

STRATIGRAPHIC SIGNIFICANCE OF CRINOIDAL
COLUMNS OF THE TRAVERSE OF MICHIGAN

by

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INTRODUCTION

Crinoidal remains, although very common as fossils in many formations, have seldom been used as index or marker fossils. Probably most geologists have realized the hopelessness of associating an individual fragment of a crinoid with the whole crinoid of which it was once a part. As a result most crinoidal remains have been lumped together in that familiar term "Crinoidea".

Only a few articles have appeared in print in which the classification of crinoidal fragments has been discussed and no previous attempt has been made to evaluate the detailed stratigraphic significance of crinoid columns. Moore (1938) laid down the principles of classification of fragmental crinoid remains.

In the Traverse group of northern Michigan there are a number of interbedded limestones and shales in which crinoidal fragments are fairly common. To date the crinoid columns of the Traverse have received little attention. The present study is concerned with the possibility of using the columnals to differentiate the various formations of the group.

The material on which the investigation is based was obtained by students and instructors of the Department of Geology of Michigan State College on numerous field trips to the outcrops of the Traverse in the northern part of the Lower Peninsula of Michigan.

Some specimens were also obtained from well samples.

PURPOSE OF STUDY

Although fragmentary crinoidal remains are not considered to be worthy of the stratigrapher's attention, and in faunal lists are grouped under the single term "Crinoidea, indet.", an attempt is made in the present study to evaluate their importance. Even with brief examination fragmentary crinoidal material can easily be separated into artificial groups. With this in mind the crinoid columnals of the Traverse group have been classified and an attempt has been made to evaluate the stratigraphic importance of such remains.

Only crinoid columns are considered in this study for they are the most abundant and widespread crinoidal remains in the Traverse group and hence have the greatest stratigraphic value.

Moore's classification has not been followed rigidly in this study. A series of letters and numbers instead of names are used to designate the various columnals.

STRATIGRAPHY

Plate IV and the brief descriptions listed below serve as a summary of the stratigraphy of the Traverse group in northern Michigan.

Alpena Area (Warthin and Cooper)

SQUAW BAY LIMESTONE: Brown limestone, dolomitic in some parts. Contains Styliolina and upper Devonian goniatites. Thickness 12 feet.

PARTRIDGE POINT FORMATION: Grey and bluish argillaceous limestones, and grey calcareous shales. Blastoid and crinoid remains numerous. Known thickness 14 feet.

POTTER FARM FORMATION: Blue to grey shales, and local interbedded crinoidal, sublithographic or argillaceous limestones. Cylindrophyllum abundant. 36 feet maximum thickness.

NORWAY POINT FORMATION: Brown and grey limestones grading upward into argillaceous and calcareous clay. Spirifer cf. granulosus and Cryphaeus boothi. 46 feet.

ALPENA LIMESTONE: Massive grey and brown granular limestone, cherty near the top. Coral reefs common and extensive. Maximum thickness about 125 feet. The Dock Street clay is a local grey clay facies of the Upper Alpena.

KILLIANS LIMESTONE: Dark grey to black limestone and black shale. This is the topmost zone of a series of black shales and limestones that interfinger with the Genshaw. It is probably a black facies of the Genshaw.

GENSHAW FORMATION: Thin grey limestones alternating with grey calcareous shales containing a large form of Atrypa and Gypidula romingeri. Maximum thickness of Genshaw and Killians, 75 feet.

FERRON POINT SHALE: Green to bluish clays, interbedded with argillaceous limestones, very fossiliferous. Thickness about 35 feet.

ROCKPORT LIMESTONE: Blue to dark grey limestone with much bituminous material. Numerous fossils. Thickness about 40 feet.

BELL SHALE: Soft, dark grey to black argillaceous shale, abundantly fossiliferous.

Afton Area

The formations in this area are similar to those around Alpena except for the beds between the Killians and the Potter Farm. This interval at Afton is made up of beds provisionally known as the Marvin, Ellis and Beebe in the upper part and the Afton beds below (Kelly, 1940). The upper beds consist of dark grey to black limestone (Marvin), massive, grey crystalline limestone (Ellis), and grey limestones, somewhat siliceous and green grey shale (Beebe). The Afton is a dense to finely granular, light grey limestone about 50 feet thick.

Petoskey Area (Pohl)

PETOSKEY FORMATION: Buff grey to black limestone, occasionally bituminous, interbedded with grey to black shale.

CHARLEVOIX LIMESTONE: Granular to massive grey and brown limestone.

GRAVEL POINT FORMATION: Dark grey to black limestone with a brownish tinge. Some bluish grey shale near the top.

These correspond in age to the Alpena-Partridge Point interval of the Alpena area and the Marvin-Beebe interval of the Afton area. The lower half of the Traverse is concealed in the Petoskey area.

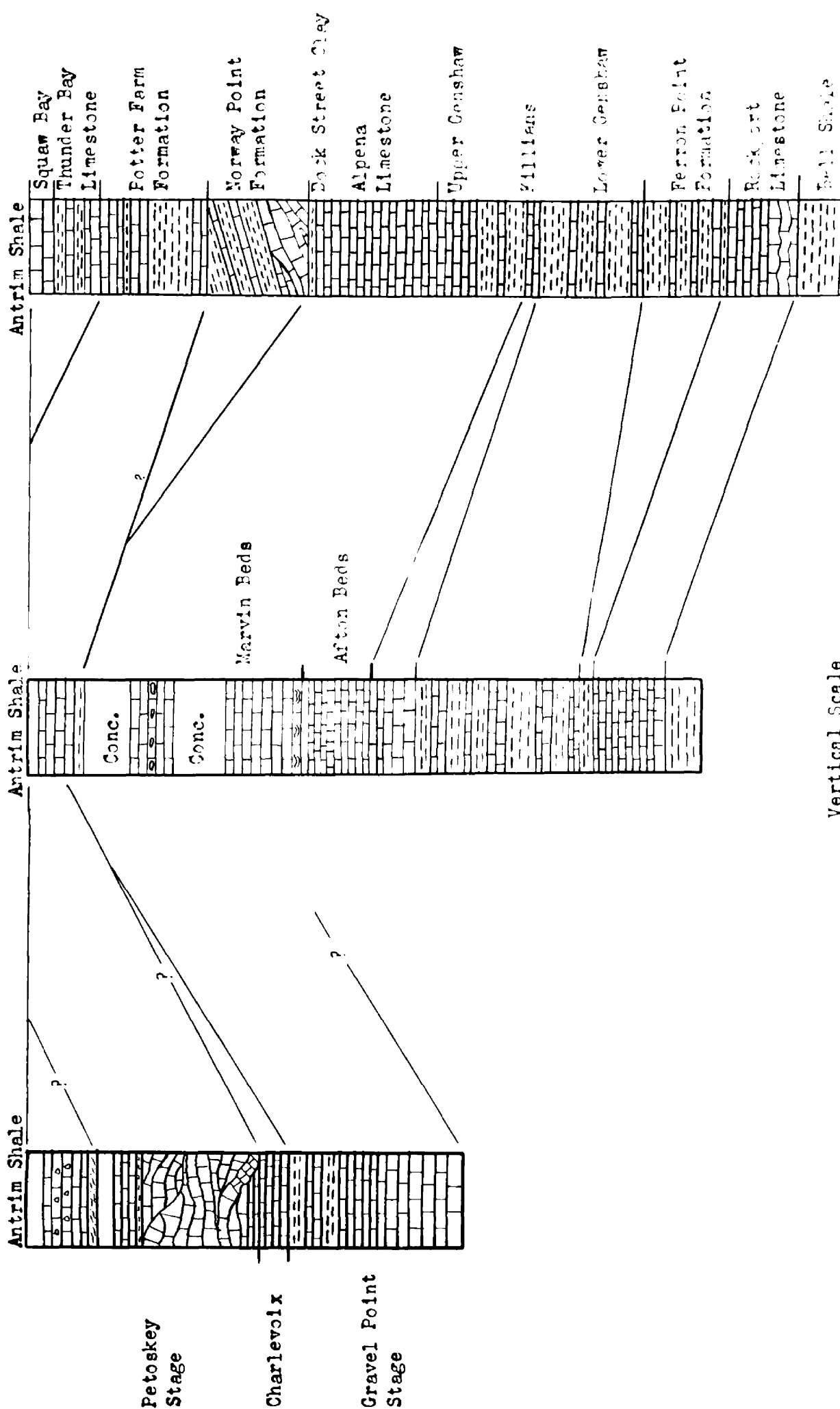
PLATE IV

Columnar sections of the Traverse group, northern part of
the Lower Peninsula of Michigan. Modified from Kelly (1940).

LITTLE TRAVERSE BAY AREA

AFTON AREA

ALPENA AREA



Vertical Scale
1 inch equals 100 ft.

METHOD OF PREPARATION

The majority of the columnals examined were free from surrounding rock and needed little preparation beyond cleaning. Those that occurred in rock matrix required special preparation. The arrangement and thickness of such columnals were obtained by making longitudinal polished sections of the stems embedded in the rock. The articulate surface proved rather difficult to obtain. Etching proved unsuccessful for it would destroy one feature of the surface while bringing out another. Polished sections were made parallel to the articulate surface. In the case of a flat articulate surface the face was ground down until it had reached the level of an articulate surface and then polished. The details of the surface were easily observed then. In the case of a concave articulate surface it was necessary to grind the surface down by successive stages and note the changes that took place in the details on the surface. On the specimens that were free of surrounding rock it was found necessary to grind and polish one articulate surface in order to be certain of the shape of the lumen.

MORPHOLOGIC CHARACTER OF CRINOID COLUMNALS

Crinoid columns are made up of disc-like or keg-shaped segments known as columnals. The top and bottom surfaces (articulate surfaces) are generally flat or slightly depressed and are pierced at the center by a canal (lumen) whose axis is perpendicular to the articulate surface.

Most columnals are circular in cross section although forms

occasionally occur in which the shape is elliptical, pentagonal, quadrangular or stellate. In the column of a single individual the columnals are usually of the same cross sectional outline but individual columnals vary in size. Those discs possessing nodes (nodal discs) are generally wider and thicker than the non-nodal segments. In the column the arrangement of nodal and non-nodal columnals is uniform and serve as a feature in distinguishing various columns.

The diameter of a columnal is considered to be the maximum distance across a columnal on the articulate surface measured through the lumen. The thickness is the maximum thickness measured parallel to the axis of the lumen.

The articulate surfaces of the columnals are grided by fine radiating ridges which are known as crenellae. Most crenellae are single, straight ridges in which case they are termed simple. Occasionally the crenellae divide on approaching the periphery. Crenellae of this type are designated as bifurcating crenellae. Along the edge of the columnal the number of crenellae is often increased by the addition of short crenellae. Such crenellae are known as implanted crenellae. In most columnals the implanted crenellae occur on one articulate surface while on the other surface bifurcating crenellae occur. When the two surfaces are in contact the implanted crenellae fit into the grooves formed by the bifurcating crenellae. The presence of implanted crenellae, however, does not imply the presence of opposite bifurcating ones

as often discs are found which have implanted crenellae on both articulate surfaces without corresponding bifurcating crenellae.

The zone between the lumen and the crenellae is designated as the central area. In many columnals this area is missing as the crenellae extend to the lumen. The central area is generally smooth and flat or slightly concave.

Most lumens were found to be circular in outline. Another very common form was the cinquefoil or pentapetaloid. Other less common outlines were pentagonal, five pointed stars, elliptical, or mere slits. The diametral ratio of the lumen is also an important feature to be noted in classification. In many columns the lumen is wider at the articulate surface than at the center of the disc. In rare cases the lumen is of different shape in different parts of the columnal.

The periphery or non-articulate surface is generally smooth. In profile it is plane, concave, convex. The most common modifications of this surface are keels, ridges and flanges. More rarely tubercles, spines or granules occur on the periphery.

TABLE I

STRATIGRAPHIC OCCURRENCE OF CRINOID COLUMNS IN
THE TRAVERSE GROUP

THE TRAVERSE GROUP													
	Lower Bell shale	Upper Bell shale	Ferron Point shale	Genshaw formation	Killians limestone	Alpena limestone	Marvin beds	Beebe beds	Dock Street clay	Norway Point ftn.	Partridge Point ftn.	Petoskey formation	Gravel Point ftn.
CC1A	.	X	.	.	.	.	.	.	X	.	.	X	.
CC1B	.	X	.	.	.	.	.	.	.	.	.	.	.
CC1C	.	X	X	.	.	.	.	.	.	X	X	.	.
CC1D	X	X	.	.	.	.	.	.	.	.	.	.	.
CC1E	.	.	.	.	.	.	.	.	.	X	.	.	.
CC1F	.	X	.	.	.	.	.	.	.	.	.	.	.
CC2A	.	.	.	X	.	.	.	.	.	.	.	.	.
CC2B	.	.	.	.	.	.	X	.	.	.	.	X	X
CC2C	.	.	.	.	.	.	.	.	X	.	X	.	.
CC2D	.	.	.	X	.	.	.	.	.	.	.	.	.
CC2E	.	.	.	.	.	.	.	.	X	.	.	.	.
CC2F	.	.	.	.	.	.	.	.	.	.	X	.	.
CC2G	.	.	X	.	.	.	.	.	.	.	.	.	.
CC3A	.	.	.	X	.	.	.	.	X	.	.	.	.
CC3B	.	.	.	X	.	.	.	.	X	.	.	.	X
CC4A	.	.	.	X	.	.	.	.	.	.	.	.	X
CC4B	.	.	X	X	.	.	.	.	.	X	.	.	.
CC4C	.	.	.	X	.	.	.	.	.	.	.	.	.
CC4D	X	.	.	.	.	.	.	.	.	.	.	.	.
CC4E	X	.	.	.	.	.	.	.	.	.	.	.	.
CC5A	.	.	.	.	.	.	.	.	.	.	X	.	.
CC6A	.	X	.	.	.	.	.	.	.	.	.	.	.
CC6B	.	X	.	.	.	.	.	.	.	.	.	.	.
CC6C	.	X	.	.	.	.	.	.	.	X	.	.	.
CC7A	.	.	.	X	.	.	.	.	X	.	.	.	.
CC7B	.	.	.	X	.	.	.	.	.	.	.	.	.
CC8A	.	.	.	.	.	.	.	.	X	.	.	.	.
CC8B	.	.	X	.	.	.	.	.	.	.	.	.	.
CC8C	.	.	X	.	.	.	.	.	.	.	.	.	.
CC9A	.	.	.	.	.	.	.	.	X	.	.	.	.
CC10A	.	.	.	X	.	.	.	.	.	.	.	.	.
CC11A	X	X	.	.	.	.	.	.	.	.	.	.	.
CC11B	.	.	.	.	.	.	.	.	.	.	X	.	.
CC12A	.	.	.	.	.	.	.	.	X	.	.	.	.
CF1A	.	.	.	.	.	X	.	.	X	.	.	.	.
CF1B	.	.	.	.	.	.	.	.	X	.	.	.	.
CF1C	X	X	.	.	.	.	.	.	.	.	.	.	.
CF1D	.	.	.	.	.	.	.	X	X	.	.	.	X
CF1E	.	.	X	X	.	.	.	.	.	.	.	.	.
CF2A	.	.	X	.	.	.	.	.	.	.	.	.	.
CF2B	.	.	.	.	.	.	.	X	.	.	.	.	.
CF3A	.	.	.	.	.	.	X	.	X	.	.	.	.
CF3B	.	.	.	.	.	.	.	.	.	X	X	.	.
CF4A	.	.	.	X	.	.	.	.	.	.	.	.	.
CF5A	.	.	X	X	.	.	.	.	.	.	.	.	.
CF5B	.	.	.	X	.	.	.	.	.	.	.	.	.
CF5C	.	.	.	.	.	X	.	.	X	.	.	.	X
CF5D	.	.	.	.	.	X	.	.	.	.	.	.	.
CF5E	.	.	.	.	.	.	.	.	X	.	.	.	.
CF5F	.	.	.	.	.	.	.	.	X	.	.	.	.
CF6A	.	.	X	.	.	.	.	.	X	.	.	.	.
CF6B	.	.	.	.	.	.	.	.	X	.	.	.	.
CF6C	.	.	X	.	.	.	.	X	.	.	.	.	.
CF6D	.	X	.	.	.	.	.	.	.	.	.	.	.
CF6E	.	.	.	.	.	.	.	.	.	X	.	.	.
CF6F	.	.	X	.	.	.	.	.	.	.	.	.	.
CT1A	.	.	.	X	.	.	.	.	.	.	.	.	.
CP1A	.	X	.	.	.	.	.	.	.	.	.	.	.
CS1A	.	X	.	.	.	.	.	.	X	.	.	.	.
CS1B	.	X	.	.	.	.	.	.	.	.	.	.	.
PC1A	.	X	.	.	.	.	.	.	.	.	.	.	.
PC2A	.	X	.	.	.	.	.	.	.	.	.	.	.
PC3A	.	X	.	.	.	.	.	.	.	.	.	.	.
PC4A	.	.	X	.	.	.	.	.	.	.	.	.	.
PC5A	.	X	.	.	.	.	.	.	.	.	.	.	.

CONCLUSIONS

This study is based on over 1000 specimens obtained from 26 localities, representing 11 geologic horizons. From the collection 65 subsections were distinguished. Not all localities were equally represented. In some localities over 100 specimens were obtained while from others only a single specimen was available for examination. Many of the specimens were in material that had been obtained by the collector for other purposes. Localities from which such collections were made are therefore poorly represented.

The conclusions reached can only be tentative. More thorough collecting at each locality will make possible a definite conclusion as to the stratigraphic value of each type of columnal.

From the material classified there is a strong suggestion that certain crinoid columns can be used as index fossils. The possibility of correlation between the Alpena - Afton area and the Petoskey area was also indicated by the few columnals that were classified from the Petoskey area.

The columnals from the Petoskey area showed many new forms that were distinct from those of the Afton - Alpena area. These forms were not classified as they were beyond the scope of the study. Only the upper half of the Traverse is exposed around Petoskey. In the Afton - Alpena area the lower half is best exposed, the upper half being mainly concealed. The difference in horizon from which the columnals of the two areas were obtained would account for the many new forms in the Petoskey area.

Limitations upon the work may be imposed as further study is carried on. For example: If certain columnals without a central area like C - C - 2 - A (Pl. I, fig. 8) prove to be a part of the column of the same species as that which in another part of the column possesses a central area as typified by C - C - 3 - A (Pl. I, fig. 10) then the value as a guide fossil will disappear, since C - C - 3 - A has an extensive stratigraphic range.

The test of whether the subsections are equivalent to true species with definite stratigraphic ranges will come with further intense collecting. The collecting which has been done so far has not been selective and unless coincidence be called upon it seems difficult to account for the presence of columnals of one subsection and the absence of columnals of another subsection in a horizon if they were both parts of the same column.

Conversely, there is no implication that because one subsection occurs in beds stratigraphically far apart, that the same species is represented. Such an occurrence may be an example of homeomorphy. From the stratigrapher's viewpoint, however, such reoccurrences of a subsection detracts from its value in correlation.

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DESCRIPTION OF COLUMNALS

Moore's classification has not been followed rigidly in this study. The broader terms used by Moore have been retained but in the smaller subdivisions a system of letters and numbers has been substituted in place of names. The classification used in this study divides Moore's section designation into subsections in order to obtain a more detailed classification which is necessary if the columnals are to be of stratigraphic value.

In this system the first letter designates the cross sectional outline: C indicates a circular cross section, P a pentagonal cross section. The second letter signifies the outline of the lumen: C is a circular lumen, F a cinquefoil one, P a pentagonal one, S a slit-like lumen. The number and last letter combine to make up the section and subsection identification.

Division CRINOSTYLI Moore (Columnals)

Main Group CYCLOSTYLI Moore

All columnals that are essentially circular in outline are included in this group.

Group CYCLOCYCLOPAE Moore

Cyclostyli which possess a circular lumen.

Section C - C - 1 Davies

Cyclocyclopae with a small lumen which is surrounded by a

tube-like ridge and no central area. Section type C - C - 1 - A

C - C - 1 - A Davies

Plate I Figure 1.

Circular cross section. Diameter 8 to 10 mm. Annulate:
Alternate nodose and non-nodose discs. Nodose disc about 1 mm.
thick, keeled and about 0.5 mm. wider than the non-nodose disc.
Non-nodose disc 1 mm. thick; periphery plane and smooth. Artic-
ulate surface slightly concave, center being depressed about 0.5
mm. Articulate surface grilled with radiating crenellae, mainly
simple; bifurcating ones rare. Lumen circular, about 0.2 mm. wide;
surrounded by a tube-like ridge 0.2 mm. wide. Ridge grilled with
crenellae.

Remarks: This columnal is very common in the Bell shale at the
Rockport Quarry. It also occurs sparingly in the Dock Street
clay. A type closely resembling this form occurs abundantly in
the Petoskey formation in the western part of the State.

C - C - 1 - B Davies

Plate I Figure 2

Circular cross section. Diameter 5 to 8 mm. Annulate:
Columnals in a series of four.

1. Nodose disc about 1 mm. thick, keeled; about 0.5 mm.
wider than columnals 2 and 4.
2. Non-nodose disc about 0.5 mm. thick.
3. Non-nodose disc about 0.5 mm. thick; about 0.2 mm wider
than columnals 2 and 4.
4. Non-nodose disc about 0.5 mm. thick.

Articulate surface slightly concave, center depressed about 0.5 mm. Lumen circular, surrounded by a tube-like ridge. Lumen 0.2 mm. wide. Ridge surrounding lumen grilled with crenellae. Articulate surface grilled with crenellae. Bifurcating and implanted crenellae common. No central area.

Remarks: This form is probably from the same species as C - C - 1 - A. It differs from that form only in the arrangement of the columnals. C - C - 1 - B is common in the Bell shale at the Rockport Quarry.

C - C - 1 - C Davies

Plate I Figure 3.

Circular cross section. Diameter 5 to 8 mm. Annulate: Alternate non-nodose discs 1 mm. thick. Each alternate disc is keeled and is 0.2 mm. wider than the other disc. Articulate surface slightly concave. Grilled with radiating crenellae. Crenellae mainly simple with some implanted. Bifurcating crenellae present on opposite side of disc. Lumen circular, 1 mm. diameter, surrounded by a tube-like ridge. No central area.

Remarks: Abundant in the Bell and Ferron Point in Presque Isle county. Also occurs in the Norway Point and the Partridge Point formations. Type specimen from the Bell shale, Rockport Quarry.

C - C - 1 - D Davies

Plate 1 Figure 4

Circular cross section. Diameter 2 to 7 mm. Columnals similar, 0.7 mm. thick and slightly keeled on periphery. Articulate surface grilled with simple and a few bifurcating crenellae. Articulate surface slightly concave. Lumen circular, 0.1 mm. wide, surrounded by a tube-like ridge, 0.2 mm. wide. Remarks: Common in the Bell shale at Rockport and Rogers City.

C - C - 1 - E Davies

Plate I Figure 5

Circular cross section. Diameter 4 mm. Annulate: Disc 1 mm. thick, slightly keeled alternating with disc 0.1 mm. thick. Articulate surface slightly concave. Grilled with simple crenellae. Lumen circular, 0.5 mm. wide, surrounded by a tube-like ridge which is grilled on the articulate surface. Remarks: Resembles others in Section C - C - 1 but the articulate surface is less concave and the tube surrounding the lumen is not so prominent. Occurs in the Norway Point formation at Seven Mile Dam, Alpena County.

C - C - 1 - F Davies

Plate I Figure 6

Circular cross section. Diameter 6 to 9 mm. Annulate: All discs similar, 1.2 mm. thick. Periphery slightly convex and smooth. Some discs slightly keeled along the periphery.

Every fourth disc occasionally nodose. Articulate surface slightly concave. Grilled with simple crenellae. Lumen circular, 0.2 mm. diameter. Surrounded by a tube-like ridge 0.2 mm. wide. No central area.

Remarks: Occurs in the Bell shale at the Rockport Quarry.

Section C - C - 2 Davies

Cyclocyclopae with a flat articulate surface, small lumen, and no central area. Section type C - C - 2 - A. One form shows a slightly concave articulate surface.

C - C - 2 - A Davies

Plate I Figure 8

Circular cross section. Diameter 4 to 8 mm. Columnals similar. Periphery plane and smooth. Each disc about 1 mm. thick. Articulate surface flat; grilled, crenellae mainly bifurcating with many short, implanted. Lumen circular, about 1 mm. in diameter. No central area.

Remarks: Very common in the Genshaw formation and confined to it. Type specimen from Roberts School corner, Presque Isle county.

C - C - 2 - B Davies

Plate I Figure 9

Circular cross section. Diameter 5 mm. Discs similar. Periphery plane and smooth. Thickness about 1.5 mm. Articulate surface flat, grilled with coarse crenellae which bifurcate at the periphery. No central area. Lumen circular, 1 mm. in diam-

eter. About half way from the center to the periphery the crenellae are crossed by a line concentric about the center.

Remarks: Found in the Marvin beds in the Afton area. Very common in the Gravel Point and Petoskey formations in the western part of the State.

C - C - 2 - C Davies

Plate I Figure 7.

Circular cross section. Diameter 5 mm. Discs similar. Periphery strongly convex and smooth. Articulate surface flat to slightly concave, grilled with fine radiating crenellae. Lumen circular, about 1 mm. in diameter. No central area. Remarks: Common in the Partridge Point formation at Partridge Point. Also common in the Dock Street clay.

C - C - 2 - D Davies

Plate I Figure 28

Circular cross section. Diameter 5 mm. Columnals alternate: Protruding columnal with a convex periphery alternating with a non-protruding one with a plane periphery. Columnals about 1.4 mm. thick. Articulate surface flat, crenellae simple. No central area. Lumen circular, 1.2 mm. in diameter. Remarks: Common in the Genshaw, S. E. corner section 25, 3 miles south of Black Lake, Cheboygan county.

C - C - 2 - E Davies

Plate I Figure 14

Circular cross section. Diameter 3 to 4 mm. Columnals similar, about 1.5 mm. thick. Periphery plane and smooth. Articulate surface flat. Crenellae mainly bifurcating, some implanted. Lumen circular, extremely small, 0.05 mm. diameter. No central area.

Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena.

C - C - 2 - F Davies

Plate I Figure 13

Circular cross section. Diameter 5 mm. Annulate, Columnals arranged in series of four:

1. Thick disc, 1 mm. thick; about 0.3 mm. wider than discs 2 and 4.
2. Thin disc, 0.2 mm. thick.
3. Thick disc, 0.5 mm. thick; about 0.1 mm. wider than discs 2 and 4.
4. Thin disc, 0.2 mm. thick.

Articulate surface slightly concave. Grilled with simple and implanted crenellae. Lumen circular, 1 mm. in diameter.

Remarks: Occurs in the Partridge Point formation at Partridge Point.

C - C - 2 - G Davies

Plate II Figure 4

Circular cross section. Diameter 2 to 3 mm. Annulate, Columnals in series of three:

1. Disc 3 mm. diameter, periphery convex and smooth.
2. Disc 2.5 mm. diameter; periphery plane and smooth.
3. Disc 2.5 mm. diameter; periphery plane and smooth.

Discs about 0.5 mm. thick. Articulate surface flat; grilled with simple, fine crenellae. Lumen circular, 0.2 mm. diameter.

Remarks: Occurs in the Ferron Point formation at Black Lake.

Section C - C - 3 Davies

Cyclocyclopae with a flat articulate surface, small lumen, and a narrow central area. Section type C - C - 3 - A.

C - C - 3 - A Davies

Plate I Figure 10

Circular cross section. Diameter 4 to 7 mm. Annulate: Discs similar, about 1 mm. thick. Periphery plane and smooth. Articulate surface flat. Crenellae mainly simple with some implanted. Lumen circular, 0.75 mm. diameter. Central area about 0.5 to 0.8 mm. wide. Smooth and flat.

Remarks: Abundant in the Genshaw, S. E. corner section 25, 3 miles south of Black Lake, Cheboygan county and at other places in Cheboygan and Presque Isle counties. Also occurs in the Dock

Street clay, the Norway Point formation and the Beebe beds.

C - C - 3 - B Davies

Plate I Figure 11.

Circular cross section. Diameter 2 mm. All discs similar. Periphery plane and smooth. Crenellae coarse and simple. Articulate surface flat. Lumen circular, 0.2 mm. diameter.

Remarks: Occurs in the Genshaw, S.E. corner section 25, 3 miles south of Black Lake, Cheboygan County. Also occurs in the Dock Street clay and the Gravel Point formation.

Section C - C - 4 Davies

Cyclocyclopae with a flat articulate surface, small lumen, and large central area. Section type C - C - 4 - A.

C - C - 4 - A Davies

Plate I Figure 12

Circular cross section. Diameter 2 to 4 mm. Discs similar, 1 mm. thick. Articulate surface flat. Grilled along periphery only. Crenellae coarse, about 0.3 mm. long. Central area flat and smooth, about 0.5 mm. wide. Lumen circular, 0.2 mm. in diameter.

Remarks: Abundant in the Genshaw at the S.E. corner section 25, 3 miles south of Black Lake, Cheboygan county and at other places in Cheboygan and Presque Isle counties. Also occurs in the Gravel Point formation.

C - C - 4 - B Davies

Plate I Figure 19

Circular cross section. Diameter 2 to 5 mm. Discs alternate: 1. Disc 1 mm. thick, keeled.

2. Disc 0.5 mm. thick. Periphery plane, smooth.

Articulate surface flat; crenellae along edge only, about 1 mm. long. Central area flat, smooth, about 0.5 mm. wide.

Remarks: Very common in the Genshaw, S.E. corner section 25, 3 miles south of Black Lake and at other places in Cheboygan county. Occurs also in the Ferron Point and the Norway Point formations in Presque Isle county.

C - C - 4 - C Davies

Plate I Figure 18

Circular cross section. Diameter 4 mm. Discs similar. 1 mm. thick. Periphery smooth and convex. Articulate surface flat with crenellae along the periphery only. Crenellae about 0.8 mm. long. Lumen circular, about 1.5 mm. in diameter. Central area smooth and flat, about 0.5 mm. wide.

Remarks: Confined to and very common in the Genshaw of Cheboygan and Presque Isle counties. Type specimen from the S.E. corner section 25, 3 miles south of Black Lake, Cheboygan county.

C - C - 4 - D Davies

Plate I Figure 15

Circular cross section. Diameter 5 mm. Annulate, Columnals in series of four:

1. Nodose disc, 1 mm. thick; 0.2 mm. wider than discs 2 and 4.
2. Non-nodose disc, 0.5 mm. thick.
3. Non-nodose disc, 0.5 mm. thick; slightly wider than discs 2 and 4.
4. Non-nodose disc, 0.5 mm. thick.

Discs 1 and 3 have a convex, smooth periphery. Discs 2 and 4 have a plane, smooth periphery. Articulate surface flat. Grilled, crenellae along periphery only, about 0.5 mm. long. Lumen circular, 1 mm. wide. Central area flat and smooth, 1 mm. wide.

Remarks: Occurs in the Bell shale at Rogers City.

C - C - 4 - E Davies

Plate I Figure 16

Circular cross section. Diameter 5 mm. Discs similar, 1 mm. thick. Periphery strongly convex and smooth. Articulate surface flat. Crenellae along periphery only, about 0.4 mm. long. Central area slightly depressed, 1 mm. wide, smooth. Lumen circular at center of disc. At articulate surface lumen is a five pointed star, 1.5 mm. in width. Lumen about 0.7 mm. wide at center of disc.

Remarks: Closely resembles C - C - 4 - C except for lumen, which in C - C - 4 - C is circular in all parts of the disc.

Occurs in the Bell shale at Rogers City.

Section C - C - 5 Davies

Cyclocyclopae with a broad lumen and no central area. Section type C - C - 5 - A

C - C - 5 - A Davies

Plate I Figure 23

Circular cross section. Diameter 7 mm. Articulate surface flat, grilled with simple crenellae alternating with implanted ones. Lumen circular, 2 mm. in diameter. Disc about 1.5 mm. thick. Periphery convex and smooth. Columnals similar. Remarks: Occurs in the Partridge Point formation at Partridge Point.

Section C - C - 6 Davies

Cyclocyclopae with a broad lumen, slightly concave articulate surface and no central area. Section type C - C - 6 - A

C - C - 6 - A Davies

Plate I Figure 25

Circular cross section. Diameter 7 mm. Annulate, alternate columnals:

1. Non-nodose disc, 0.5 mm. thick. Periphery convex, smooth; protrudes about 0.2 mm.
2. Non-nodose disc, 0.2 mm. thick. Periphery slightly convex.

Articulate surface slightly concave, grilled with bifurcating

crenellae. Lumen circular, about 2 mm. in diameter.

Remarks: Occurs in the Bell shale at Rockport.

C - C - 6 - B Davies

Plate I Figure 26

Circular cross section. Diameter 7 mm. Annulate, columnals similar, 0.8 mm. thick, keeled. Articulate surface flat, grilled with simple crenellae. Lumen circular, about 3 mm. in diameter.

Remarks: Occurs in the Bell shale at Rockport.

C - C - 6 - C Davies

Plate I Figure 24

Circular cross section. Diameter 6 mm. Annulate, Columnals in series of four:

1. Non-nodose disc, 1 mm. thick; periphery convex, keeled; disc protrudes about 0.5 mm.
2. Non-nodose disc, 1 mm. thick; periphery flat and smooth.
3. Non-nodose disc, 1 mm. thick; periphery convex, weakly keeled; protrudes about 0.25mm.
4. Non-nodose, disc, 1 mm. thick; periphery flat and smooth.

Articulate surface slightly concave. Grilled with simple crenellae. Lumen circular, 2.5 mm. in diameter. No central area.

Remarks: Occurs in the Bell shale, Rockport Quarry and the Norway Point formation at Seven Mile Dam, Alpena county.

Section C - C - 7 Davies

Cyclocyclopae with a very broad lumen, concave articulate surface and no central area. Section type C - C - 7 - A.

C - C - 7 - A Davies

Plate I Figure 20

Circular cross section. Diameter 5 mm. Annulate; alternate thick and thin discs. Thick disc 1.5 mm. thick, thin disc 1 mm. thick. Discs equal in width. Periphery of all discs smooth and flat. Articulate surface concave; grilled with bifurcating crenellae. No central area. Lumen circular, about 1.5 mm. in diameter.

Remarks: Common in the Genshaw at Roberts School, Presque Isle county. Similar form also occurs in the Dock Street clay.

C - C - 7 - B Davies

Plate I Figure 27

Circular cross section. Diameter 3 to 6 mm. Discs alternate in size. 1. Nodose, 2 mm. thick.

2. Non-nodose, 1.5 mm. thick.

Periphery of discs slightly convex, smooth. Articulate surface strongly concave. Crenellae simple. Lumen circular, about 1 mm. wide. No central area.

Remarks: Occurs in the Genshaw, S.E. corner section 25, 3 miles south of Black Lake, Cheboygan county.

Section C - C - 8 Davies

Cyclocyclopae with a very broad lumen, flat articulate surface and no central area. Section type C - C - 8 - A.

C - C - 8 - A Davies

Plate I Figure 17

Circular cross section. Diameter 5 mm. Articulate surface flat, gridded with coarse simple crenellae. Lumen large, 1.5 mm. No central area. Columnals similar, about 3 mm. thick.
Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena.

C - C - 8 - B Davies

Plate I Figure 21

Circular cross section. Diameter 3 mm. All columnals similar. 0.5 mm. thick; periphery plane, smooth. Articulate surface flat, crenellae simple. No central area. Lumen large, 1 mm. in diameter. Lumen circular in outline.
Remarks: Occurs in the Ferron Point shale, Black Lake Quarry.

C - C - 8 - C Davies

Plate I Figure 22

Circular cross section. Diameter 4 mm. Annulate: Columnals about 0.5 mm thick. Alternate discs: One disc about 0.1 mm. wider than other disc. Periphery slightly convex. Articulate surface slightly concave. Crenellae simple. Lumen circular, 2 mm. wide. No central area.

Remarks: Occurs in the Ferron Point formation, Black Lake Quarry.

Section C - C - 9 Davies

Cyclocyclopae with a very complex arrangement of crenellae on the articulate surface. Section type C - C - 9 - A.

C - C - 9 - A Davies

Plate I Figure 29

Circular cross section. Diameter 3 mm. Discs similar. 1.5 mm. thick, periphery plane and smooth. Articulate surface flat. Lumen very small, 0.05 mm diameter, circular. No central area. Crenellae complex, consisting of four groups of simple crenellae alternating with groups of crenellae made by one crenella bifurcating into numerous parallel crenellae.

Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena.

Section C - C - 10 Davies

Cyclocyclopae with a star-shaped central area. Section type C - C - 10 - A.

C - C - 10 - A Davies

Plate I Figure 30

Circular cross section. Diameter 3 mm. Lumen circular, 0.3 mm. wide. Simple crenellae along edge of disc only. Central area stellate in outline, smooth and flat.

Remarks: Only one disc of this form was observed. It was from a well in Empire township, Leelanau county (Permit 5505) at a depth of 1194 to 1200 feet. This is probably above the Bell shale and in a shale facies of the Genshaw. The Bell is 20 feet below

this zone.

Section C - C - 11 Davies

Cyclocyclopae , annulate, with cycles of eight discs to a series. Section type C - C - 11 - A

C - C - 11 - A Davies

Plate II Figure 1

Circular cross section. Diameter 3 mm. Annulate, columnals in series of eight discs:

1. Non-nodose, 0.2 mm. thick, protrudes 0.5 mm.
2. Three thin discs, 0.1 mm. thick; plane, smooth periphery.
3. Thin disc, 0.1 mm. thick, protrudes 0.2 mm.
4. Three thin discs, 0.1 mm. thick; plane, smooth periphery.

Every fourth disc of 1 above protrudes about 1 mm.. Articulate surface grilled, crenellae simple. Lumen about 1 mm. wide, circular. Articulate surface slightly concave.

Remarks: Common in the Bell shale at Rockport Quarry and Rogers City.

C - C - 11 - B Davies

Plate II Figure 2.

Circular cross section. Diameter 4 mm. Annulate: Wide disc, 4 mm. in diameter and 0.8 mm. thick followed by seven similar discs, each 3 mm. in diameter, 0.5 mm. thick; periphery plane and smooth. Articulate surface flat. Crenellae simple. No central area. Lumen circular, 1.5 mm. diameter.

Remarks: Occurs in the Partridge Point formation at Partridge Point.

Section C - C - 12 Davies

Cyclocyclopae with a flat articulate surface, coarse crenellae uniting with a broad flat ridge which surrounds the lumen. Section type C - C - 12 - A

C - C - 12 - A Davies

Plate II Figure 3

Circular cross section. Diameter 2 mm. Articulate surface flat and elevated above the edge of the disc. Coarse crenellae. Lumen circular, 0.25 mm. in diameter. Lumen is surrounded by a flat ridge to which the crenellae are united. No central area. Known from only one disc. Periphery plane and smooth.

Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena.

Group CYCLOPENTAGONOPAE Moore

Cyclostyli with cinquefoil or pentapetaloid lumens.

Section C - F - 1 Davies

Cyclopentagonopae with small lumens, flat articulate surfaces, and no central area. Section type C - F - 1 - A.

C - F - 1 - A Davies

Plate II Figure 5

Circular cross section. Diameter 6 mm. Annulate, columnals in series of four:

1. Thick disc, 1.5 mm. thick, slightly protruding, commonly

nodose.

3..Thin disc, 1 mm. thick; non-protruding.

3. Moderately thick disc, 1.2 mm. thick; slightly protruding.

4. Thin disc, 1 mm. thick; non-protruding.

Articulate surface flat. Grilled with coarse, simple crenellae.

Lumen slightly depressed, cinquefoil in shape, 1 mm. diameter.

Remarks: Occurs in the Dock Street clay and the Alpena limestone at Alpena. Type specimen from the Dock Street clay, Thunder Bay Quarry, Alpena.

C - F - 1 - B Davies

Plate II Figure 6.

Circular cross section. Diameter 6 mm. Annulate, alternate discs: 1. Thin disc, 0.5 mm. thick; keeled, keel protrudes 0.5 mm.

2. Thin disc, 0.5 mm. thick; periphery flat, smooth.

Articulate surface flat. Grilled with fine, simple crenellae.

Lumen 1.2 mm. diameter, cinquefoil in outline. No central area.

Remarks: Occurs in the Dock Street clay. This form and C - F - 1 - A probably are stems of the genus Megistocrinus.

C - F - 1 - C Davies

Plate II Figure 7

Circular cross section. Diameter 6 mm. Discs approximately equal in size, about 1 to 1.2 mm. thick. Periphery flat, smooth.

Articulate surface flat, grilled with bifurcating crenellae.

Lumen cinquefoil, 1 mm. in diameter.

Remarks: Occurs in the Bell shale at the Rockport Quarry and

Rogers City.

C - F - 1 - D Davies

Plate II Figure 8

Circular cross section. Diameter 5 mm. Columnals similar. 2 mm. thick; periphery flat and smooth. Articulate surface flat. Crenellae coarse, bifurcate at the periphery. Lumen cinquefoil, 1 mm. in diameter surrounded by a smooth area slightly depressed. Remarks : Occurs in the Gravel Point formation, the Beebe beds, and in the Dock Street clay. Type specimen from the Dock Street clay, Thunder Bay Quarry, Alpena. This form is a good index fossil as it occurs relatively high in the Traverse in the eastern, central and western part of the State.

C - F - 1 - E Davies

Plate II Figure 9.

Circular cross section, Diameter 5 to 7 mm. Columnals similar, about 1.5 mm. thick. Periphery slightly convex and covered with fine, vertical ridges which are prolongations of the crenellae. Articulate surface flat, crenellae coarse, simple. Lumen cinquefoil, 1 mm. wide. No central area. Remarks: Common in the Genshaw, S.E. corner section 25, 3 miles south of Black Lake, Cheboygan county. A similar form occurs in the Ferron Point shale in Cheboygan county but differs in a somewhat annulate character.

Section C - F - 2 Davies

Cyclopentagonopae with a small lumen, flat to slightly concave articulate surface, and a narrow central area. Section type C - F - 2 - A.

C - F - 2 - A Davies

Plate II Figure 10

Circular cross section, Diameter 5 to 7 mm. Alternate discs: 2.5 mm. and 1 mm. thick. Periphery slightly convex. Articulate surface slightly concave. Central area flat, smooth, 1 mm. wide. Crenellae simple. Lumen cinquefoil, 1.0 to 1.5 mm. in diameter. Remarks: Occurs in the Ferron ⁰Pint shale, Black Lake Quarry.

C - F - 2 - B Davies

Plate III Figure I

Circular cross section. Diameter 3 mm. Discs similar. Each about 2 mm. thick. Periphery broadly convex.. Articulate surface flat. Grilled with simple, coarse crenellae. Lumen cinquefoil, 0.2 mm. wide. Central area smooth and flat, 0.2 mm. wide.

Remarks: Occurs in the Beebe beds, Beebe School, 2 1/2 miles south of Afton.

Section C - F - 3 Davies

Cyclopentagonopae with no central area, large lumen and a very wide cross section. Section type G - F - 3 - A. Lumen indistinctly cinquefoil.

C - F - 3 - A Davies

Plate II Figure 11

Circular cross section. Diameter 8 mm. Annulate, discs similar. About 1 mm. thick, strongly keeled. Articulate surface grilled with fine, bifurcating crenellae. Lumen cinquefoil, about 3 mm. wide. Articulate surface flat. No central area.

Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena, and in the Marvin beds at Afton.

C - F - 3 - B Davies

Plate II Figure 12

Circular cross section. Diameter 13 mm. Each plate is very thin, about 0.5 mm. thick. Plates are irregular in arrangement. Each alternate plate has a tendency to be slightly thickened and protrudes slightly. Articulate surface grilled with fine bifurcating crenellae. Lumen is cinquefoil, about 3 mm. wide. Articulate surface is flat. No central area.

Remarks: Occurs in the Partridge Point at Partridge Point, and in the Norway Point at Four Mile Dam, Alpena county.

Section C - F - 4 Davies

Cyclopentagonopae with a large lumen, flat articulate surface, and no central area. Section type C - F - 4 - A.

C - F - 4 - A Davies

Plate II Figure 13

Circular cross section. Diameter 5 mm. Discs similar. 1 mm. thick. Periphery convex and smooth. Articulate surface flat. Crenellae coarse, mainly simple, some implanted. No central area. Lumen cinquefoil, 1.8 mm. in diameter.

Remarks: Occurs in the Genshaw in Cheboygan county.

Section C - F - 5 Davies

Cyclopentagonopae with large central areas and flat articulate surfaces. Section type C - F - 5 - A.

C - F - 5 - A Davies

Plate II Figure 14

Circular cross section. Diameter 4 mm. Columnals similar, 2 mm thick. Periphery plane and smooth, covered with coarse vertical ridges which are prolongations of the crenellae. Lumen cinquefoil, 1 mm. in diameter. Articulate surface flat with coarse, simple crenellae about 1.5 mm. long along the periphery. Central area flat, smooth, 0.5 mm. wide.

Remarks: Occurs in the Ferron Point at Black Lake Quarry and in the Genshaw, S.E. corner section 25, 3 miles south of Black Lake, Cheboygan county.

C - F - 5 - B Davies

Plate II Figure 15

Circular cross section. Diameter 3 to 5 mm. Columnals

similar. Each disc about 1 mm. thick. Periphery convex and keeled. Articulate surface flat. Simple crenellae along the periphery only. Crenellae about 0.75 mm. long. Central area flat, smooth, 1 mm. wide. Lumen cinquefoil, about 0.5 mm. diameter. Remarks: Occurs in the Genshaw, S.E. corner section 25, 3 miles south of Black Lake, Cheboygan county.

C - F - 5 - C Davies

Plate II Figure 16

Circular cross section. Diameter 4 mm. Articulate surface flat, grilled along the periphery only. Crenellae coarse, 0.2 mm. long. Central area about 1 mm. wide, flat and smooth. Lumen cinquefoil, 1.5 mm. wide. Slight swelling at edge of lumen. Discs about 0.75 mm. thick. Periphery slightly convex, smooth. Arrangement of columnals unknown as only single discs of this form have so far been found.

Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena and in the Gravel Point formation. This form is probably a good index fossil for this part of the upper Traverse.

C - F - 5 - D Davies

Plate II Figure 17

Circular cross section. Diameter 4 mm. Columnals alternate. Periphery slightly convex. Each alternate disc occurs with a diameter slightly less than other. Discs 0.8 mm. thick. Articulate surface flat. Crenellae along edge of disc, simple. Lumen

cinquefoil, 1 mm. in diameter. Central area 0.5 mm. wide, slightly swelled and smooth.

Remarks: Occurs in the lower Alpena Limestone, Michigan Alkali Quarry, Alpena.

C - F - 5 - E Davies

Plate III Figure 4

Circular cross section. Diameter 5 mm. Annulate, Columnals in series of four:

1. Disc 1 mm. thick, periphery strongly convex, protrudes 1 mm.
2. Disc 0.2 mm. thick, periphery flat and smooth.
3. Disc 0.4 mm. thick, periphery convex, protrudes 0.2 mm.
4. Disc 0.2 mm. thick, periphery flat, smooth.

Articulate surface flat. Grilled along the periphery only.

Crenellae simple. Central area smooth and flat. Lumen cinquefoil, 1 mm. wide.

Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena.

C - F - 5 - F Davies

Plate III Figure 6

Circular cross section. Diameter 3 mm. Articulate surface grilled along the periphery. Crenellae fine, 0.25 mm. long. Lumen cinquefoil in outline, 0.5 mm. in diameter. The lumen is surrounded by a low ridge. Central area about 1 mm. wide, smooth, depressed below the periphery and ridge. Disc about 0.5 mm. thick. Periphery convex. Arrangement of discs unknown.

Remarks: Resembles C - F - 5 - C except that central area in C - F - 5 - C is not depressed. Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena.

Section C - F - 6 Davies

Cyclopentagonopae with moderately wide columnals, very broad, distinctly cinquefoil lumens and no central area. Section type C - F - 6 - A.

C - F - 6 - A Davies

Plate II Figure 18

Circular cross section. Diameter 5 to 7 mm. Annulate, alternate protruding and non-protruding discs, 7 and 6 mm. wide respectively. 1.5 mm. thick. Periphery convex. Articulate surface flat, grilled; crenellae coarse and bifurcating. Lumen cinquefoil, large, 3 mm. in diameter.

Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena; and in the Ferron Point shale, Black Lake Quarry.

C - F - 6 - B Davies

Plate II Figure 19

Circular cross section. Diameter 5 to 7 mm. Alternate discs. Discs 1 mm. thick alternating with a group each 0.2 mm. thick. Thick discs convex on periphery and protrude slightly. Articulate surface flat, grilled. Crenellae coarse, bifurcating. Some implanted crenellae. Lumen cinquefoil, 3 mm. in diameter. No central area.

Remarks: Occurs in the Dock Street clay, Thunder Bay Quarry, Alpena.

C - F - 6 - C Davies

Plate II Figure 20

Circular cross section. Diameter 7 mm. Alternate columnals:

1. Thick disc, 1 mm. thick; periphery smooth and convex.
2. Thin disc, 0.2 mm. thick; periphery smooth and convex.

Articulate surface flat, crenellae coarse, bifurcating. Lumen cinquefoil, 3 mm. in diameter.

Remarks: Occurs in the Beebe beds, Beebe school, 2 1/2 miles south of Afton, and the Ferron Point shale at Black Lake Quarry.

C - F - 6 - D Davies

Plate III Figure 2.

Circular cross section. Diameter 7 mm. Discs similar, 0.5 mm. thick, protrude 0.2 mm. Articulate surface flat, grilled. Crenellae mainly bifurcating, some implanted. No central area. Lumen cinquefoil, 4 mm. diameter.

Remarks: Occurs in the Bell shale, Rockport Quarry.

C - F - 6 - E Davies

Plate III Figure 3

Circular cross section. Diameter 4 mm. Discs alternate. One disc protrudes with convex periphery, other disc plane periphery. Discs about 1 mm. thick. Articulate surface flat, crenellae simple. Lumen cinquefoil, 1.2 mm. wide. No central area.

Remarks: Occurs in the Norway Point formation, Four Mile Dam, Alpena county.

C - F - 6 - F Davies

Plate III Figure 5

Circular cross section. Diameter 5 to 9 mm. Articulate surface slightly concave, crenellae simple with numerous implanetd ones. Articulate surface slopes towards lumen. Lumen large, 4 mm. in diameter, cinquefoil in shape; periphery smooth, convex. Arrangements of columnals unknown.

Remarks: Occurs in the Ferron Point shale, Black Lake Quarry.

Group CYCLOSTELLANOPAE Davies

Cyclostyli with a stellate (five sided star) lumen.

Section C - T - 1 Davies

Cyclostellanopae with a flat articulate surface and a large central area. Section type C - T - 1 - A.

C - T - 1 - A Davies

Plate III Figure 7.

Circular cross section. Diameter 7 mm. Columnals about 0.8 mm. thick; periphery convex, strongly keeled. Discs similar. Articulate surface flat, crenellae simple; along edge of disc only. Central area flat, about 1 mm. wide. Lumen stellate, 0.8 mm. diameter; surrounded by a central depression 0.2 mm. wide.

Remarks: Occurs in the Genshaw formation, S.E. corner section 25,

3 miles south of Black Lake, Cheboygan county.

Group CYCLOPENTANOPAE Davies

Cyclostyli with a pentagonal lumen.

Section C - P - 1 Davies

Cyclopentanopae with a flat articulate surface and no central area. Section type C - P - 1 - A.

C - P - 1 - A Davies

Plate III Figure 8

Cross section circular. Diameter 3 to 5 mm. Articulate surface flat, grilled with simple and bifurcating crenellae. Lumen pentagonal in outline. 1 mm. in diameter. Discs about 0.8 mm. thick. Periphery convex. Arrangement of discs unknown. Remarks: Occurs in the Bell shale, Well in Empire township, Leelanau county. (Permit 5505). 1285 to 1290 feet.

Group CYCLOLINEANOPAE Davies

Cyclostyli with straight, slit-like lumens.

Section C - S - 1 Davies

Cyclolineanopae with a flat articulate surface and a central area. Section type C - S - 1 - A.

C - S - 1 - A Davies

Plate III Figure 9

Circular cross section. Diameter 2 to 4 mm. All columnals similar. Periphery plane and smooth. Columnals about 1 mm. thick. Articulate surface flat, grilled along periphery only. Crenellae coarse, simple, about 0.2 mm. long. Lumen a narrow slit 0.75 mm. long, 0.1 mm. wide. Central area flat, smooth, 1 mm. wide. Remarks: Common in the Bell shale at the Empire township, Leelanau county well and in the Dock Street clay, Thunder Bay Quarry, Alpena.

C - S - 1 - B Davies

Plate III Figure 10

Circular cross section. Diameter 2 to 3 mm. All columnals similar. Periphery slightly concave, smooth. Columnals about 1.5 mm. thick. Articulate surface flat. Grilled along edge of disc only; simple crenellae, 0.2 mm. long. Lumen a narrow slit 0.7 mm. long, 0.01 mm. wide. Central area flat to slightly depressed, smooth, 1 mm. wide.

Remarks: Differs from C - S - 1 - A in that the periphery on that form is plane while on C - S - 1 - B it is concave. Occurs in the Empire township well, Leelanau county in the Bell shale.

Main Group PENTAGONOSTYLI Moore

Crinoid columns with pentagonal or subpentagonal cross sections.

Group PENTAGONOCYCLOPAE Moore

Pentagonostyli with a circular lumen.

Section P - C - 1 Davies

Pentagonocyclopae with a stellate central area. Section type P - C - 1 - A.

P - C - 1 - A Davies

Plate III Figure 11

Pentagonal cross section. Diameter 4 mm. Discs similar. 1.5 mm. thick. Periphery plane and smooth. Articulate surface flat, crenellae along edge only. Lumen circular, 0.1 mm. wide. Central area star-shaped; segments of star extend to edge of disc, dividing disc into five parts.

Remarks: Specimen from the Bell shale, Campbell well, section 7, Walker township, 370 feet. Cheboygan County.

Section P - C - 2 Davies

Pentagonocyclopae with a central area with five circular depressions in it. Section type P - C - 2 - A

P - C - 2 - A Davies

Plate III Figure 12

Pentagonal cross section. Diameter 4 mm. Annulate, Columnals in series of four:

1. Disc 1 mm. thick.
2. Disc 0.5 mm. thick.
3. Disc 0.8 mm. thick.
4. Disc 0.5 mm. thick.

Occasionally a very thin disc occurs between discs 2 and 3; and 3 and 4. Articulate surface flat, grilled along edge only. Lumen circular, about 0.2 mm. wide. Central area flat. At each angle on the surface are circular depressions 0.8 mm. in diameter. Remarks: Occurs in the Bell shale, Rockport Quarry.

Section P - C - 3 Davies

Pentagonocyclopae with a broad, smooth central area. Section type P - C - 3 - A.

P - C - 3 - A Davies

Plate III Figure 13

Pentagonal cross section. Diameter 5 mm. Articulate surface grilled along the periphery only, crenellae about 0.3 mm. Central area flat, slightly depressed below grilling, smooth,

about 1 mm. wide. Lumen circular, 1 mm. wide. Periphery plane and smooth. Arrangement of discs unknown.

Remarks: Occurs in the Bell shale, Empire township well, Lee-lanau county, 1285 to 1290 feet.

Section P - C - 4 Davies

Pentagonocyclopae with large lumens, depressed central areas and strongly keeled discs. Section type P - C - 4 - A.

P - C - 4 - A Davies

Plate III Figure 14

Pentagonal cross section. Diameter 2 mm. Discs similar. 2 mm. thick. Periphery convex, strongly keeled. Articulate surface concave. Crenellae along edge only. 0.1 mm. long. Central area smooth and depressed. Lumen circular, 0.1 mm. diameter.

Remarks: Occurs in the Genshaw formation, Roadside, 1/4 mile south of Ocqueoc, Presque Isle county.

Section P - C - 5 Davies

Pentagonocyclopae with large lumen and a subpentagonal cross section. Section type P - C - 5 - A.

P - C - 5 - A Davies

Plate III Figure 15

Subpentagonal cross section. Diameter 2 to 3 mm. Annulate: The arrangement of the discs is very irregular. Articulate surface grilled along the edge only. Central area slightly raised and rolling. Five distinct, low ridges, arranged symmetrically extend from the raised center to the periphery. Lumen circular, 0.5 mm. diameter. Cross sectional area in this form is somewhat modified by the rounding of the angular edges of the discs.

Remarks: Occurs in the Bell shale, Rockport Quarry.

PLATE I

Figure:

- | | | | |
|-----|---------------|---------------------|--------|
| 1. | C - C - 1 - A | Articulate surface. | X 3. |
| | | Column | X 1. |
| 2. | C - C - 1 - B | Articulate surface. | X 3. |
| | | Column | X 1. |
| 3. | C - C - 1 - C | Articulate surface. | X 3. |
| | | Column | X 1.5. |
| 4. | C - C - 1 - D | Articulate surface | X 4. |
| | | Column | X 1. |
| 5. | C - C - 1 - E | Articulate surface | X 6. |
| | | Column | X 3. |
| 6. | C - C - 1 - F | Articulate surface | X 3. |
| | | Column | X 1. |
| 7. | C - C - 2 - C | Articulate surface | X 5. |
| | | Column | X 2. |
| 8. | C - C - 2 - A | Articulate surface | X 4. |
| | | Column | X 1. |
| 9. | C - C - 2 - B | Articulate surface | X 4. |
| | | Column | X 1. |
| 10. | C - C - 3 - A | Articulate surface | X 6. |
| | | Column | X 1. |
| 11. | C - C - 3 - B | Articulate surface | X 8. |
| | | Column | X 1.5. |
| 12. | C - C - 4 - A | Articulate surface | X 6. |
| | | Column | X 1.5. |

PLATE I (cont.)

Figure:

- | | | | |
|-----|---------------|--------------------|--------|
| 13. | C - C - 2 - F | Articulate surface | X 6. |
| | | Column | X 2. |
| 14. | C - C - 2 - E | Articulate surface | X 8. |
| | | Column | X 1.5. |
| 15. | C - C - 4 - D | Articulate surface | X 6. |
| | | Column | X 1. |
| 16. | C - C - 4 - E | Articulate surface | X 6. |
| | | Column | X 1. |
| 17. | C - C - 8 - A | Articulate surface | X 6. |
| | | Column | X 0.5. |
| 18. | C - C - 4 - C | Articulate surface | X 8. |
| | | Column | X 1.5. |
| 19. | C - C - 4 - B | Articulate surface | X 6. |
| | | Column | X 1.5. |
| 20. | C - C - 7 - A | Articulate surface | X 5. |
| | | Column | X 1. |
| 21. | C - C - 8 - B | Articulate surface | X 10. |
| | | Column | X 2. |
| 22. | C - C - 8 - C | Articulate surface | X 10. |
| | | Column | X 2. |
| 23. | C - C - 5 - A | Articulate surface | X 3. |
| | | Column | X 1. |
| 24. | C - C - 6 - C | Articulate surface | X 4. |
| | | Column | X 1. |

PLATE I (cont.)

Figure:

- | | | |
|-----|----------------|--------------------------|
| 25. | C - C - 6 - A | Articulate surface X 4. |
| | | Column X 1.5. |
| 26. | C - C - 6 - B | Articulate surface X 3. |
| | | Column X 1. |
| 27. | C - C - 7 - B | Articulate surface X 5. |
| | | Column X 1. |
| 28. | C - C - 2 - D | Articulate surface X 6. |
| | | Column X 1. |
| 29. | C - C - 9 - A | Articulate surface X 10. |
| | | Column X 1. |
| 30. | C - C - 10 - A | Articulate surface X 10. |
| | | Column X 2. |

PLATE I

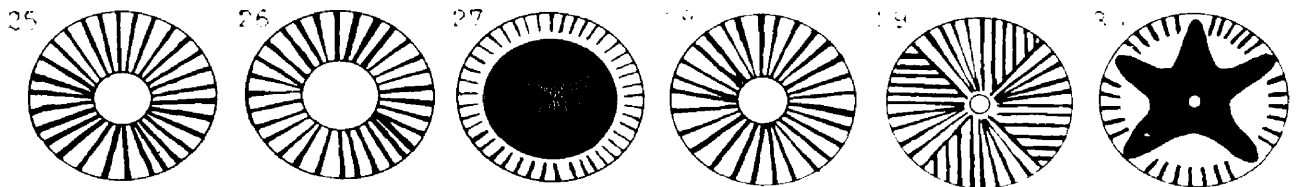
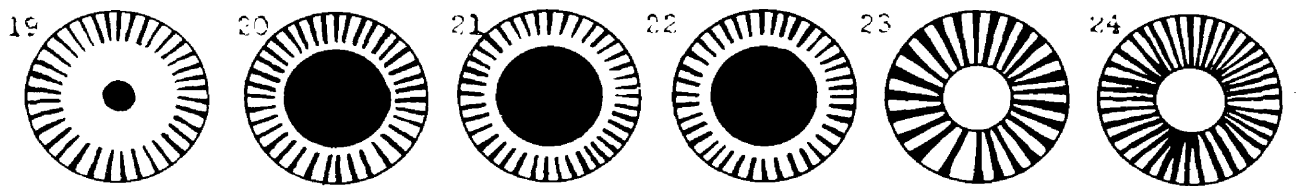
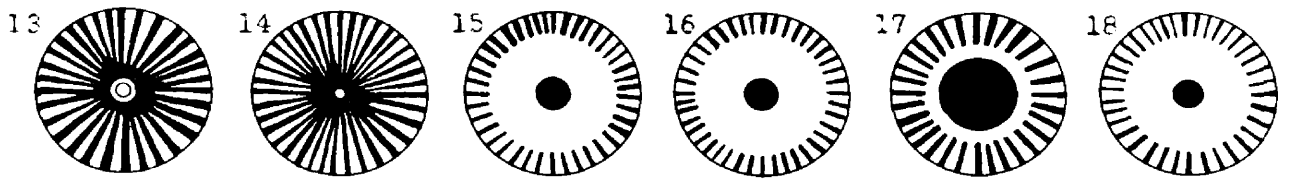
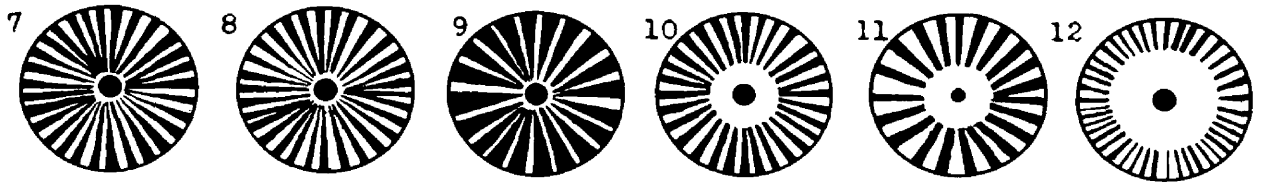
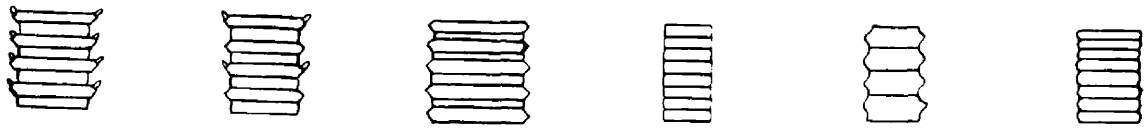
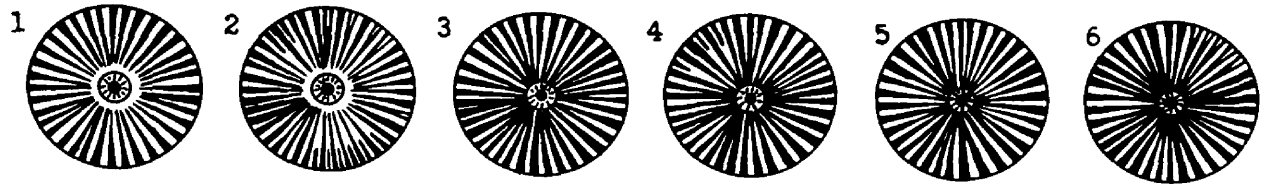


PLATE II

Figure:

- | | | |
|-----|----------------|---|
| 1. | C - C - 11 - A | Articulate surface X 8.
Column X 1. |
| 2. | C - C - 11 - B | Articulate surface X 8.
Column X 1. |
| 3. | C - C - 12 - A | Articulate surface X 10.
Column X 1. |
| 4. | C - C - 2 - G | Articulate surface X 8.
Column X 2. |
| 5. | C - F - 1 - A | Articulate surface X 4.
Column X 1. |
| 6. | C - F - 1 - B | Articulate surface X 4.
Column X 1. |
| 7. | C - F - 1 - C | Articulate surface X 4.
Column X 1. |
| 8. | C - F - 1 - D | Articulate surface X 6.
Column X 1. |
| 9. | C - F - 1 - E | Articulate surface X 4.
Column X 1. |
| 10. | C - F - 2 - A | Articulate surface X 5.
Column X 1. |
| 11. | C - F - 3 - A | Articulate surface X 3.
Column X 1. |
| 12. | C - F - 3 - B | Articulate surface X 2.
Column X 1. |

PLATE II (cont.)

Figure:

- | | | | |
|-----|---------------|--------------------|--------|
| 13. | C - F - 4 - A | Articulate surface | X 6. |
| | | Column | X 0.5. |
| 14. | C - F - 5 - A | Articulate surface | X 8. |
| | | Column | X 1. |
| 15. | C - F - 5 - B | Articulate surface | X 6. |
| | | Column | X 1. |
| 16. | C - F - 5 - C | Articulate surface | X 6. |
| | | Column | X 1. |
| 17. | C - F - 5 - D | Articulate surface | X 10. |
| | | Column | X 2. |
| 18. | C - F - 6 - A | Articulate surface | X 5. |
| | | Column | X 2. |
| 19. | C - F - 6 - B | Articulate surface | X 5. |
| | | Column | X 2. |
| 20. | C - F - 6 - C | Articulate surface | X 5. |
| | | Column | X 2. |

PLATE II

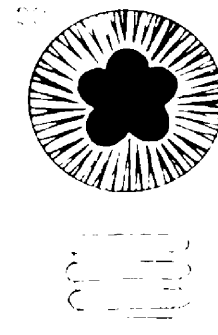
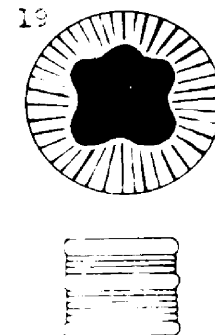
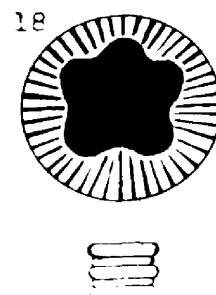
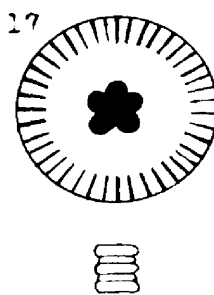
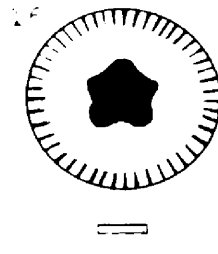
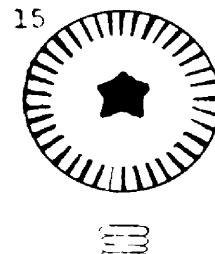
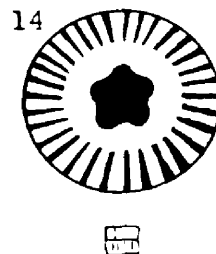
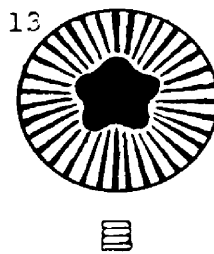
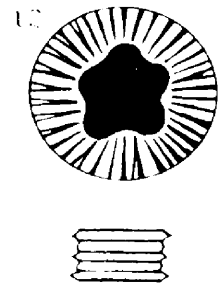
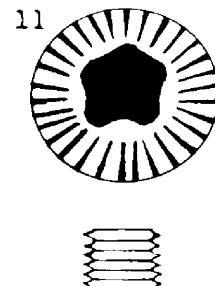
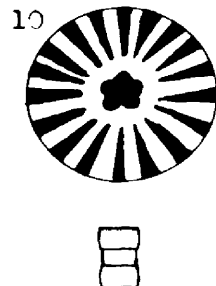
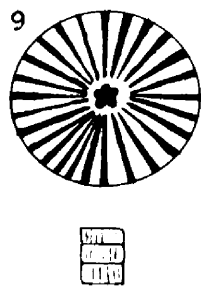
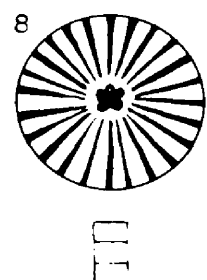
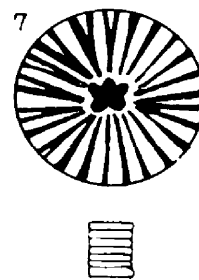
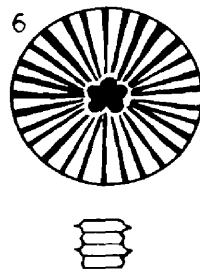
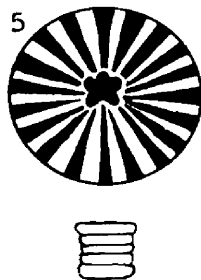
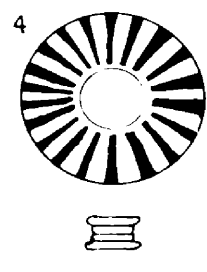
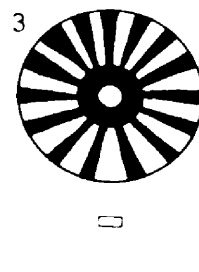
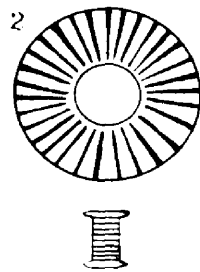
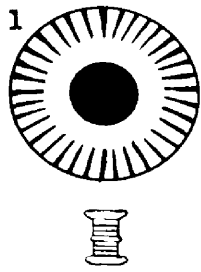


PLATE III

Figure:

1. C - F - 2 - B Articulate surface X 8.
Column X 1.
2. C - F - 6 - D Articulate surface X 4.
Column X 1.
3. C - F - 6 - E Articulate surface X 6.
Column X 1.
4. C - F - 5 - E Articulate surface X 8.
Column X 2.
5. C - F - 6 - F Articulate surface X 4.
Column X 1.
6. C - F - 5 - F Articulate surface X 8.
Column X 1.
7. C - T - 1 - A Articulate surface X 6.
Column X 1.
8. C - P - 1 - A Articulate surface X 6.
Column X 1.
9. C - S - 1 - A Articulate surface X 10.
Column X 1.
10. C - S - 1 - B Articulate surface X 10.
Column X 1.
11. P - C - 1 - A Articulate surface X 10.
Column X 1.
12. P - C - 2 - A Articulate surface X 8.
Column X 1.

PLATE III (cont.)

Figure:

13. P - C - 3 - A Articulate surface X 8.
Column X 1.
14. P - C - 4 - A Articulate surface X 10.
Column X 2.
15. P - C - 5 - A Articulate surface X 8.
Column X 1.

PLATE III

