being soluble in eight parts of this menstruum, still so much of the strychnine is still retained in the organic matter that the portion that can be obtained from the chloroform solution is only a fraction of that which was originally present. It is probable that by more perfect extraction with chloroform, a greater quantity of strychnine can be obtained, but the experiments described above are made especially to show what will be the result, if the ordinary methods of extraction are followed.

A New Labyrinthodont from the Kansas Carboniferous.

BY S. W. WILLISTON.

With Plate XXI.

The past summer Mr. Herbert Bailey, of the University of Kansas, discovered, in the vicinity of Louisville in this state, a large fossil tooth in most excellent preservation. An examination of the tooth proved it to be of such especial interest that I shortly afterward visited the precise locality where it had been found, at the crossing of the Vermillion, east of Louisville, in company with Mr. Bailey. The geological horizon was determined by the discovery of other bone fragments, in situ. It is a dark grey shale. Below the bridge at the crossing there is an outcrop of about twenty feet of these shales, but no massive limestone layers, so that, without further examination, the precise position of the beds can not be determined. They are, however, nearly at the upper part of the Carboniferous, probably within one hundred feet of the Manhattan Limestone.

Labyrinthodont Tooth—natural size.

The specimen preserved comprises the entire crown, measuring thirty-eight millimeters in length by fourteen in diameter at the base. The immediate tip has been partly worn away in life, but was acuminate. It is composed of a dense blackish material, with the exterior smooth, shining black. It has about twenty narrow flutings nearly straight, running from the base to the tip, separating shallow grooves. A transverse section of the base shows a narrow pulp-cavity not more than five millimeters in diameter, which extends in about the same proportional width to beyond the middle of the tooth, and in all probability to near the apex. The cross-section of the tooth throughout is nearly or quite circular.

A hemisection of the tooth was made near the middle showed a structure most remarkably like that of *Mastodonsaurus*. So nearly alike, in fact, that I can discover no difference from the large figure given by Owen of a section of *Mastodonsaurus*. Indeed, had the tooth been found in Triassic deposits, without other evidence, it would be referred to that genus. Whether or not important structural differences in the labyrinthodonts are accompanied by differences in the microscopic tooth-structure I cannot say, but, until such is shown not to be the case, the present tooth may be referred to the genus *Mastodonsaurus*.

From the difficulty of obtaining a sufficiently thin section of the very opaque material of which the tooth is composed, I have not been able to make a photograph showing the entire structure. Such, however, is unnecessary, as it will show but very little not already given by Owen for *Mastodonsaurus*. I give in an accompanying plate a half-tone reproduction of a photograph of a small portion of the tooth, showing under high magnification the minute structure of the dentinal tubules.

The discovery of this tooth in the Kansas Carboniferous is of great interest, proving, as it does, the presence of true labyrinthodonts from a lower horizon than I can find any record of elsewhere. It is the only labyrinthodont hitherto discovered in America, I believe, aside from some fragmentary remains from the Triassic, described by Cope. The footprints of Amphibians, described by Marsh from the Osage beds, show very clearly that such animals were both diverse and abundant in the Upper Carboniferous times of Kansas, and it is not at all improbable that some of those which Marsh described were made by animals with teeth like the one described, inasmuch as the geological horizons can not be far separated and may be identical.

SECTION OF LABYRINTHODONT TOOTH.