ABSTRACT

Nautiloids are widely distributed in the marine Permian of western United States, and a few specimens are known from southwestern Canada, northeastern Mexico, and northern Colombia (and probably adjacent portions of Venezuela). Stratigraphically they range throughout the system and locally they are abundant in the Lower Permian of north-central Texas and southeastern Wyoming and the Middle Permian of the Southwest.

All of them have either orthoceraconic or nautiliconic conchs, but that of one genus (*Pseudorthoceras*) is slightly cyrtoceraconic. Ribs, nodes, and even spines are present on many of the coiled forms. Most of the straight (and the slightly curved) ones have cyrtochoanitic siphuncles, but a few of these and all of the coiled ones are orthochoanites.

Altogether about a hundred species of nautiloids are known from the Permian of the Americas. On the basis of the structure of the siphuncle, the form of the conch, the shape of the sutures, and the nature of the surface "ornamentation" of the test, these can be grouped into nine families: (1) the Pseudorthoceratidae, which includes *Pseudorthoceras* and *Mooreoceras*; (2) the Orthocerotidae, which includes *Michelinoceras* and *Bitaunioceras*; (3) the Bactritidae, which includes *Bactrites*; (4) the Koninckioceratidae, which includes *Koninckioceras*, *Knightoceras*, and *Endolobus*; (5) the Domatoceratidae, which includes *Domatoceras*, *Stearoceras*, *Titanoceras*, and *Stenopoceras*; (6) the Tainoceratidae, which includes *Tainoceras*, *Aulametacoceras*, *Temnocheilus*, *Foordiceras*, *Metacoceras*, and *Cooperoceras*; (7) the Liroceratidae, which includes *Liroceras* and *Coelogasteroceras*; (8) the Ephippioceratidae, which includes *Ephippioceras*; and (9) the Solenochilidae, which includes *Solenochilus*. The first of these families contains all of the cyrtochoanites known from the Permian; the first three contain all of the orthoceracones (and cyrtoceracones); and the last six consist exclusively of nautilicones.

INTRODUCTION AND ACKNOWLEDGMENTS

Very little attention has been given to the nautiloids of the Permian in comparison to the ammonoids. They seem to be far less abundant, but their relative dearth may be somewhat more apparent than real. That is, they are generally believed to have comparatively little stratigraphic value, and therefore they are not sought as diligently and when found are often neglected.

Although we have no illusions in regard to the value of Late Paleozoic nautiloids as index fossils, we believe that they should be given consideration. In some cases they occur in beds that contain few if any ammonoids or other fossils that are good stratigraphic indices, and furthermore Permian forms need to be studied so that those which occur in older and younger systems can be better understood. Accordingly, we have attempted to assemble as much new material as possible and to bring together in one volume all of the available data in regard to the Permian nautiloids of this hemisphere. A brief summary of those known from elsewhere is included. It is our hope that this report will be helpful to geologists and paleontologists in general, and that it will stimulate some of them to collect and study Permian nautiloids when opportunity arises.

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PREVIOUS WORK

In the older literature, American Permian nautiloids are for the most part treated more or less incidentally. Nevertheless, certain reports are noteworthy. For example, as early as 1858 Swallow described four species that Major Frederick Hawn had collected in Kansas, and in the following year Shumard (1859, p. 399–400) mentioned that both straight and coiled forms occur in the Permian strata of the Guadalupe Mountains of west Texas. Then in 1891, White illustrated a considerable cephalopod fauna, consisting of both nautiloids and ammonoids, from the Clyde formation at the "Old Military Crossing" of the Big Wichita River in north-central Texas; and in the same year Hyatt published on some specimens that Mr.

Robert Hay and Captain George E. Pond had collected near Junction City, Kansas, presumably from the Fort Riley limestone. Two years later, this last author described five species from the same horizon and locality as those studied in 1891 by White; and he also reported the occurrence of a somewhat similar fauna near Ballinger, Texas, presumably in the Lueders formation, and of a single specimen in the "upper valley of Zuni Plateau, 12 to 15 miles" southwest of Grants, New Mexico, probably in the Chupadera formation.

Considerably more progress has been made during the portion of the present century that has elapsed, and many of the published papers merit special mention. In 1908 Girty described several species of nautiloids from three rather widely separated horizons in the Permian of the Guadalupe Mountains; and a year later he published studies of a few specimens from the Abo, Yeso, and San Andres formations in the upper Rio Grande valley of southern New Mexico. Sporadic cephalopods have long been known from the Permian of the Rocky Mountain area, but the first nautiloid fauna of this age to be described from there is that which in 1936 Miller and Thomas reported from the Casper formation of southeastern Wyoming. Additional material from that state was described in 1942 by Miller and Unklesbay, who also had a considerable assemblage of nautiloids from the Permian of the Arizona-New Mexico region. These authors included in their report a brief summary of the data in regard to Permian nautiloids that were available at the time. In the same issue of the JOURNAL OF PALEONTOLOGY in which the Miller-Unklesbay paper was published, there appeared a report by R. L. Clifton on the invertebrate faunas of the Blaine and Dog Creek formations of north-central Texas, and he had straight and coiled nautiloids from both formations. Then in 1945, Miller illustrated and described some fine silicified specimens which G. A. Cooper and Stanislaus Kříž had obtained by dissolving in hydrochloric acid blocks of Permian limestone from the Glass Mountains and the Sierra Diablo of west Texas. Still more recently, Miller and Kemp (1947) established the occurrence of *Koninckioceras* in the Permian and listed the nautiloid genera known to be represented in the Lower Permian formations of Baylor County, Texas. Also, in 1947 Miller and Youngquist published a study of a variety of Lower Permian nautiloids (and associated ammonoids) which R. C. Moore had obtained from the Lower Permian of the Texas Colorado River valley.

It should be added that very little information indeed has been published in regard to Permian nautiloids in the western hemisphere outside the confines of the United States. However, in 1927 Christ stated that poorly preserved specimens occur in the Permian of northwestern Venezuela; in 1936 Miller and Crockford illustrated an orthoceraconic form from the Cache Creek series of southern British Columbia; in 1944 Miller described representatives of five genera from the zones of *Perrinites*, *Waagenoceras*, and *Timorites* in southwestern Coahuila; and the following year Miller and Williams mentioned the discovery of a coiled specimen in the zone of *Perrinites* in northern Colombia. (*See also* Thompson and Miller, 1949.)

OCCURRENCE

GENERAL STATEMENT

Relatively few nautiloid cephalopods are known from the Permian in comparison to the rest of the Paleozoic except the Cambrian. As a matter of fact, after Pennsyl-

vanian times nautiloids were not abundant, with a few notable exceptions such as *Eutrephoceras* in the Cretaceous and *Cimomia* and *Hercoglossa* in the Paleocene. This general stratigraphic distribution contrasts strongly with that of the ammonoids and of course suggests that the two groups were mutually complementary. Nevertheless, almost all Late Paleozoic ammonoid faunas contain at least a few nautiloids, though the reverse cannot be said to be true, for example, that known from the Casper sandstone of Wyoming.

For the most part, nautiloids are sporadic in the Permian, and because their shells, like those of modern *Nautilus*, were almost certainly quite buoyant, they may have floated a considerable distance before coming to rest. Their extreme abundance at certain localities in strata of various ages is probably a result of concentration by currents, particularly eddies.

In Texas, where the Permian strata have been studied extensively, certain generalizations have become apparent. For example, in the Guadalupe Mountains, nautiloids, which have heavier shells than ammonoids, are relatively abundant in the more massive limestones. Also, at one locality in the Sierra Diablo, a massively bedded limestone member of the Bone Spring formation has yielded a considerable variety of nautiloids in association with sparse ammonoids. A comparable case is known from the upper part of the Leonard formation of the Glass Mountains, but nautiloids seem to be rare in the Word formation which overlies the Leonard and which carries ammonoids "by the thousands". However, in north-central Texas both nautiloids and ammonoids occur abundantly in direct association in the Lower Permian Wildcat Creek ("Indian Creek") shale and Grape Creek limestone.

AMERICAN MID-CONTINENT REGION

In the Permian of the northern portion of the Mid-Continent region of North America, that is, in Nebraska and Kansas, nautiloids are not abundant and for the most part are sporadic. The same can be said for ammonoids. Many other types of invertebrates are, however, not rare. Therefore it does not seem that the conditions for preservation were unsatisfactory, but rather that the ecology was such as to discourage extensive migration of cephalopods from the southern part of the same region, where both nautiloids and ammonoids are much more abundant. It is likely that the controlling factor was abnormal salinity of the waters in the northern Mid-Continent region. The fact that the rocks there are predominantly shales might lead one to the conclusion that the waters were muddy, but in many parts of the world cephalopods are not rare in Late Paleozoic shales.

As is well known, there is no generally recognized dividing line between the Pennsylvanian and the Permian in this northern area. However, it now seems that some of the oldest Permian nautiloids that have been found here came from the Hughes Creek shale in Nebraska. These are referable to *Tainoceras nebrascense* Miller, Dunbar, and Condra, and *Solenochilus syracusense* of the same authors—the latter is known from only one specimen. Something like 100 feet higher in the section comes the well-known Neva limestone, which has been regarded by some stratigraphers as the base of the Permian in this area. It carries two species of nautiloids, *Stearoceras sublaeve* Miller, Dunbar, and Condra (from Nebraska) and *Steno-*

poceras cooperi Miller and Unklesbay (from Kansas)—the latter is again known from only one specimen. The Florena shale of Kansas, about 50 feet higher than the Neva, has yielded a single nautiloid, *Stenopoceras* sp.

The only Permian formation in the northern Mid-Continent region that has been found to carry an appreciable nautiloid fauna is the Fort Riley limestone, some 300 feet stratigraphically above the Florena. Long ago, Hyatt described four species from this formation near Junction City, Kansas, and since then two additional forms have been found in southeastern Nebraska. Altogether we now know the following nautiloids from the Fort Riley:

Stenopoceras dumbli (Hyatt)
Tainoceras nebrascense Miller, Dunbar, and Condra
Metacoceras dubium Hyatt
M. hayi Hyatt
M. inconspicuum Hyatt
M. sp.

In this connection it should be mentioned that the literature contains descriptions of one poorly known species, *Tainoceras occidentale* (Swallow), from some unrecorded horizon and locality in the Late Paleozoic of the "valley of the Cotton-wood" River of east-central Kansas, and the following four from "near the Smoky-Hill Fork" of the Kansas River in central Kansas: *Mooreoceras kickapooense* (Swallow), *Koninckioceras? eccentricum* (Meek and Hayden), *Stearoceras? permianum* (Swallow), and *Solenochilus? dorsatum* (Swallow). Most probably all of these are Lower Permian in age.

In the Permian deposits of the southern part of our Mid-Continent region, that is, in north-central Texas, cephalopods are not particularly rare at several horizons, and locally they are quite abundant, for example, in the Wildcat Creek shale member of the Admiral formation some 4½ miles south-southwest of Coleman, Texas. The dividing line between the Pennsylvanian and the Permian in this area, just as in Kansas and Nebraska, has not been well established. However, several authors have recently suggested that it should probably be drawn slightly below the Camp Creek shale member of the Pueblo formation (which is some 25 feet above the Saddle Creek limestone). The Camp Creek is now known to carry two species of nautiloids, *Pseudorthoceras knoxense* (McChesney)? and *Ephippioceras inexpectens* Miller and Youngquist, as well as one of ammonoids, *Artinskia lilianae* Miller and Youngquist. These cephalopods cannot be said to establish a Lower Permian age for the containing beds, but they are certainly in harmony with it.

About 600 feet stratigraphically above the Camp Creek are some beds that were formerly called the Indian Creek shale but are now known as the Wildcat Creek shale member of the Admiral formation. Both ammonoids and nautiloids are abundant in them. The ammonoids belong in the genera *Neopronorites?*, *Artinskia*, *Pseudogastrioceras*, *Metalegoceras*, *Agathiceras*, *Peritrochia*, and *Properrinites*; and the nautiloids are referable to the following species:

Pseudorthoceras knoxense (McChesney)
Bitaunioceras texanum Miller and Youngquist
Liroceras globulare (Hyatt)
Foordiceras ornatissimum, n. sp.
Metacoceras cheneyi Miller and Youngquist
Stenopoceras sp.

It should probably be stated that in this fauna *Agathiceras applini* Plummer and Scott and *Pseudorthoceras knoxense* (McChesney) are extremely abundant, and

Liroceras globulare and *Metacoceras cheneyi* (as well as representatives of the ammonoid genera *Artinskia*, *Metalegoceras*, *Peritrochia*, and *Properrinites*) are not rare.

The uppermost member of the Admiral formation, the Elm Creek limestone, lies about 165 feet stratigraphically above the Wildcat Creek shale. No ammonoids are known from it, but from outcrops in Baylor County, Texas, Mrs. Augusta Hasslock Kemp has collected quite a variety of only moderately well preserved nautiloids:

Pseudorthoceras knoxense (McChesney)
Mooreoceras sp.
Stearoceras sp.
Stenopoceras whitei, n. sp.?
Temnocheilus sp.
Metacoceras sp.
Liroceras globulare (Hyatt)

Some 500 feet higher in the north-central Texas section, in the Grape Creek limestone of the Clyde formation (the horizon of the well known "Old Military Crossing" of the Big Wichita River), both ammonoids and nautiloids occur in some abundance. The former represent the genera *Medlicottia*, *Metalegoceras*, *Popanoceras*, and *Properrinites*; and the latter the following species:

Pseudorthoceras knoxense (McChesney)
Mooreoceras sp.
Knightoceras kempae, n. sp.
Stearoceras conchiferum (Hyatt)
S. militarium (Hyatt)
S. simplex (Hyatt)
Stenopoceras whitei, n. sp.
Tainoceras clydense Miller and Kemp
Temnocheilus sp.
Foordiceras sp.
Metacoceras sp.
Liroceras globulare (Hyatt)

In the Lueders formation (and possibly just below its base), about 100 feet stratigraphically above the Grape Creek limestone, a considerable variety of nautiloids (but no ammonoids) has been found:

Mooreoceras sp.
Koninckioceras bibbi Miller and Kemp
Endolobus renfroae, n. sp.
Stearoceras conchiferum (Hyatt)
Stenopoceras whitei, n. sp.
Tainoceras clydense Miller and Kemp
Temnocheilus sp.
Metacoceras baylorense, n. sp.
Metacoceras sp.
Solenochilus kempae, n. sp.

The Lower Permian of north-central Texas has also yielded a few nautiloids of which the exact horizon is uncertain. That is, long ago Hyatt described from near the city of Ballinger four forms:

Endolobus? sp.
Stearoceras simplex (Hyatt)
Tainoceras cavatum Hyatt
Solenochilus sp.

Also, the genotype of *Stenopoceras*, *S. dumbli* (Hyatt), was based on specimens from the Fort Riley limestone of Kansas and from some unrecorded horizon and locality in Texas.

Largely through the work of Clifton, we now know a considerable molluscan fauna from the Middle Permian Blaine and Dog Creek formations of this same general area in north-central Texas. He (1944, p. 1026) states that the faunas of these two formations "are nearly identical", and his lists indicate that altogether they contain representatives of the ammonoid genera *Propinacoceras*, *Medlicottia*, *Pseudogastrioceras*, *Adrianites*, *Agathiceras*, and *Perrinites*, and the following nautiloids:

Pseudorthoceras knoxense (McChesney)
Mooreoceras giganteum Clifton
M. sp.
Domatoceras cf. *D. walteri* Miller and Unklesbay?
D. sp.
Stearoceras sanandreasense (Miller, Dunbar, and Condra)
Stenopoceras sp.
Tainoceras cf. *T. schellbachi* Miller and Unklesbay
Temnocheilus? sp.
Metacoceras inconspicuum Hyatt?
M. cf. *M. unklesbayi*, n. name
(?) *Cooperoceras texanum* Miller
Coelogasteroceras mexicanum (Girty)

Most, if not all of these forms, are stated to occur in the Acme member of the Blaine and the Guthrie member of the Dog Creek. The specimens are preserved as dolomitic internal molds, and their specific affinities are in many cases not easy to determine with certainty.

It should perhaps be mentioned in this connection that Clifton believes that a

"relative depth can be inferred for Blaine and Dog Creek seas. Occurrences of nautiloid remains and those of other benthonic invertebrates in ripple-marked carbonate strata suggest that the normal marine sea must have been only relatively shallow, since these fossils as living creatures were bathymetrically limited to depths greater than those in the very shallow seas."

Furthermore he mentions that an

"example of possible orientation by waves is suggested by phragmacones of the nautiloid *Pseudorthoceras*. . . . It was estimated that 50 per cent or more of the[se] nautiloid phragmacones in . . . [a thin carbonate stratum at the falls on Salt Croton Creek in Stonewall County, Texas] are now oriented northeast and southwest, with the adoral end of the phragmacones northeastward."

SOUTHWESTERN UNITED STATES

The Lower Permian Hueco limestone of west Texas and adjacent portions of New Mexico has yielded a considerable ammonoid fauna (including among other things representatives of *Artinskia*, *Metalegoceras*, and *Properrinites*) but only a few fragments of nautiloids which belong in the genera *Mooreoceras*, *Stenopoceras*, *Temnocheilus*, and *Ephippioceras*. The last is one of the youngest representatives of the Ephippioceratidae known (see Addendum).

The Hueco is overlain by the Bone Spring limestone, which is the approximate stratigraphic equivalent of the Leonard formation of west Texas. Both the Bone Spring and the Leonard carry *Perrinites hilli* (Smith) and other ammonoids as well as a good many nautiloids:

Bone Spring
- *Pseudorthoceras knoxense* (McChesney)
- *Mooreoceras* sp.
- *Michelinoceras* sp.
- *Foordiceras mammiferum* (Miller)
- *F. megaporum* (Miller)
- *F. praecursor* Girty
- *Cooperoceras texanum* Miller

Leonard
- (?) *Pseudorthoceras knoxense* (McChesney)?
- (?) *Mooreoceras* sp.
- (?) *Michelinoceras? guadalupense* (Girty)
- *Stearoceras hesperium*, n. sp.
- (?) *S.* sp.
- *Stenopoceras inexpectans* Miller
- *Temnocheilus inaequilaterale*, n. sp.
- *Foordiceras cooperi* (Miller)
- *F. gregarium* (Miller)
- *F. magnicostatum* (Miller)
- *F. mutatum* (Miller)
- *Metacoceras bituberculatum*, n. sp.
- *Cooperoceras texanum* Miller

The Word formation of west Texas, which directly overlies the Leonard, also contains a considerable cephalopod fauna. Altogether, we now know from it nine or ten ammonoid genera, the most characteristic of which is perhaps *Waagenoceras*. Nautiloids seem to be relatively rare in this formation, but nevertheless several forms have been found in it:

- (?) *Pseudorthoceras knoxense* (McChesney)?
- *Mooreoceras* spp.
- (?) *Michelinoceras? guadalupense* (Girty)
- (?) *Stearoceras* sp.
- *Foordiceras gregarium* (Miller)
- *Cooperocereas texanum* Miller

It should be mentioned that Clifton (1945, p. 1769, 1770, 1774) has discussed the occurrence of cephalopods in this horizon and has pointed out that they

"are not everywhere abundant but they are widely distributed in some strata of the Word and its

correlatives. Among them, the nautiloids have been little used for criteria in stratigraphic determination, though they are important elements in Permian faunas. Nautiloid assemblages of diversified forms, by their association and occurrence in many places with ammonoids, doubtless afford criteria supplementing those from the more diagnostic ammonoid elements, in correlation."

In the Guadalupe Mountains of west Texas, beds that are equivalent to part of the Word formation and the overlying Capitan limestone are known to have yielded three types of nautiloids. That is, the holotype of *Michelinoceras? guadalupense* (Girty) is believed to have come from a limestone just below the Getaway member of the Cherry Canyon formation [about middle Word in age] near El Capitan. Clifton (1946, p. 557) in discussing his species "*Pseudorthoceras splendens*," which we regard as a synonym of *P. knoxense* (McChesney), states that "two specimens were collected from the South Wells limestone member of the Cherry Canyon formation [which is upper Word in age] at a locality about three miles northeast of Pine Spring Camp". The syntypes of *Foordiceras shumardianum* Girty are from the "middle of Capitan formation, Capitan Peak".

The Manzano group of southern New Mexico, northwest of the Guadalupe Mountains, is believed to be largely or wholly Leonard in age, but its upper portion may possibly be as young as Word. It is divided into the Abo, Yeso, and San Andres formations. No ammonoids have been found in the Abo or the Yeso, but the San Andres carries *Perrinites hilli* (Smith). Girty (Lee and Girty, 1909) has described a few nautiloids from the Abo and the Yeso, and he and others have published on San Andres forms. Altogether, we can now list the following nautiloids from this group:

Abo
Mooreoceras sp.
Stearoceras? sp.

Yeso
Domatoceras? sp.
Stearoceras? spp.
Coelogasteroceras mexicanum (Girty)

San Andres
Pseudorthoceras knoxense (McChesney)
Domatoceras bradyi Miller and Unklesbay
D. walteri Miller and Unklesbay
Stearoceras rotundatum (Miller and Unklesbay)
S. sanandreasense (Miller, Dunbar, and Condra)
S.? spp.

Some authors have classed the Yeso and the San Andres as members of the Chupadera formation. Although King (1942, p. 687) has abandoned that term, we are employing it here for beds to which we are unable to give a more nearly precise designation, and from these in New Mexico we know the following nautiloids:

Mooreoceras sp.
Domatoceras bradyi Miller and Unklesbay
D. northropi Miller and Unklesbay
***D.* sp.**
Stearoceras aberrans (Miller and Unklesbay)
S. rotundatum (Miller and Unklesbay)
Tainoceras duttoni Hyatt
Metacoceras unklesbayi, n. name

The Toroweap and Kaibab formations of northern Arizona, southern Utah, and Nevada are fossiliferous, but, as stated by McKee, the "scarcity of cephalopods in general and the almost complete absence of ammonoids in particular are striking features of the Kaibab-Toroweap faunas". Nevertheless, published faunal lists (McKee, 1938, p. 165) indicate that both formations contain sporadic straight and coiled nautiloids, and that at least at one locality the Kaibab probably contains ammonoids. The only cephalopod we have seen from the Toroweap is the holotype of *Tainoceras unklesbayi*, n. sp., but according to McKee "*Orthoceras*" and "*Domatoceras?*" are also represented in that formation in northern Arizona. From the

overlying Kaibab in Utah, Girty has identified representatives of *Metacoceras*, *Coloceras* [=? *Liroceras*], "*Gastrioceras*," and "*Orthoceras?*." We have been able to study no specimens from that state but have assembled quite a variety of nautiloids from the Kaibab in northern Arizona:

Mooreoceras sp.
Domatoceras bradyi Miller and Unklesbay
Stearoceras rotundatum (Miller and Unklesbay)
S. sanandreasense (Miller, Dunbar, and Condra)
Tainoceras schellbachi Miller and Unklesbay
Aulametacoceras mckeei Miller and Unklesbay
Metacoceras unklesbayi, n. name

The fact that three or four of these species also occur in the San Andres of New Mexico indicates that at least the cephalopod-bearing portions of these two formations are not greatly different in age. Furthermore, inasmuch as we believe that the San Andres is the approximate equivalent of the Leonard formation of west Texas, we are in agreement with McKee (1938, p. 171) who, largely on the basis of brachiopods, correlated the Kaibab with the Leonard of the Glass Mountains.

ROCKY MOUNTAIN AREA

In the Southern Rockies the Jacque Mountain limestone of central Colorado carries *Pseudorthoceras?*, *Mooreoceras*, and particularly *Domatoceras*. Unfortunately, none of the specimens available is very complete, and the assemblage does not permit us to make a satisfactory age determination.

To the north, near Laramie in southeastern Wyoming, the Casper sandstone has yielded a considerable nautiloid fauna:

Pseudorthoceras knoxense (McChesney)
Mooreoceras sp.
Stenopoceras abundum Miller and Thomas
Tainoceras wyomingense Miller and Thomas
Metacoceras knighti Miller and Thomas
M. sulciferum Miller and Thomas
M. sp.
Liroceras sp.
Solenochilus cf. *S. brammeri* Miller, Dunbar, and Condra

The age of the Casper is a moot question. Branson (1939, p. 1219) has stated that he "is doubtful of the presence of beds younger than Des Moines". However, Horace D. Thomas (Personal communication dated May 21, 1947) has recently written us that apparently the Casper has a "time span . . . from early Pennsylvanian into early Permian," and that the beds which yielded the nautiloids just listed are probably Lower Permian in age. Insofar as we can ascertain, this nautiloid assemblage could be either Pennsylvanian or Permian.

Two cephalopods have been reported from the Satanka shale, which immediately overlies the Casper. They are not very satisfactory specimens, but their affinities are with the genera *Mooreoceras* and *Coelogasteroceras*. The latter is similar to *C. mexicanum* (Girty) and *C. thomasi* Miller and Cline, and can therefore be said to be in harmony with a Middle Permian age for the formation, but of course little or no reliance can be placed on one incomplete nautiloid. The genus *Mooreoceras* has a long range in the Late Paleozoic, and therefore its probable presence in the Satanka is of little stratigraphic significance.

In the Shirley Mountains northwest of Laramie, Wyoming, *Coelogasteroceras mexicanum* (Girty) has been found in the "Minnekahta" formation, about 73 feet above the Tensleep sandstone. This species is known to occur in the Middle Permian elsewhere in Wyoming, New Mexico, and Texas, and presumably therefore the containing beds near Laramie are probably of that age.

In central and western Wyoming cephalopods occur sporadically in the Phosphoria formation, and locally (in the Sublette Range) they are fairly abundant in it. Altogether, from this formation we now know representatives of the ammonoid genera *Pseudogastrioceras*, *Peritrochia*, and *Stacheoceras*, and the following nautiloids:

Mooreoceras sp.
Stearoceras phosphoriense (Branson)
S. sp.
Coelogasteroceras mexicanum (Girty)
C. thomasi Miller and Cline

Both these ammonoids and nautiloids are in harmony with a Middle Permian age for the Phosphoria, but they do not permit us to determine just which part of that series is represented.

Permian cephalopods have been collected at only one locality in British Columbia. That is, in an impure glauconitic limestone near the top of the Cache Creek series in the vicinity of Kamloops, Crockford secured representatives of three ammonoid genera (*Propinacoceras*, *Adrianites*, and *Agathiceras*) and one nautiloid genus (*Mooreoceras*). The last is of little significance, but it is mentioned for the sake of completeness. This fauna is most probably Middle Permian in age, but its precise affinities are not clear.

NORTHEASTERN MEXICO

The prolific Permian faunas of the Valle de Las Delicias in southwestern Coahuila, like those of west Texas, have yielded many ammonoids but relatively few nautiloids. A species of *Bitaunioceras* occurs in the Leonard, Word, and Capitan equivalents there; and from the oldest and youngest of these three we have a form that is being referred with question to *Bactrites*. Also, a representative of *Domatoceras* is known from beds of Word age there, and specimens that belong in *Liroceras* and *Stearoceras* have been found nearby in the Capitan equivalent.

NORTHERN SOUTH AMERICA

Insofar as we have been able to ascertain, the only Permian cephalopods known from all of South America came from the vicinity of the Maracaibo Basin. In 1927 Christ (p. 399, 411) mentioned the occurrence in northwestern Venezuela of some poorly preserved nautiloids that we have not seen. The collections available to us contain five specimens from two localities in the Sierra de Perijá, just west of the northern part of the Colombian-Venezuelan border in the Departamento de Magdalena of Colombia. These are referable to the genera *Mooreoceras*, *Domatoceras*, and *Stearoceras*, and all but one (a straight form from limestone float) were found in association with *Perrinites* and *Medlicottia* and are believed to be Leonard in age.

EASTERN HEMISPHERE

The presence of Permian strata in Eurasia has been known for a long time, and a great deal of attention has been devoted to them and to their faunas. As a result, the literature contains a wealth of information in regard to the nautiloids of this age in Australia, the East Indies, India, China, Soviet Russia, western Europe, and Madagascar.

In a general report on the *Upper Paleozoic of Western Australia*, Teichert (1941,

p. 377, 382, 383, 387) indicates that nautiloid cephalopods are present there in the Middle Permian Artinskian (approximately Leonard) equivalents at three localities. That is, he states that the Fossil Cliff limestone of the Irwin River district has yielded representatives of *Pseudorthoceras*, *Domatoceras*, and *Stearoceras*; in the North-West artesian basin the lowest of the four divisions of the Wandagee series carries *Permonautilus* [=? *Acanthonautilus*], the second contains *Stearoceras* and *Titanoceras* [=? *Domatoceras*], and the fourth (uppermost) contains *Phacoceras* [=? *Stenopoceras*]; and in the West Kimberley division "a few nautiloids" have been found in the Nura Nura limestone in association with ammonoids and other mollusks.

One of the largest and most varied Permian nautiloid faunas known is from the Bitauni beds of Timor, which are of approximately the same age as the Leonard formation of west Texas. A few nautiloids have been found in other Permian strata of that island, and altogether the following forms are known from there:

Somohole beds
Liroceras? sp.

Bitauni beds
Bitaunioceras bitauniense (Haniel)
Neorthoceras verbeeki (Haniel)
N.? welteri (Haniel)
"Orthoceras" maubesiense Haniel
Bactrites? sp.
Domatoceras arthaberi (Haniel)
Stearoceras? molengraaffi (Haniel)
Foordiceras? sp.
Liroceras brouweri (Haniel)
L.? sp.
Peripetoceras wanneri (Haniel)
"Aganides" bitauniensis (Haniel)

Basleo beds
Neorthoceras verbeeki (Haniel)
Foordiceras dyadicum (Haniel)

Amarassi beds
Domatoceras arthaberi (Haniel)
Foordiceras dyadicum (Haniel)

It should also be mentioned in this connection that Roemer and Fliegel have illustrated and described several nautiloids from the Lower Permian of Sumatra:

Brachycycloceras? orientale (Fliegel)
Foordiceras lóczyi (Fliegel)
F. sumatrense (Fliegel)
Metacoceras aff. *M. hayi* Hyatt

Another extensive fauna (or faunas) of Permian nautiloids, which is also one of the youngest, is from the Productus limestone of the Salt Range of India. Only one species, *Tainoceras trimuense* Reed, seems to be known from the Lower Productus limestone, but de Koninck, Waagen, Frech, and Reed have described two closely related assemblages from the other portions of the formation. The older of these came from the Middle Productus limestone and consists of the following species:

Michelinoceras? punjabiense (Waagen)
(?) *Michelinoceras?* sp.
Domatoceras connectens (Waagen)
D. convolutum (Waagen)
Pselioceras ophioneum (Waagen)
Stearoceras grypoceroides (Reed)
S. postremum (Reed)
Stenopoceras? peregrinum (Waagen)
(?) *Tainoceras subglobosum* Reed
Foordiceras flemingianum (de Koninck)
F. goliathum (Waagen)
F. multicostatum Reed
F. cf. *F. praecursor* Girty
(?) *F. warchense* (Reed)
Metacoceras chiltidilense Reed
M.? medlicottianum (Waagen)
Liroceras bakhense Reed
(?) *L. immane* (Reed)
(?) *Peripetoceras* cf. *P. wanneri* (Haniel)
(?) *Coelogasteroceras* sp.

The other Permian nautiloid assemblage from the Salt Range came from the Upper Productus limestone. It is composed of the following:

(?) *Michelinoceras?* sp.
Brachycycloceras? cyclophorum (Waagen)
B.? oblique-annulatum (Waagen)
"Orthoceras" sp.
Domatoceras convolutum (Waagen)
Pselioceras ophioneum (Waagen)
Stearoceras postremum (Reed)
S. punjabicum Reed
S. sp.
Tainoceras comptum Reed
T. debile Reed
T. noetlingi Frech
(?) *T. subglobosum* Reed
Temnocheilus? cf. *T. grewingki* (Tschernyschew)
T.? multituberculatum (Waagen)
Foordiceras goliathum (Waagen)
F.? latissimum (Waagen)
F. transitorium (Waagen)
F. venustum (Reed)
(?) *F. warchense* (Reed)
F. wynnei (Waagen)
Liroceras bakhense Reed
(?) *L. immane* (Reed)
(?) *Peripetoceras* cf. *P. wanneri* (Haniel)
(?) *Coelogasteroceras* sp.
Asymptoceras? buriense (Reed)

Both of these assemblages differ from those known from America, which is perhaps to be explained by their age and by the remoteness of the locality from which they came. It should also be mentioned here that Diener has described a typical representative of *Domatoceras*, *D. hunicum* (Diener), from the Upper Permian limestone crag of Chitichun No. 1 in the central Himalayas. Furthermore, Suess, basing his statements on fossils collected by Ferdinand Stoliczka and studied by Mojsisovics, reported the occurrence of *"Orthoceras"* and *Domatoceras* aff. *D. convolutum* (Waagen) in the Permian marble north of the Karakoram Pass in northern India close to the Tibetan border. Also, Merla has described *Temnocheilus? reedianum* (Merla) and *"Nautilus* sp. ind." from the Upper? Permian of the Karakoram Mountains, and Renz has recorded *Michelinoceras? aghilense* (Renz) and *Brachycycloceras? oblique-annulatum* (Waagen) from the Permian of the Aghil Mountains, just northeast of the Karakorams.

The literature on the Permian of China is scattered and is difficult to interpret, but certain contributions should perhaps be noted. Loweneck has illustrated a representative of *Foordiceras* from the Lower Permian of Tianshan in Sinkiang (western China). As suggested by Schellwien (1903, p. 140) the form from the Permian of Nan-shan in Szechwan (central China) which Lóczy (1899, p. 44–45) and Branson (1948, p. 810) tentatively regarded as a nautiloid is more probably an ammonoid. To the south of there in the Lower Permian of Yunnan, *Brachycycloceras?* and *Foordiceras?* are to be found according to the published works of Mansuy (1912, p. 106–107) and Lóczy (1899, p. 44–46). The first of these two genera may also be represented in the Permian Productus beds of Tonkin, northeastern French Indo-China (Patte, 1926). In 1883 Kayser described several species of Permian nautiloids which von Richthofen had obtained at the famous Loping locality in northeastern Kiangsi (east-central China):

Mooreoceras? spp.
Brachycycloceras? sp.
Tainoceras mingshanense (Kayser)
T. orientale (Kayser)
"Nautilus" sp.

In adjacent Chekiang, *Liroceras* [*"Coloceras"*], *Foordiceras?* [*"Tungkuanoceras"*], and *Tainoceras* [*"Hexagonites"*] occur in association with *Waagenoceras* and other Middle Permian ammonoids in the Lotungfu limestone (Hayasaka, 1947). From the

Taiyuan series of Shansi and Hopei (northeastern China) Grabau, Yin, and Yabe and Mabuti record the following nautiloids:

"Orthoceras" sp.
Domatoceras? falciferum (Yin)
D.? grabaui (Yin)
D. cf. *D. mosquense* (Tzwetaev)
D. planotergatum (McCoy)?
D.? singulare (Yin)
D. subquadrangulare (Grabau)
D. sp.
Metacoceras cf. *M. "dorso armatum"* (Abich)
M. sp.
Huanghoceras linchengense Yin
H. simplicostatum Grabau (Yin)
H. wangi Yin
H. spp.
Temnocheilus asiaticum Grabau
T.? transitorium (Yin)
T.? sp.
Foordiceras ozakii (Yabe and Mabuti)
Pleuronautilus? nodostriatus Yin
P.? ornatissimus Yin
P.? pernodosus Grabau
Tainoceras? nodostriatum (Yin)

The extensive Permian deposits of Soviet Russia have yielded many nautiloids. However, the literature is so difficult to obtain that our lists are probably far from complete. Kruglov and others have described the following forms from the Sakmarian and Artinskian beds of the Ural region:

Sakmarian

Pseudorthoceras? lateralaeforme (Fredericks)
Domatoceras aff. *D. hunicum* (Diener)
D. aff. *D. mosquense* (Tzwetaev)
D.? sp.
Stearoceras minimum (Kruglov)
S.? sargaense (Fredericks)
S. uralicum (Fredericks)
S. sp.
Temnocheilus sp.
Foordiceras carbonarium (Kruglov)
F. kasarmenskense (Kruglov)
F. multicostatum (Kruglov)
F. simense (Kruglov)
F. subglabrum (Kruglov)
F. tastubense (Kruglov)
(?) *F. ufimskense* (Kruglov)
Metacoceras cf. *M. pernodosum* (Tschernyschew)
M.? sp.
Liroceras tastubense (Kruglov)
Solenochilus sp.

Artinskian

Pseudorthoceras? siphocentrale (Krotow)
"Orthoceras" verneuili (Möller)
Domatoceras fredericksi Kruglov
D. krotovi (Kruglov)
D.? sp.
Temnocheilus posttuberculatum (Karpinsky)
T. posttuberculatum kosswae Kruglov
T. posttuberculatum waschkuricum Kruglov
Metacoceras? piszovi artiense Kruglov
M. spinosum Kruglov
M.? aff. *M.? uralicum* (Fredericks)
Liroceras? sarvaense (Kruglov)
Solenochilus aff. *S. collectum* Meek and Worthen
"Stroboceras" sp.

It should also be mentioned that Kruglov has described *Domatoceras krotovi* (Kruglov) and *D. fredericksi* Kruglov from the Kungurian beds of the Ural region and *Stearoceras? uralicum* (Fredericks), *S.?* sp., and *Metacoceras piszovi* Kruglov from the Upper Carboniferous or the Lower Permian of the Ufa Plateau, and that he has recorded the occurrence of *Tainoceras* and another genus of coiled nautiloids in the Permian? of the Ussuri region near Vladivostok. The Middle Permian dolomite beds of the Donetz basin in the southern part of European Soviet Russia carry a considerable nautiloid fauna; the collections of Boris Licharew in Leningrad contain typical representatives of *Foordiceras* from there, and Jakowlew has described the following forms from the same general horizon and locality:

Mooreoceras kodimae (Jakowlew)
Domatoceras? nikitowense (Jakowlew)
Foordiceras variabile (Jakowlew)
Temnocheilus cf. *T. crassum* Hyatt
T. grewingki Tschernyschew
Metacoceras pernodosum (Tschernyschew)?
M.? trigonotuberculatum Jakowlew
Liroceras? korkulense (Jakowlew)
L.? sp.

Licharew and Kruglov have illustrated representatives of *Domatoceras*, *Stearoceras*, *Liroceras?*, and *Acanthonautilus* from the Upper? Permian of the Vaga, Pinega, and Kuloi river basins in the north-central portion of European Soviet Russia. A varied fauna of Permian nautiloids has been described from the Upper Permian beds near Djoulfa in Armenia. Unfortunately, there is much difference of opinion in regard to the age of these beds and to the specific identity of the fossils contained in them. Nevertheless, it is clear from the published illustrations that at least the following nautiloid genera are represented there: *Mooreoceras*, *Brachycycloceras?*, *Domatoceras*, *Stearoceras*, *Foordiceras*, *Metacoceras*, and *Tainoceras?*. Although this assemblage of genera might seem to suggest a close relationship to American faunas, many of the species are not very similar to our forms but are more like those known from the Upper Permian of India. This variance from American faunas is probably due to difference in age more than to geographic position, for the Permian nautiloids from the Ural region (like the Upper Carboniferous forms from central European Soviet Russia) are similar to those that occur in the United States.

The occurrence of nautiloids in the Zechstein of Germany was recorded long ago when *Peripetoceras freieslebeni* (Geinitz) was described from Thuringia. Conspecific specimens are said to have been found in the Magnesian limestone of Durham and Yorkshire, England. *Pseudorthoceras knoxense* McChesney is stated to occur in the "Permo-Carboniferous" of the Carnic Alps, and the Upper Permian Bellerophon limestone of the southern part of the eastern Alps has yielded a good many nautiloids which have been described by Stache, Diener, Caneva, Merla, and others. It is now clear that at least *Brachycycloceras?*, *Stearoceras?*, *Tainoceras*, *Foordiceras*, *Metacoceras*, and *Liroceras* are represented there. Simić has illustrated and described a few nautiloids from the Upper Permian of western Serbia which appear to be referable to *Pseudorthoceras?*, *Temnocheilus?*, and *Tainoceras*. From farther south, in Sicily, we know through the work of Gemmellaro and Greco several species of *Mooreoceras*, *Michelinoceras?*, *Bitaunioceras*, *Brachycycloceras?*, "*Orthoceras*," and *Bactrites*, as well as the following coiled nautiloids:

Stearoceras? pleuronautiloides (Gemmellaro)
Tainoceras toulai (Gemmellaro)
Temnocheilus gemmellaroi Canavari
Foordiceras nodoso-costatum (Gemmellaro)
Liroceras salomonense (Gemmellaro)

Of these three southern European faunas, only the Sicilian is well known, and it is for the most part like those that occur in the American Permian. However, with the exception of straight forms, which are very difficult to interpret, nautiloids are exceedingly rare in the Permian of Sicily.

It should also be mentioned that in 1933 Vaillant-Couturier Treat illustrated and described a few rather mediocre straight and coiled nautiloids from Madagascar. Both of the localities from which these specimens came have yielded *Cyclolobus*, so presumably the beds that contained them are very late Permian in age. For the sake of completeness it should be added that Solignac and Berkaloff have reported the discovery of a single annulated orthoceracone in the Permian of southern Tunis.

These several lists seem to indicate that our present knowledge of Permian nautiloids does not enable us to use them very satisfactorily for detailed correlation. Almost all of the genera occur also in the Pennsylvanian, and at least one ranges into

the Triassic. Several of the Pennsylvanian-Permian genera, for example, *Metacoceras*, *Foordiceras*, *Tainoceras*, and *Domatoceras*, are almost world-wide in their distribution, and certain American and Eurasian species are quite similar.

CLASSIFICATION OF PERMIAN NAUTILOIDS

During the first part of the present century, nautiloid cephalopods received relatively little attention all over the world. Then, from about 1921 until his death in 1936, Foerste restudied many of the American Early and Middle Paleozoic forms; in Eurasia Kobayashi, Kruglov, Schindewolf, Spath, Strand, Teichert, Troedsson, and others made noteworthy contributions; and Flower, Schenck, Stenzel, and the senior author of the present report have continued the work here. However, almost all of these authors have concerned themselves chiefly with Ordovician, Silurian, Devonian, or post-Triassic forms, and the only major studies of Late Paleozoic nautiloids that have appeared since 1900 are Kruglov's *Upper Carboniferous and Artinskian Nautiloidae of the Ural* and Miller, Dunbar, and Condra's *The nautiloid cephalopods of the Pennsylvanian system in the Mid-Continent region.*

Unfortunately, Foerste did not live to summarize his varied studies, and none of the other recent authors have had wide enough experience to enable them to prepare a thorough taxonomic revision of the entire order. As a result, the classification of the nautiloid cephalopods is not in as satisfactory condition as is that of the ammonoids and most of the other major groups of fossil invertebrates, and the best existing systematic arrangement seems to be that which Hyatt published in 1900 in the Zittel-Eastman *Text-book of palaeontology*. It is admittedly only tentative, and whereas it embodies the chief features of Hyatt's philosophy, many of the details are still to be worked out. Almost certainly the major subdivisions of the Nautiloidea all became well established during the first half of the Paleozoic, and a proper understanding of their differentiation and interrelationships can therefore come from only a study of Early Paleozoic forms. For these reasons, we are making no attempt to revise the existing scheme of classification, though we are fully aware of its many weaknesses, and insofar as possible we are referring our genera and species to the suborders and families recognized by Hyatt in his final systematic work of 1900 and to a few families that have been established by subsequent authors.

It should, however, be stated that we have in preparation a general study of Pennsylvanian nautiloids, and in it we plan to include a thorough discussion of the interrelationships of the Carboniferous and Permian forms and particularly of the evolution of the nautiloids during the Late Paleozoic. In the remarks which accompany the various generic diagnoses in the present volume, attempts at generalizations are to be found, but these are tentative and may have to be modified as we complete a study of the wealth of Pennsylvanian material that is now at our disposal. Most of the genera represented in the Permian had their inception in the Pennsylvanian, and few major changes were made during the closing period of the Paleozoic.

SYSTEMATIC PALEONTOLOGY

Suborder CYRTOCHOANITES Hyatt, 1900

The forms that are included in this suborder have septal funnels or necks that are recurved, and the segments of the siphuncle are expanded within the camerae and are ellipsoidal, pyriform, or globular in shape—some of the Early and Middle Paleozoic members have siphuncles with nummuloidal segments. The suborder is exclusively Paleozoic, and only two genera that belong in it, *Pseudorthoceras* and *Mooreoceras*, range into the Permian. In both of these the mature portion of the conch is straight, but that of *Pseudorthoceras* is curved during adolescence.

Hyatt (1900, p. 527–532) recognized two subdivisions of the Cyrtochoanites, the Annulosiphonata and the Actinosiphonata. In the former, the siphuncle "may be empty, but organic deposits when present [are] always gathered about or encrusting the funnels as hollow or solid internal rings". In the latter, the siphuncle is "sometimes empty; [and] organic deposits when present [are] in the form of laminae radiating from the sheath of each segment towards the interior". No Permian forms have actinosiphonate siphuncles, and such are not known to occur above the Devonian.

After reviewing the families and genera which Hyatt assigned to the Annulosiphonata, Flower (1939, p. 77–78) has concluded that Foerste and Teichert's "actinoceroids" (Hyatt's Actinoceratidae with some slight modifications) are the only forms originally included in the Annulosiphonata that can be placed there with confidence, and that aside from them the Pseudorthoceratidae appears to be the only group of cephalopods that are cyrtochoanitic and annulosiphonate. The "actinoceroids" have been carefully studied by Foerste and Teichert (1930) and later by Teichert (1933), and the group now contains numerous genera most of which resulted from a division of those recognized by Hyatt and none of which probably ranges above the Mississippian.

Family PSEUDORTHOCERATIDAE Flower and Caster, 1935

This family has recently been the subject of a major study by Flower (1939), who defined it as follows:

"The Pseudorthoceratidae contain largely orthoceracones, with slightly exogastric cyrtoconic apices, although two specialized genera attain a cyrtochoanitic [cyrtoceraconic] form and one is breviconic. The earliest stages of the siphuncle are slender and orthochoanitic. Later segments are definitely expanded and cyrtochoanitic, though rarely wider than long. The necks are short, their length averaging less than one-seventh the length of the segment. The brims are variously developed, but are never recumbent. Siphonal deposits are annulosiphonate and parietal, consisting of rings formed at the septal foramina, extended adorally. When well developed, the segmental deposits fuse to form a continuous lining within the siphuncle. Deposits of the camerae are mainly mural, although episeptal and hyposeptal deposits occur in a few specialized forms."

Flower divided this family into three subfamilies for which he coined the names Dolorthoceratinae, Pseudorthoceratinae, and Cayutoceratinae. The first of these is said to be characterized by siphonal deposits which show little dorsoventral differentiation, the second by the fusion of adjacent segmental deposits on the venter before any trace of siphonal deposit appears on the dorsum, and the third by the development of a double deposit consisting of discrete calcareous annulosiphonate deposits covered by a carbonaceous deposit which appears to be continuous when fully developed but which is actually composed of fused segmental elements. The range of the Dolorthoceratinae is given as Lower Devonian to Pennsylvanian, that of the Pseudorthoceratinae as Upper Devonian to Middle Permian, and that of the Cayutoceratinae as Upper Devonian. Both *Pseudorthoceras* and *Mooreoceras* are placed in the Pseudorthoceratinae along with the exclusively Lower Carboniferous (Viséan) genera *Paraloxoceras* Flower and *Bergoceras* Flower.

Flower recognized that the family Pseudorthoceratidae was originally established "largely as a receptacle to contain forms customarily assigned to the uncertain Loxoceratidae. The family Sactoceratidae was previously proposed by Troedsson for the same purpose, but cannot be used in that way because *Sactoceras* is a true actinoceroid". He believed that the Pseudorthoceratidae "is a cyrtochoanitic family of orthochoanitic origin, and is apparently unrelated to other cyrtochoanitic groups".

Although we are tentatively following Flower's classification, it should be stated clearly that in many cases we are unable to distinguish with a reasonable degree of certainty indigenous from adventitious siphuncular and cameral deposits. Furthermore, it seems to us that when representatives of the genotype of *Loxoceras* are secured and studied in accordance with the methods of modern paleontological investigations, the name Loxoceratidae should be revived, and it may well be synonymous with Pseudorthoceratidae (which does not have priority). Furthermore, we are not entirely convinced that *Pseudorthoceras* and particularly *Mooreoceras* should be eliminated from the Sactoceratidae.

Genus ***Pseudorthoceras*** Girty, 1911

GENOTYPE: *Orthoceras knoxensis* McChesney

When this genus was established, its author designated a genotype and stated that its "most diagnostic features are probably the enlarged siphuncle and more especially the secondary deposits accumulated not axially, but circumferentially." Specimens that are referred to the type species are now known to be both abundant and widespread throughout essentially all of the marine portions of the Pennsylvanian system in the United States and to occur also in the Wolfcamp and Leonard series of this country. After studying hundreds of these from various horizons and localities, we believe that the genus should be diagnosed about as follows:

Conch long, slender, circular or nearly so in cross section, and straight except in adapical portion which is slightly but distinctly curved. Living chamber unknown. Test thin and its surface smooth, or essentially so. Septa moderately convex apicad, and sutures straight and directly transverse. Siphuncle central in position, cyrtochoanitic in structure, small at its passage through septa, and expanded within camera. Septal necks short and rather strongly recurved. Connecting rings ellipsoidal, subspherical, or pyriform in shape. In most cases walls of siphuncle are lined with deposits that may be organic in origin. Camerae contain lamellar deposits which line their walls and extend along adoral surface of septa toward center of conch.

Representatives of this genus are easily recognized by the curved adapical portion of conch, central cyrtochoanitic siphuncle, and unique cameral deposits. In *Mooreoceras*, with which *Pseudortheroceras* commonly occurs in association in the Late Paleozoic, siphuncle is not quite central in position, and insofar as is now known adapical portion of conch is not curved. Also, according to Flower, there is a difference in the cameral and probably the siphuncular deposits in these two genera —we are not certain that any of those in the representatives of *Mooreoceras* we have studied are indigenous.

In 1939 Flower described two species of this genus from the Upper Devonian Cashaqua shale of New York (and removed from it a form from the Upper Devonian of Ohio that he and Caster had placed in it in 1935). The genotype ranges throughout most of the marine Pennsylvanian of the United States and may occur in the Upper Carboniferous of Europe and Argentina. Teichert (1941, p. 337) has reported that the genus is represented in the Middle Permian (approximately Leonard equivalent) of Western Australia, and locally the type species is not rare in the Lower Permian of Wyoming and Texas and the Middle Permian of the latter state and probably New Mexico. In summary, then, it can be said that this genus is known to be widespread geographically, and stratigraphically to range from the Upper Devonian to the Middle Permian, inclusive.

Pseudorthoceras knoxense (McChesney)

(Plate 2, figures 1–7; Plate 3, figures 2–8; Plate 55, figures 15–17)

1860 [1859]. *Orthoceras knoxensis* McCHESNEY, Descriptions of new species of fossils from the Paleozoic rocks of the Western States, p. 69.

1866. *Orthoceras cribrosum* GEINITZ, K. Leopoldino-Carolinischen deut. Akad. Naturf., Verh. 33, Abh. 4, p. 4, pl. 1, fig. 5.

1872. *Orthoceras cribrosum* MEEK, U. S. Geol. Surv., Nebraska, Final Rept., p. 234, pl. 1, figs. 18a, 18b.

1873. *Orthoceras Rushensis?* MEEK AND WORTHEN, Illinois Geol. Surv., vol. 5, p. 612, pl. 30, fig. 4.

1884. *Orthoceras Rushensis* WHITE, Indiana Dept. Geol. and Nat. Hist., 13th Ann. Rept., pt. 2, p. 164, pl. 36, fig. 5.

1887. *Orthoceras cribrosum?* HERRICK, Dennison Univ., Bull. Sci. Labs., vol. 2, p. 17, pl. 5, fig. 2.
1888. *Orthoceras rushensis* KEYES, Philadelphia Acad. Nat. Sci., Pr., p. 242.
1891. *Orthoceras rushensis?* [part?] WHITE, U. S. Geol. Surv., Bull. 77, p. 16, 22, pl. 2, figs. 14–16.
1892. *Orthoceras cribrosum* MILLER, Indiana Dept. Geol. and Nat. Res., 18th Ann. Rept., Advance sheets, p. 65–67.
1894. *Orthoceras cribrosum* MILLER, Indiana Dept. Geol. and Nat. Res., 18th Ann. Rept., p. 319–321.
1895 [1894]. *Orthoceras rushense* [part] KEYES, Missouri Geol. Surv., vol. 5, p. 226, pl. 56, fig. 6.
1896. *Orthoceras cribrosum* SMITH, Am. Philos. Soc., Pr., vol. 35, p. 253.
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1897 [1896]. *Orthoceras cribrosum* SMITH, Leland Stanford Junior Univ. Pub., Contr. Biol. Hopkins Seaside Lab., No. 9, p. 43.
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(?) 1946. *Pseudorthoceras splendens* CLIFTON, Jour. Paleont., vol. 20, p. 556, 557.
1947. *Pseudorthoceras* sp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.
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Conch long, slender, gradually and regularly expanded orad, circular in cross section (commonly elliptical due to distortion during fossilization), and straight except for extreme adapical part, which is slightly but distinctly curved. Living chamber unknown. Test of phragmacone thin, and its surface smooth, or essentially so. Sutures straight and directly transverse to long axis of conch and therefore form simple circles. Septa moderately convex apicad, and amount of their curvature averages about a fifth their diameter. Length of camerae varies considerably in different specimens and in different parts of the same individual; but in general camerae become relatively longer adorally, and from two to five of them occupy a length equal to diameter of conch.

Most of the numerous specimens available for study do not retain the small curved adapical portion of the conch, but part of it is present on the individual represented by Figure 2 on Plate 3. The Labette shale of the Pennsylvanian outlier at St. Louis, Missouri, has yielded many well preserved conspecific individuals that are complete adapically. They show that the apex of the conch is bluntly rounded, but no trace of a scar or cicatrix of attachment of a protoconch is discernible. However, in 1916 Girty described two pyritized specimens from the Des Moines group of Iowa, each of which shows a structure that he regarded as a cicatrix; the extreme adapical portion of both of these specimens is finely reticulate, but neither longitudinal nor transverse markings can be discerned on any of the numerous specimens available for study.

The well-preserved Pennsylvanian specimens show that the first camera, though slightly asymmetrical, is subhemispherical in shape. The siphuncle starts in it as a nearly spherical caecum, which is about three-fifths as long as the camerae and nearly two-fifths as wide. It is central in position and appears to be similar in construction to the rest of the segments of the siphuncle; that is, its adoral part is composed of short recurved septal necks, apparently identical in composition with the septa, whereas the rest of its wall is much thinner and seems to be composed of the same type of material that forms the connecting rings of the other segments of the siphuncle. The nearly spherical siphonal caecum appears to be attached to the rest of the conch only by the septal necks of the adapical septum, and it is not in contact with the apical wall of the conch as is that of modern *Nautilus*. The siphuncle of the rest of the phragmacone is likewise central in position and is small at its passage through the septa, but its segments are expanded within the camerae. In the adapical part of the conch they are fusiform in shape, but they gradually become relatively broader adorally and in the mature part of the phragmacone are subspherical. However, the maximum diameter of these segments, about a fourth that of the phragmacone, is attained slightly orad of the mid-length of the camerae, and they are more abruptly rounded adorally than adapically and are therefore more or less pyriform in shape. The connecting rings are not in contact with the septa outside of the septal

necks. The septal necks are short and strongly recurved; their length is equal to about a third the diameter of the septal foramen, which in turn is equal to about a twelfth the diameter of the phragmacone. The length of the brim is slightly less than that of the septal necks. As shown by Figures 1, 2, and 4–6 on Plate 2 and Figure 6 on Plate 3, rather thick deposits line the wall of the siphuncle in most (but not all) of the specimens sectioned.

The walls of the camerae also are lined internally by deposits which are lamellar and which extend from the walls toward the center of the conch along the adoral surface of the septa; in some specimens they are greatly thickened adorally. They vary considerably in size and shape in different specimens, but in general they are much thicker along the ventral than along the dorsal side of the conch. They appear to fill the adapical camerae more or less completely, but they decrease in relative thickness adorally along the dorsal side of the conch, where in the mature portion of the phragmacone their thickness generally averages only about a third to a fifth the radius of the camerae.

REMARKS.—This species, as now interpreted, is somewhat variable, particularly insofar as the spacing of the septa, the shape of the siphuncular segments, and the nature of the internal deposits are concerned; but the variations do not seem to follow any consistent pattern or patterns. The origin of the deposits in the siphuncle and the camerae is a moot question; but at least those in the camera are almost certainly of organic genesis, and they are preserved in the great majority of the specimens sectioned. In many cases, the deposits in the siphuncle tend to be thickest where the siphuncular segments attain their maximum diameter. In the specimen represented by Figures 1 and 2 on Plate 2 there is a somewhat irregular cylindrical tube inside the siphuncle; its diameter is about equal to that of the septal foramina, and near the mid-length of the siphuncular segments there are transverse structures (presumably partitions) which appear to be identical in composition with the intrasiphuncular tube and which extend from that tube to the connecting rings. No such structures were observed in any of the other specimens studied, and in the thin section of the well preserved individual represented by Figure 6 on Plate 2 no suggestion of organic deposits can be discerned in the siphuncle.

Recently Clifton has proposed the name *Pseudorthoceras splendens* for some specimens from the Permian Blaine and Dog Creek formations of north-central Texas. A direct comparison of his type specimens with typical representatives of *P. knoxense* from the Pennsylvanian has convinced us that all are conspecific. Also, as was pointed out by Miller, Dunbar, and Condra, *P. seminolense* Girty should be suppressed as a synonym of *P. knoxense*.

OCCURRENCE.—This species is widely distributed both geographically and stratigraphically in the Pennsylvanian and the lower half of the Permian of North America, and it may occur also in the Upper Carboniferous of Europe and the Middle Permian of Australia. In the United States it ranges stratigraphically from the Morrow (Hale formation) at least to the Leonard (Dog Creek formation) and possibly to the Guadalupe (South Wells limestone of Cherry Canyon formation); and geographically it is known from Pennsylvania on the east to Colorado on the west, and from Texas on the south to Michigan on the north. In 1930 and 1931, Misch and Heritsch referred to this species some specimens from the Upper Carboniferous or Lower Permian near Nassfeld, in the Carnic Alps on the Austro-Italian border, and insofar as we are able to tell from their descriptions and illustrations their identification may well be correct. Flower (1939, p. 190) states that Teichert had informed him "of the presence of *P. knoxense* in the Artinskian" (approximately Leonard equivalent) of Australia; and two years later Teichert (1941, p. 377) presumably referred to the same specimens when he mentioned that the genus *Pseudorthoceras* is represented in the Fossil Cliff beds of the Irwin River district in Western Australia. Reed (1927, p. 145) has compared with this species a single fragment from the Upper Carboniferous of Argentina—we are uncertain in regard to its affinities.

It should perhaps be stated that in the Permian of America, we know *P. knoxense* from only Wyoming, Texas, and probably New Mexico. All of the specimens from Wyoming came from the Casper formation in Gilmore Canyon about 8 miles southeast of Laramie in Albany County. As long ago as 1891, White illustrated and briefly described some specimens that appear to belong to this species, from the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas (see Pl. 55, figs. 15–17, of the present publication). Stainbrook and Madera in 1941 reported on two small fragments from the Leonard or Word equivalent in a well (5125 feet below the surface) in Hockley County, Texas, that may belong in this species. In 1942, Clifton published a

detailed description and good illustrations of definite representatives of the species which he had found in abundance in the following horizons and localities in north-central Texas: (1) the Acme member of the Blaine formation north and northwest of Quanah in Hardeman County; (2) the same general horizon in northeastern Nolan and southeastern Fisher counties; (3) the Guthrie member of the Dog Creek formation northeast and southeast of Kirkland in Childress County; and (4) the same general horizon as the last about 2 miles south of Sylvester in Fisher County—at all four of these localities Clifton also found *Perrinites hilli* (Smith). The fragmentary representatives of *Pseudorthoceras* mentioned by Miller in 1945 almost certainly belong in *P. knoxense* as we are interpreting it; they came from about 100 feet above the base of the Bone Spring limestone near the mouth of Apache Canyon about 0.2 mile north of the Van Horn quadrangle on the second promontory north of the lower bench on the outside rim of the northern part of Apache Canyon in the Sierra Diablo of Hudspeth County, Texas.

In 1946 Clifton stated that he had collected *P. splendens*, which we regard as a synonym of *P. knoxense*, in

"the Pease River (El Reno) group in north central Texas. Two specimens were collected from the South Wells limestone member of the Cherry Canyon formation at a locality about 3 miles northeast of Pine Spring Camp, Guadalupe Mountains, Texas. A number of specimens were collected from strata of the San Andres group at localities in New Mexico"—that is, "at several localities in the Sacramento Mountains near Cloudcroft and along the Rio Penasco. Two specimens were collected at a locality in Last Chance Canyon about one mile northwest of Sitting Bull Falls, Eddy County, New Mexico, in strata that are doubtless time-stratigraphic equivalents (Clifton, 1945) of part of the San Andres group."

We have not seen any of these specimens and hence have no basis for an opinion in regard to their affinities.

Recently Miller and Kemp have recorded the occurrence of fragmentary specimens of this species in the Elm Creek limestone of the Admiral formation in Baylor County, Texas. Finally, Miller and Youngquist have reported a single specimen which R. C. Moore obtained from the Camp Creek shale member of the Pueblo formation (about 24 feet above the Saddle Creek limestone) 1.2 miles south and 0.6 mile west of the mouth of Saddle Creek, Mc Culloch County, Texas; and about 150 specimens which the same individual collected from the Wildcat Creek shale member of the Admiral formation about 4½ miles south-southwest of Coleman, Coleman County, Texas.

A discussion of the occurrence of this species should include the following statements which were made by Clifton (1944, p. 1018, 1030) in his report on the "Paleoecology and environments inferred for some marginal Middle Permian marine strata" in west Texas:

"An example of possible orientation by waves is suggested by phramacones of the nautiloid *Pseudorthoceras*. Great numbers of these phragmacones, whose individual lengths vary from less than an inch to 5 inches are fortuitous and should be responsive to action from any directional force. At the Croton Falls locality [in Stonewall County, Texas], where ripple-marked carbonates also occur, *Pseudorthoceras splendens* [= *P. knoxense*] is abundantly present in a thin carbonate stratum, whose outcrop extends northwest and southeast. It was estimated that 50 per cent or more of the nautiloid phragmacones in this stratum are now oriented northeast and southwest, with the adoral end of the phragmacones northeastward. Other *Pseudorthoceras* phragmacones in the rich assemblage are otherwise variously oriented. . . . Assumably none of the nautiloids [of the Blaine and the Dog Creek formations of north-central Texas] lived more than a casual planktonic existence. Though not everywhere abundant, their distribution is nevertheless uniform and not spotty, so that widely isolated or sporadic occurrences are not common. A case in point involves the distribution of the nautiloid *Pseudorthoceras splendens* [= *P. knoxense*] whose fossils, though abundant at some localities, appear to be rather closely restricted to those occurrences. This species, if a floater or a surface swimmer, might be expected sporadically at widely separated areas, by reason of postulated gas-filled chambers of the phragmacone. Its limited distribution seems to be evidence against a probable planktonic existence, or its transportation by waves or currents after death."

FIGURED TYPES.—The specimens illustrated on Plates 3 and 55 are at the U. S. National Museum. Those figures on Plate 2 are at the State University of Iowa, where they are numbered 1147 (fig. 7) 1148 (fig. 6), 1467 (figs. 4, 5), 1468 (figs. 1, 2), and 1469 (fig. 3).

Genus *Mooreoceras* Miller, Dunbar, and Condra, 1933

GENOTYPE: *Mooreoceras normale* Miller, Dunbar, and Condra

This genus, which was named in honor of Professor R. C. Moore, can be diagnosed as follows: Conch long, slender, straight, gradually and regularly expanded orad, slightly depressed dorsoventrally, and subcircular in cross section. Surface of test almost smooth, but in at least some cases bears fine inconspicuous longitudinal and transverse markings. Septa simple saucer-shaped disks moderately convex apicad. Sutures almost straight and directly transverse. Siphuncle slightly but distinctly ventrad of center of conch; small at its passage through the septa but expanded within the camera. Septa necks short and recurved, and length of brim approximately equal to that of septal necks. Segments of siphuncle fusiform to subspherical in shape; they become relatively broader in the adoral part of the phragmacone and in most cases are more or less pyriform as they are more abruptly rounded orad than apicad. The connecting rings are not in contact with the adjacent septa outside of the septal necks.

In 1939 Flower discussed this genus at some length and stated that representatives of it possess siphonal deposits "of the *Pseudorthoceras* type" and cameral deposits which "are concentrated on the ventral side of the conch." However, the holotype of the genotype, a well preserved individual (Pl. 4, figs. 1–4) does not seem to us to possess any siphuncular or cameral deposits that we can be reasonably certain are organic in origin; nor do any of the other numerous specimens from various horizons and localities in the Late Paleozoic that we are referring to this genus. As a matter of fact, we find that the absence of indigenous cameral deposits in representatives of *Mooreoceras* and their presence in those of *Pseudorthoceras* is one of the ways by means of which the two can be distinguished quite readily. Other differences are the shape of the cross section of the conch and the position of the siphuncle—that is, in *Pseudorthoceras* the conch is circular in cross section and the siphuncle is central in position, whereas in *Mooreoceras* the cross section of the conch is very broadly elliptical (due to a slight dorsoventral depression) and the siphuncle is located slightly but distinctly ventrad of the center.

Flower has referred to this genus several specimens from the Upper Devonian of Pennsylvania. Also, it is known to be of rather widespread occurrence in the Mississippian and particularly the Pennsylvanian of this country, and we are referring to it specimens from the Permian of Kansas, Texas, New Mexico, Arizona, Wyoming, British Columbia, and Colombia—stratigraphically it ranges at least up into the Word formation of Texas. It is difficult to determine from the published illustrations and descriptions alone, the generic affinities of many of the orthoconic nautiloids that have been recorded in the literature, but it seems likely that *Mooreoceras* is of essentially world-wide occurrence in both the Carboniferous and the Permian (and possibly the Devonian).

Mooreoceras giganteum Clifton

(Plate 3, figure 9; Plate 4, figures 7–9; Plate 5, figure 1)

1942. *Mooreoceras gigantea* CLIFTON, Jour. Paleont., vol. 16, p. 688, 695–696, pl. 103, figs. 4–6.
1944. *Mooreoceras gigantea* CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.

The holotype of this species (Pl. 4, figs. 8, 9) is an internal mold representing much of 17 camerae of the phragmacone. Its overall length measures about 138 mm. The cross section of the conch, which has obviously been distorted during preservation, is now broadly elliptical due to lateral compression. At a transverse break near the mid-length of the specimen, the width of the conch (in its present crushed condition) is some 43 mm. (estimated), and the corresponding height is about 53 mm. (Pl. 4, fig. 9). The rate of adoral expansion is fairly great, and the maximum height attained by the preserved portion of the holotype measures about 62 mm.

The surface of the internal mold appears to be devoid of markings other than the sutures. The camerae are of about average length, the septa are moderately convex apicad, and the sutures are essentially straight and directly transverse—those of the holotype are sinuous, presumably as a result of distortion during preservation.

The siphuncle is small at its passage through the septa and is considerably eccentric. At the transverse break along a septum near the mid-length of the holotype, the siphuncle is about 3 mm. in diameter and its center is some 21 mm. from the venter and some 32 mm. from the dorsum. It should be noted that as a result of distortion, the siphuncle is not in the median plane of the specimen.

REMARKS.—According to Clifton, the small fragment represented by Figure 5 on his Plate 103 of 1942 is part of the holotype of this species. However, its sutures are rather strongly sinuous, and its siphuncle is only some 7 or 8 mm. from the venter where the conch is clearly more than 40 mm. high. In this fragment, the segments of the siphuncle appear to be fusiform in shape.

The specimen which Clifton designated as a figured paratype (Pl. 4, fig. 7, of the present publication) is almost circular in cross section. Slightly orad of its mid-length, where its conch is about 23½ mm. high, its siphuncle is almost 2 mm. in diameter and is about 5½ mm. from the venter and 16 mm. from the dorsum. This specimen appears to be less rapidly expanded than the holotype and may not be conspecific with it.

Fairly recently C. C. Branson sent us a few specimens from the Hueco limestone of south-central New Mexico that we are referring to this species (Pl. 3, fig. 9; Pl. 5, fig. 1). All of these are fragmentary and most of them are crushed. The largest is illustrated on Plate 5. The preserved portion of it attains a maximum width of about 50 mm., in its present crushed condition. The siphuncle of this specimen is small at its passage through the septa and is located considerably nearer the venter than the dorsum. The individual represented by Figure 9 on Plate 3 appears to be essentially free from distortion, and it is subcircular in cross section. At its adapical end, there is exposed a slightly eccentric structure that may represent the siphuncle. A fragment of the test that adheres to this internal mold is fairly thick and has an essentially smooth surface. We are very uncertain in regard to the specific affinities of this specimen and are referring it to *M. giganteum* chiefly because it was found in direct association with several similar but larger fragments which appear to belong in that species.

It should perhaps be mentioned that the holotype of this species is the largest orthoconic nautiloid that has been illustrated or described from the Permian of America. However, several geologists have told us about much larger specimens that they have seen in the field.

OCCURRENCE.—All of the specimens that we are referring to this species came from the Lower Permian Hueco formation of south-central New Mexico and the Middle Permian Blaine and Dog Creek formations of north-central Texas. In the Hueco it is known to occur at three localities in T. 22 S., R. 10 E., Otero County, New Mexico: (1) near the center of sec. 9 [in and just below the "*Dictyoclostus* beds"]; (2) in a west-facing escarpment between two small east-west faults in the NE¼ sec. 15; and (3) along a strike wash on both sides of the saddle in the hill just north of the south line of sec. 20, at the center of the SW¼, on the McGregor Ranch, about ⅜ mile west and south of Little Crockett tank (Clover tank of U. S. Grazing Service map). The Acme member of the Blaine formation has yielded representatives of this species at two localities in north-central Texas: (1) north and northwest of Quanah, Hardeman County, and (2) northeastern Nolan and southeastern Fisher counties—common at the former locality, which yielded the holotype. Also, the Guthrie member of the Dog Creek formation has yielded conspecific specimens at two localities in north central Texas: (1) northeast and southeast of Kirkland in Childress County, and (2) "section 139 and areas northeast" in Stonewall County—common at the latter locality, which yielded the specimen represented by Figure 7 on Plate 4 and which contains the very important Croton Falls area in section 139.

TYPES.—State University of Iowa, 1471 (holotype) and 1472 (Pl. 4, fig. 7); and U. S. National Museum (Pl. 3, fig. 9; and Pl. 5, fig. 1).

Mooreoceras kickapooense (Swallow)

1858. *Orthoceras Kickapooense* SWALLOW, Acad. Sci. St. Louis, Trans., vol. 1, p. 178, 197.
1942. *Mooreoceras kickapooense* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 719.

All of the available information in regard to this species is contained in the original description, which reads as follows:

"*Shell* elongate, conical, tapering gradually, sub-cylindrical, slightly flattened on the side next to the siphuncle; septa convex, distant less than one-third their smallest diameter; periphery sub-

elliptical and slightly curved in the direction of the major axis; siphuncle small, eccentric, one-third of the diameter from the flattened side. Surface markings not seen.

"Maj. Hawn's collection from the Upper Permian Rocks, near Smoky-Hill Fork."

REMARKS.—The type specimen or specimens of this species were never illustrated or restudied, and we have not been able to locate them. The shape of the conch and the position of the siphuncle suggest a relationship to *Mooreoceras*, to which genus the species is accordingly referred. It is, however, so poorly known that even its generic affinities are uncertain, and it is not possible to place specimens in it with a reasonable degree of assurance.

OCCURRENCE.—Some unknown horizon in the Permian near the Smoky Hill River in central Kansas.

TYPE(S).—Probably lost in the fire at the University of Missouri in 1892.

Mooreoceras spp.

(Plate 4, figures 5, 6; Plate 6, figures 8-10; Plate 35, figures 1-3; Plate 47, figure 1; Plate 55, figures 15-17)

1891. *Orthoceras rushensis?* [part?] WHITE, U. S. Geol. Surv., Bull. 77, p. 22, pl. 2, figs. 14–16.
1909. *Orthoceras* sp. GIRTY, U. S. Geol. Surv., Bull. 389, p. 49, 112–113, pl. 12, figs. 2–2b.
(?) 1934. *"Orthoceras"* sp. MILLER AND CLINE, Jour. Paleont., vol. 8, p. 283, 289–290.
1936. *Mooreoceras?* sp. MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 726–727, pl. 97, fig. 1.
1936. *"Orthoceras"* sp. MILLER AND CROCKFORD, Roy. Soc. Canada, Trans., 3d. ser., sec. 4, vol. 30, p. 23–24, pl. 1, figs. 5, 6.
1941. *Orthoceras guadalupense* [part?] STAINBROOK AND MADERA, Jour. Paleont., vol. 15, p. 376, 382–383, pl. 55, fig. 27.
1942. *Mooreoceras normale* CLIFTON, Jour. Paleont., vol. 16, p. 688, 695, pl. 103, fig. 2.
1942. *Mooreoceras* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720, 721.
1944. *Mooreoceras normale* CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.
1945. *Mooreoceras* spp. MILLER, Jour. Paleont., vol. 19, p. 282, 283–284, pl. 44, figs. 8–10.
1945. *Mooreoceras* sp. CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 29, p. 1769, 1770.
1947. *Mooreoceras* sp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.
1949. *Mooreoceras* spp. THOMPSON AND MILLER, Jour. Paleont., vol. 23, p. 7, 8, pl. 8, figs. 3–5.

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At several widely separated localities, the Permian of the Americas has yielded fragments o smooth slender orthoconic nautiloids which are broadly elliptical in cross section and which have siphuncles that are not quite central in position. Presumably these belong in the genus *Mooreoceras*, but it is difficult in most cases to be certain in regard to their affinities.

As long ago as 1891, White noted that at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas, the beds now known as the Grape Creek limestone of the Clyde formation contain fragmentary orthoconic nautiloids "which possibly represent more than one species" (see Pl. 55, figs. 15–17). Miller and Kemp have recently found that both *Pseudorthoceras* and *Mooreoceras* are represented there, and almost certainly they are the forms to which White referred. In addition, these latter authors indicate that *Mooreoceras* (and *Pseudorthoceras*) occur in the Lower Permian of Baylor County in the Elm Creek limestone of the Admiral formation and near the base of the Lueders formation.

In his study of the paleontology of the Manzano group of the Rio Grande Valley, Girty (Lee and Girty, 1909, p. 112) under the heading *"Orthoceras* sp." stated:

"Of this type our collection has furnished a single specimen [Pl. 35, figs. 1–3] preserving the living chamber and a few of the septal chambers below. The size is rather large and the taper rather rapid. The section is somewhat elliptical and the siphuncle distinctly eccentric. The smaller end is 20 mm. by 19 mm. in diameter. The longer diameter of the larger end must have been about 26 mm. The length of the fragment is 46 mm. On the smaller end the siphuncle is 12 mm. from the farther side and 7 mm. from the nearer. It is very small. The sutures are not straight, but have a well-developed, broad lobe upon what may provisionally be called the ventral side. It is this side near which the siphuncle is situated and upon which the flattening chiefly occurs. Upon the dorsal side the sutures are directly transverse, but laterally they naturally bend upward in process of forming the ventral lobe. The normal height of the chambers at this size is 4 mm., or one-fifth the larger diameter, as shown by the final chamber on the specimen as figured and by two imperfect detached chambers, but the chamber just below the living chamber is almost 8 mm., while there is some indication of another septum 22 mm. above that forming the base of what is here regarded as the living chamber. This narrow groove upon the interior mold may indicate a septum, but is provisionally considered a varix of growth near the real aperture. At all events, the irregularity in the height of the chambers may probably be interpreted as an indication that the specimen is mature, with a rather short chamber of habitation."

We have not had an opportunity to study this specimen, but almost certainly it is a representative of *Mooreoceras* that has been slightly distorted during preservation. It is stated to be from the Abo sandstone (about 50 feet above base of red beds) at head of Abo Canyon "south of railroad line and ½ mile east of a deserted stone cabin" at south end of Manzano Mountains, New Mexico.

Miller and Cline (1934, p. 289–290) found a single orthoconic nautiloid in the "Goniatite beds" of the phosphatic shale member of the Phosphoria formation on the south side of Raymond Canyon in the Sublette Range of westernmost Wyoming. This specimen appears to be the only nautiloid

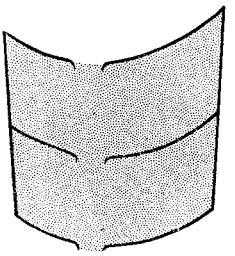

FIGURE 1.—*Mooreoceras? sp.*

Diagrammatic median longitudinal dorsoventral section of a specimen from the Cache Creek series near Kamloops, British Columbia, × 2.

of this general type known from the Phosphoria formation. It is an internal mold of part of three chambers of the phragmacone. The part of the conch that is represented was about 15 mm. in diameter and was expanded orad very gradually. The surface of the internal mold, at least, is smooth and is entirely devoid of markings other than the sutures, which apparently are straight and, being directly transverse to the long axis of the conch, form simple circles. The camerae are long and their length is equal to about half their diameter. The internal structures of this specimen are not preserved, and therefore its generic affinities cannot be ascertained. It may belong in *Mooreoceras*, *Pseudorthoceras*, *Bitaunioceras*, *Michelinoceras*, or some similar genus.

During the summer of 1934, Crockford obtained a few nautiloids from grayish glauconitic beds of impure limestone at the top of the Cache Creek shale near Kamloops, British Columbia (Pl. 4, fig. 6). As indicated by Miller and him, all of these appear to belong to a single species. The largest individual is about 60 mm. long, and it is incomplete adapically and adorally. Its conch is subcircular in cross section and is expanded gradually and regularly from a diameter of about 11 mm. at its adapical end to about 18 mm. near its adoral end. The test appears to be smooth. The septa are saucer-shaped and are rather strongly convex apicad, with the convexity equal to about a fourth their diameter. The camerae are scarcely half as long as wide. The siphuncle is small, circular in cross section, and slightly eccentric. The septal necks are short and appear to be fairly straight (Fig. 1—which represents a larger individual than Pl. 4, fig. 6). The shape of the connecting rings could not be ascertained with a reasonable degree of certainty. The fact that the septal necks are not appreciably recurved makes the reference of this form to *Mooreoceras* uncertain.

In Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming, Miller and Thomas obtained from the Casper formation a few straight cephalopods in which the conch is slightly depressed dorsoventrally, the siphuncle is located distinctly ventrad of the center, and there appear to be no peripheral deposits in the camerae. The largest of these specimens attains a maximum width of about 30 mm. The test is thin and is marked externally by only straight or very slightly sinuous transverse growth lines, which on some individuals are quite distinct. The septa are simple saucer-shaped disks that are moderately convex apicad, and the camerae are of about average length (see Pl. 47, fig. 1). The sutures are straight or only very slightly sinuous, and they are transverse to the long axis of the conch. Due to the rather poor preservation of the specimens, the structure of the siphuncle can not be ascertained with certainty; but in one of the individuals that was sectioned, structures that are probably siphuncular segments were encountered, and they are fusiform in shape. All in all, these specimens seem to be typical representatives of the genus *Mooreoceras*.

Clifton has referred to *Mooreoceras normale* some specimens that he collected from the Acme member of the Blaine formation and the Guthrie member of the Dog Creek formation at several localities in north-central Texas. Presumably, the one that he figured (Pl. 4, fig. 5, of the present publication) is typical. It is an only moderately well preserved portion of a phragmacone which is smooth, is gradually and regularly expanded orad, and is broadly elliptical in cross section as it is depressed dorsoventrally. The overall length of this specimen measures about 28½ mm. The width of its conch increases from about 12 mm. (estimated) near its adapical end to about 14 mm. near its adoral end; and corresponding measurements of its height are about 10 mm. and 12½ mm., respectively. Its camerae are fairly short, its septa are moderately convex apicad, and its sutures are essentially straight and directly transverse. At the adapical end of the specimen, which is formed by the impression of a septum, the siphuncle is about 1 mm. in diameter and its center is about 4½ mm. from the venter and about 5½ mm. from the dorsum. All of the characters of this specimen that can be ascertained do not appear to differ materially from those of the holotype of *M. normale* (cf. Pl. 4, figs. 1–4). However, in view of the fact that we do not know the structure of its siphuncle, we cannot be certain in regard to even its generic affinities and therefore are reluctant to identify it specifically. According to Clifton, in the Acme this form is common north and northwest of Quanah in Hardeman County, and it occurs also in the northeastern part of Nolan County and the southeastern part of Fisher County. He states that in the Guthrie it is present northeast and southeast of Kirkland in Childress County, is abundant in "section 139 and areas northeast" in Stonewall County, and was found also about 2 miles south of Sylvester in Fisher County.

Stainbrook and Madera illustrated one and briefly described two small fragments of orthoconic nautiloids from a small portion of a core taken at a depth of 5125 feet in a well located 440 feet from the south and west lines of Labor 53, League 40, Maverick County School Lands, Hockley County, Texas. Both of their specimens are stated to be smooth internal molds, the diameters of which are about 3.8 mm. and 10 mm., respectively. No information is given in regard to the siphuncles of these specimens and therefore their generic affinities are uncertain—they may well belong in *Mooreoceras*, *Pseudorthoceras*, *Michelinoceras*, or some other genus. On the basis of the associated fossils (chiefly brachiopods) Stainbrook and Madera concluded that the age of the containing beds is most probably either Leonard or Word.

For the sake of completeness, it should be mentioned that Miller and Unklesbay state that specimens which are probably referable to this genus are known from the following horizons and localities: (1) the Phosphoria formation (or the equivalent Satanka shale) of Wyoming; (2) the Chupadera formation near Bluewater Dam about 16 miles northwest of Grants, Valencia County, New Mexico; and (3) the Kaibab formation in the general vicinity of Flagstaff, Coconino County, Arizona.

Also, as was noted by Miller in 1945 we should most probably refer to *Mooreoceras* some of the numerous fragmentary smooth round orthocones known from each of the following horizons and localities in west Texas: (1) about 100 feet above the base of the Bone Spring limestone near the mouth of Apache Canyon about 0.2 mile north of the Van Horn quadrangle on the second promontory north of the lower bench on the outside rim of the northern part of Apache Canyon in the Sierra Diablo of Hudspeth County; (2) the upper Leonard (or possibly the lower Word) limestone near the top of the slope on the northwest side of the road about 0.5 mile southwest of the old Word Ranch house, some 17 miles north-northwest of Marathon, Brewster County; (3) the third limestone of the Word formation on the northern slope of the hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch house, some 14 miles north-northeast of Marathon, Brewster County; and (4) the Word formation at elevation 5250 on the southern side of a spur on the eastern side of Gilliland Canyon extending northwest to benchmark 4973 in the Glass Mountains of Brewster County—see Figures 8–10 on Plate 6. Also, Clifton (1945, p. 1769) lists "*Mooreoceras* sp." from the first limestone of the Word formation about 1 mile west-southwest of the old Word Ranch house in the Glass Mountains of west Texas.

Finally, Thompson and Miller have recently illustrated some specimens that probably belong in this genus from the following horizons and localities in northern Colombia near the Venezuelan border: (1) dark-gray limestone float in Río Molino about 6 kilometers upstream from the village of Molino in the Departamento de Magdalena; and (2) limestone which carries *Medlicottia* and *Perrinites* along the trail on top of the ridge on the north side of Quebrada Manaure about 4 kilometers east of

the village of Manaure, also in the Departamento de Magdalena. Little information is available in regard to the internal structures of these specimens, and therefore they are of no great significance. Almost certainly their age is Middle Permian (Leonard). They have been deposited at the University of California in Berkeley, where they are numbered 32899 and 32900.

FIGURED SPECIMENS.—University of Alberta (Pl. 4, fig. 6; and Text fig. 1); State University of Iowa, 1470 (Pl. 4, fig. 5) and 1150 (Pl. 47, fig. 1); U. S. National Museum, 111609 (Pl. 6, fig. 8), 111610 (Pl. 6, fig. 9), and presumably Pl. 35, figs. 1–3, and Pl. 55, figs. 15–17; and American Museum of Natural History (Pl. 6, fig. 10).

Suborder ORTHOCHOANITES Hyatt, 1900

The distinguishing characteristic of this group is an orthochoanitic siphuncle, that is, a siphuncle in which the septal necks are not appreciably recurved, and the connecting rings are cylindrical or subcylindrical in shape. The siphuncular segments are therefore not greatly expanded within the camerae as they are in the Cyrtochoanites, and they rarely contain organic deposits. The form of the conch, the shape of the sutures, the nature of the aperture, and the prominence of the surface ornamentation are all quite variable.

This group includes the majority of the nautiloids, and it is world-wide in its distribution. It appeared in the Upper Cambrian (*Plectronoceras*) and continued to the Recent (*Nautilus*). Presumably, it is ancestral to all other types of nautiloids, for it antedates them. It is indeed well represented in the Permian, and it includes all post-Paleozoic forms.

Family ORTHOCEROTIDAE Teichert and Miller, 1936

Throughout almost all of the Paleozoic and the early Mesozoic, there were long slender straight smooth (or nearly so) nautiloids with central or subcentral orthocoanitic siphuncles. In the past these have in general been lumped together under the generic term *Orthoceras*. Teichert and Miller have shown that this name cannot legally be applied to fossil cephalopods, but that Brünnich's term *Orthoceros* of 1771 can be used for part of the forms that have been called *Ortheroceras*. Furthermore those authors have suggested the family name Orthocerotidae, and it seems to be valid and to have many points in its favor.

The genotype of *Orthoceros* is *Orthoceratites regularis* Schlotheim of the Ordovician (Chazian equivalent) in the Baltic area. It is an orthoceraconic orthochoanitic nautiloid with straight transverse growth lines and sutures and with a few prominent but short longitudinal grooves or fossae on the living chamber and in some cases a broad shallow transverse constriction near the aperture. No cephalopods are known from the Permian that have similar longitudinal grooves or fossae. Presumably, therefore none of the forms under consideration can be referred to *Orthoceros*, though a good many of them are being placed in the same family.

Genus *Michelinoceras* Foerste, 1932

GENOTYPE: *Orthoceras michelini* Barrande

As was noted indirectly by Foerste, since the presence of longitudinal grooves or fossae should presumably be regarded as a diagnostic feature of *Orthoceros*, "another designation must be sought for the species in which the siphuncle is similar in its tubular form, and in which the camerae are similarly elongated vertically [longitudinally], but in which no grooves are present". For these, Foerste then proposed the generic term *Michelinoceras* and designated *Orthoceras michelini* Barrande as the type species, but he did not discuss the matter further.

Inasmuch as Barrande's works are not readily available to the great majority of American paleontologists, we are reproducing as Figures 8–11 on Plate 7 several of his illustrations of this genotype. These elucidate most of the significant characters of the species. However, attention should perhaps be called to the fact that Barrande apparently allowed it considerable latitude, particularly insofar as the rate of adoral expansion of the conch and the length of the camerae are concerned, and presumably too much significance should not be attributed to either of these characters except in extreme cases. The largest of the specimens figured or discussed by Barrande is not complete adorally

or adapically, but the preserved part of it is about 245 mm. long and has a maximum diameter of about 20 mm.—the general physiognomy of this specimen suggests that when complete it was something like twice its present length. The conch in this species is expanded orad very gradually and is circular in cross section. The living chamber is very long, and its length is at least sixteen times as great as its smallest diameter. The test is thin, attaining a maximum thickness of only about 1 mm., and no trace of surface markings is discernible on that of the type specimens. The camerae are long, the septa are considerably convex, and the sutures are straight and directly transverse. The siphuncle is small, subcentral in position, and orthochoanitic in structure. At a maximum, the eccentricity of the siphuncle does not exceed its radius. The septal necks are moderately long and essentially straight. The connecting rings, which have a slightly greater diameter than the septal necks, are cylindrical in shape. Barrande states that there is no trace of organic deposits in either the siphuncle or the camerae, but some of the drawings he published show suggestions of subfusiform deposits around the siphuncle that may possibly be indigenous. This species, as interpreted by its author, is not rare in the Middle Silurian of Bohemia, and it may occur also in the Upper Ordovician and the Lower Devonian of the same region.

Forms that seem to resemble this genotype in its essential features are of world-wide occurrence, and stratigraphically they range through most of the Paleozoic and the early Mesozoic. It is, to be sure, doubtful if the genetic relationship of all of these is very close, but we know of no satisfactory way to differentiate them generically.

Michelinoceras? guadalupense (Girty)

(Plate 2, figures 8–10)

1908. *Orthoceras guadalupense* GIRTY, U. S. Geol. Surv., Prof. Paper 58, p. 21, 55, 490, 492, 493, 494, 495, 496, 497, pl. 23, figs. 10-10b.
1941. *Orthoceras gualdalupense* [part?] STAINBROOK AND MADERA, Jour. Paleont., vol. 15, p. 376, 382–383, pl. 55, fig. 27.
1942. *Mooreoceras? gualdalupense* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720.

When Girty established this species, he described it as follows:

"Shell circular in cross section, small, slender, gradually tapering. Siphuncle rather large, central. Septa moderately concave, about 2 mm. apart.

"The single fragmentary specimen obtained has a length of 11 mm., with a diameter of about 5.5 mm. above and 4.75 mm. at the lower end. Five chambers are included within this measurement of 11 mm., together with the convexity of one chamber. The surface was possibly marked by faint concentric striae, but appears on casts of the exterior to be smooth."

REMARKS.—We have not had an opportunity to study the holotype of this species. Although Girty states that the cross section of its conch is circular, one of his illustrations (Pl. 2, fig. 9, of the present publication) indicates that it is broadly elliptical. Accordingly, we are inclined to suspect that its affinities may be with *Mooreoceras*, in typical representatives of which, however, the siphuncle is distinctly eccentric in position. Until the structure of the siphuncle is known, it will, of course, not be possible to place the species definitely in any genus. It may well be referable to *Pseudorthoceras* or *Bitauniоceras*.

In 1941 Stainbrook and Madera referred to this species two small fragments (smooth orthoconic internal molds) from a well core taken 5125 feet below the surface in Hockley County, Texas. No information is given in regard to the siphuncles of these specimens, and therefore we are uncertain in regard to even their generic affinities. They may well be referable to *Michelinoceras*, *Pseudorthoceras*, or *Mooreoceras*, and we are discussing them under the heading "*Mooreoceras* spp." Stainbrook and Madera believed that the associated fossils (chiefly brachiopods) indicate that their age is most probably either Leonard or Word.

OCCURRENCE.—Delaware Mountain formation (probably from a limestone just below the Getaway member) on the "west side of road at entrance to Guadalupe Canyon", about 2 miles southeast of El Capitan in the Guadalupe Mountains of Culbertson County, Texas.

HOLOTYPE.—U. S. National Museum.

Michelinoceras spp.

(Plate 6, figure 7)

1945. *Michelinoceras* spp. Miller, Jour. Paleont., vol. 19, p. 282, 283–284, pl. 44, fig. 7.

As was noted by Miller in 1945, the Middle Permian of west Texas has yielded a variety of fragmentary small smooth orthoconic nautiloids. Almost all of them are silicified, and the great majority cannot be placed definitely in any genus for the characteristics of their siphuncles cannot be determined. However, in a few of them the siphuncle is central in position and appears to be orthocoanitic in structure, for it is small in size and is composed of cylindrical segments. Presumably these are referable to *Michelinoceras*, as interpreted by us, but it should be clearly understood that none of these specimens is very complete, and part or all of them may well belong in *Bitaunioceras* or some other similar genus.

Occurrence.—About 100 feet above the base of the Bone Spring limestone near the mouth of Apache Canyon about 0.2 mile north of the Van Horn quadrangle on the second promontory north of the lower branch on the outside rim of the northern part of Apache Canyon in the Sierra Diablo of Hudspeth County, Texas.

Figured Specimen.—Princeton University.

Genus ***Bitaunioceras*** Shimizu and Obata, 1936

Genotype: *Orthoceras bitauniense* Haniel

When this genus was established, its authors designated *Orthoceras bitauniense* Haniel of the Middle Permian of Timor as the type species, and stated that it "is distinguished by its somewhat irregular transverse striae and periodic constrictions". In this genotype (Pl. 7, figs. 1, 2), the conch is orthoceraconic, being very gradually expanded orad, and is circular in cross section. The surface of the test bears a few shallow rounded transverse constrictions and numerous prominent transverse lirae which are not of equal size and are somewhat irregular in this respect. The septa are moderately convex apicad, and the sutures appear to be straight and to be directly transverse to the long axis of the conch. The siphuncle is almost central in position and is small at its passage through the septa. The structure of the siphuncle in the only known representative of the type species was not investigated, but very similar specimens from the Middle Permian of northern Mexico have orthochoanitic siphuncles in which the septal necks are straight and short and the connecting rings are cylindrical. These Mexican specimens also make it clear that in this genus the transverse constrictions (but not the lirae) are present on the internal mold, as well as the surface of the test (Pl. 8, figs. 1–7).

Forms that seem to be referable to this genus occur in the Permian of Timor, Sicily, Coahuila, and Texas. However, these can be differentiated from *Michelinoceras* by only the surface markings and the transverse constrictions of the conch, which may not be of generic significance. In the specimens that we are tentatively placing in *Bactrites*, the siphuncle is marginal in position, and in *Pseudorthoceras* and *Mooreoceras* it is cyrtochoanitic in structure. *Neorthoceras* Shimizu and Obata has a subcentral siphuncle, the structure of which has never been investigated—therefore the taxonomic position of the genus is unknown. Stratigraphically, *Bitaunioceras* can now be said to range throughout most of the Permian.

Bitaunioceras coahuilense Miller

(Plate 8, figures 1–7)

1942. *Bitauniceras* sp. Miller and Unklesbay, Jour. Paleont., vol. 16, p. 720.
1944. *Bituaniceras coahuilense* King, Geol. Soc. Am., Spec. Pap. 52, p. 10, 11, 12, 14.
1944. *Bituaniceras coahuilense* Miller, Geol. Soc. Am., Spec. Pap. 52, p. 72, 76–77, pl. 20, figs. 1–7.

Conch long, narrow, straight, very gradually expanded orad, circular in cross section, and moderately large—the largest of the syntypes attains a diameter of 21 mm., and it is septate throughout and therefore represents only part of the phragmacone. Length of living chamber not known. Surface of test marked by rather prominent transverse lirae; these are somewhat irregular, but in general every third one of them is distinctly larger than the interveing ones. Internal mold of

conch smooth, but marked by rounded transverse constrictions which represent internal thicknenings of the test and do not affect the exterior of the shell. The spacing of these constrictions seems to vary in different individuals (cf. Pl. 8, figs. 1 and 6), but the distance between them is never less than the length of one camera and in some cases is much more. These constrictions are more abrupt adorally than adapically.

Camerae rather long and normally about equal in length to the diameter of the conch. Septa saucer-shaped and moderately convex apicad. Sutures simple circles directly transverse to the long axis of the conch. Siphuncle central (or nearly so) in position, tubular in form, orthochoanitic in structure, and rather small—its diameter is equal to only about an eighth that of the conch. Septal necks straight and short—their length is equal to only about half the diameter of the siphuncle. Connecting rings cylindrical and segments of siphuncle not expanded within the camerae (Pl. 8, figs. 3, 4).

REMARKS.—This species is based on about 30 specimens, but most of them are very incomplete and rather poorly preserved. No nautiloids are known from America that are very similar to this species. However, Gemellaro has described a closely related form, *B. zonatum*, from the Middle Permian (zone of *Waagenoceras*) Sosio beds of Sicily, and Haniel has described another, *B. bitauniense*, from the Middle Permian (zone of *Perrinites*) Bitauni beds of Timor.

OCCURRENCE.—Abundant in the Middle Permian zone of *Waagenoceras* and the Upper Permian zone of *Timorites* in the Valle de Las Delicias, Coahuila, and present also in the Middle Permian zone of *Perrinites* in the same general locality. The available collections from the Valle de Las Delicias contain representatives of this species from the following horizons and localities: (1) 3 specimens from the *Perrinites* shale 2600 to 2800 meters S. 42° E. of Noria de Malascachas, (2) 1 from the beds presumably in the zone of *Waagenoceras* that outcrop some 800 or 900 meters south of Noria de Malascachas, (3) 1 from a limestone layer in the zone of *Waagenoceras* about 2000 meters S. 47° W. of Noria de Malascachas, (4) 17 from alternating shale and graywacke in the zone of *Waagenoceras* about 60 meters N. 35° E. of La Difunta, (5) 2 from a concretionary shale in the zone of *Waagenoceras* about 1300 meters N. 42° E. of La Difunta, and (6) 9 from concretionary shales in the zone of *Timorites* along the strike from Cerro Wencelao on the south to 300 meters west of El Indio on the north.

TYPES.—All the figured syntypes are in the Yale Peabody Museum, where they are numbered 16264 (Pl. 8, figs. 1, 2), 16265 (Pl. 8, figs. 3, 4), 16266 (Pl. 8, fig. 5), and 16267 (Pl. 8, figs. 6, 7). Unfigured syntypes are at Yale University, the State University of Iowa, and The University of Kansas.

Bitaunioceras texanum Miller and Youngquist

(Plate 3, figure 1)

1947. *Bituanioceras texanum* MILLER AND YOUNGQUIST, Kansas Univ. Paleont. Contr., Mollusca, art. 1, p. 1, 2, 4, pl. 1, fig. 15.

The only known representative of this species is an internal mold of three camerae of a phragmacone that is expanded orad very gradually and is circular in cross section. The maximum length and diameter of the preserved portion of this individual measure about 18 mm. and 6 mm., respectively.

No trace of the surface markings of the test is discernible on the holotype, but in at least each of the adapical two camerae there is a broad shallow rounded transverse constriction with rather indefinite borders. The camerae are very long in comparison to their diameter. The convexity of the septa is somewhat greater than average. The sutures form simple circles as they are straight and directly transverse. The siphuncle is central in position and at least at its passage through the septa is small; its diameter measures considerably less than 1 mm. at the ends of the holotype, which are formed by septa, or impressions of them.

REMARKS.—The very gradually expanded conch, transverse constrictions, long camerae, straight sutures, and small central siphuncle of this form all indicate that it belongs in *Bitaunioceras*. However, it is not very close to any of the other known representatives of that genus, which is perhaps to be expected, for all of them are from younger portions of the Permian system. That is, the species under consideration is by a considerable amount the oldest known representative of the genus.

OCCURRENCE.—Wildcat Creek shale member of the Admiral formation, about 4½ miles south-southwest of Coleman, Coleman County, Texas.

HOLOTYPE.—U. S. National Museum.

Family BACTRITIDAE Hyatt, 1884

As explained in the following paragraphs, most of the forms that are generally referred to this family are probably ammonoids. However, the Late Paleozoic has yielded a few specimens which

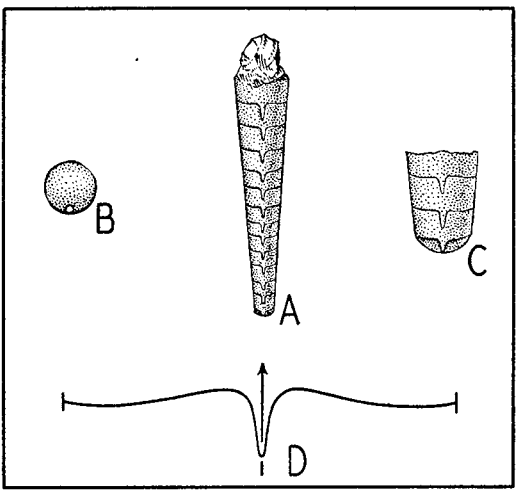

FIGURE 2.—*Bactrites subconicus* Sandberger

The genotype of *Bactrites*, from the Middle Devonian Wissenbach slate at Wissenbach, Germany, × 2. Redrawn from G. and F. Sandberger.

are similar to the type species of the typical genus, *Bactrites*, but which, at the same time, in general physiognomy seem to be nautiloids. Inasmuch as only a single American Permian species is involved, we are tentatively placing it in the genus *Bactrites*, but are indicating our uncertainty in regard to its generic affinities by the use of an interrogation point. If, as has been contended by some, all of the forms that are now generally referred to *Bactrites* are nautiloids, it may be that the family name Orthocerotidae should be suppressed as a synonym of Bactritidae, which has priority. However, in typical representatives of the Orthocerotidae the siphuncle is central or subcentral in position and the sutures are essentially straight and directly transverse throughout their entire length, whereas in the Bactritidae the siphuncle is marginal in position and the sutures form a small ventral lobe.

Genus ***Bactrites*** Sandberger, 1843

GENOTYPE: *Bactrites subconicus* Sandberger

When Sandberger established this genus, he named only one specific representative of it, *B. subconicus* Sandberger of the Middle Devonian of Germany (Wissenbach slate of Wissenbach), and that species is therefore the genotype. Numerous specimens from the Devonian, Carboniferous, and Permian of various parts of the world have been referred to this genus by different authors; also a species from the Ordovician of Bohemia was included in it for a long time but has fairly recently been removed by Schindewolf and used as the basis for a distinct genus, *Eobactrites*. Schindewolf has also established a genus *Lobobactrites* for certain of the Devonian species that have been included in *Bactrites*. Several authors have stated that the Late Paleozoic forms referred to *Bactrites* are in reality nautiloids and not ammonoids, and Spath (1933, 1936) has concluded that *Bactrites* "is merely an

Orthoceras with a marginal siphuncle" and that all the forms that have been referred to it (except those that have subsequently been removed to the genus *Lobobactrites*) are nautiloids—he regarded *Lobobactrites* as an uncoiled goniatite. However, Schindewolf (1933, 1934) has argued rather convincingly, we believe, that *Eobactrites*, *Bactrites s. s.*, and *Lobobactrites* are all very closely related and that they should be regarded as primitive ammonoids. He indicated, however, that there was some doubt in his mind in regard to the affinities of the Late Paleozoic forms that have been referred to this genus, but after a detailed comparison of several of them with Devonian representatives, we have been unable to find any satisfactory basis for differentiating them generically.

The genus can be briefly diagnosed as follows: Conch long, straight, slender, and circular or (due to slight lateral flattening) elliptical in cross section. Aperture, as indicated by growth lines, marked by a hyponomic sinus on the siphonal side of the conch. At maturity each suture forms a small but rather prominent V-shaped ventral lobe. The lateral and dorsal portions of the sutures are nearly straight, but in some representatives shallow lateral lobes and a dorsal saddle are found. Typically the septa are directly transverse to the long axis of the conch, but in some forms they are oblique. Siphuncle ventral and marginal.

Schindewolf states that this genus differs from *Eobactrites* in that the growth lines in that genus form only a very shallow ventral sinus and the sutures form narrower but longer ventral lobes.

However, in the genotype of *Bactrites*, *B. subconicus*, as illustrated by G. and F. Sandberger, the ventral lobe of the sutures is relatively longer than is that of the genotype of *Eobactrites*, and it may be that there is no valid generic distinction between these two forms. In *Lobobactrites* the conch is strongly flattened laterally and is therefore broadly elliptical or oval in cross section, and the sutures form prominent lateral lobes and dorsal saddles—this genus is therefore quite distinct from *Bactrites s. s.*

Stenoceras d'Orbigny, 1849, is apparently a synonym of *Bactrites*. However, the genotype of *Trematoceras* Eichwald, 1851, which is generally listed as a synonym of *Bactrites*, is clearly a nautiloid with a subcentral siphuncle.

Bactrites? mexicanus Miller

(Plate 3, figures 10–12; Plate 8, figures 8, 9)

1942. *Bactrites* sp. Miller and Unklesbay, Jour. Paleont., vol. 16, p. 720.
1944. *Bactrites mexicanus* Miller, Geol. Soc. Am., Spec. Pap. 52, p. 72, 82, pl. 20, figs. 8, 9; pl. 21, figs. 4–6.
1947. *Bactrites? mexicanus* Miller and Unklesbay, Carnegie Mus., Ann., vol. 30, p. 325.
1947. *Bactrites? mexicanus* Miller and Unklesbay, Kansas Univ. Paleont. Contr., Mollusca, art 2, p. 4.

Conch long, slender, straight, circular in cross section, gradually expanded orad, and rather large. The largest syntype (Pl. 8, figs. 8, 9) attains a diameter of about 50 mm. and represents only part of the phragmacone. The most nearly complete syntype (Pl. 3, figs. 10–12) is about 100 mm. long, and its diameter varies from about 14 mm. at its adapical end to about 25 mm. at its adoral end, indicating an apical angle of about 5 degrees. Length of living chamber not known. Test thin and smooth. Faint transverse markings on some of the syntypes may represent growth lines; they are directly transverse to the long axis of the conch and seem to be straight, but their course across the ventral (siphonal) side of the conch can not be determined. On the exterior of the test there are also traces of longitudinal lirae, but these are very faint. Internal mold smooth and marked by only the sutures. Camerae moderately long, and their length is equal to about three-fifths their width. Sutures straight and directly transverse to long axis of conch, but on the siphonal (ventral) side of the conch each suture seems to form a small V-shaped lobe. Siphuncle small, ventral and marginal in position, and apparently composed of cylindrical segments.

Remarks.—The above description is based on 15 specimens but most of them are fragmentary and rather poorly preserved. This species appears to be closely related to *B.? paternoi* (Gemmellaro) and *B.? adrianensis* (Gemmellaro) of the Middle Permian Sosio beds of Sicily and to several unnamed straight forms with marginal siphuncles which Haniel described from the Middle Permian Bitauni beds of Timor. *B.? mexicanus* also resembles rather closely *B.? cherokeensis* Miller and Owen of the Lower Pennsylvanian of Missouri and *B.? collinsi* Miller and Unklesbay of the Middle Pennsyl-

vanian of Ohio—in all three of these forms the conch bears transverse markings. *B.? wintersetensis* Miller and Unklesbay of the Middle Pennsylvanian of Missouri, like *B.? mexicanus*, has very long camerae, and these two species seem to resemble each other very closely; however, in view of the difference in their age, it seems probable that the relationship between them is more apparent than real.

Occurrence.—All of the known representatives of this species (the syntypes) came from the Middle (zone of *Perrinites*) and Upper (zone of *Timorites*) Permian in the Valle de Las Delicias of southwestern Coahuila. The two largest syntypes are from the *Perrinites* shale 2600 to 2800 meters S. 42° E. of Noria de Malascachas. The others were collected from concretionary shales in the zone of *Timorites* along the strike from Cerro Wencelao on the south to 300 meters west of El Indio on the north.

Types.—Figured syntypes, Yale Peabody Museum, 16277 (Pl. 8, figs. 8, 9) and 16278 (Pl. 3, figs. 10–12). Unfigured syntypes are at Yale University, the State University of Iowa, and The University of Kansas.

Family Koninckioceratidae Hyatt, 1893

When this family was established, its author stated that it was "for the reception of the series of Carboniferous Nautiloids having whorls and sutures similar to those of Koninckioceras either during the early stages or throughout life", but he referred to it only the type genus (*Koninckioceras*), *Domatoceras*, and *Stenopoceras*, all of Hyatt. Later, he (Hyatt, 1900, p. 525) included in addition two rather poorly known genera, *Potoceras* Hyatt and *Peripetoceras* Hyatt.

Our concept of the family is quite different. That is, we are placing in it nautilicones in which the whorls are depressed dorsoventrally and are not deeply impressed dorsally, the umbilicus is large, the sutures are only slightly sinuous, and the siphuncle is subcentral and is orthochoanitic. As thus interpreted, the family includes *Koninckioceras* in which the volutions are rather broadly rounded laterally, *Knightoceras* in which the lateral zones of the conch are narrowly rounded or even angular, and *Endolobus* in which there are low rounded lateral nodes.

All three of these genera are represented in both North America and Europe. Two of them (*Koninckioceras* and *Endolobus*) are known to range from at least the Mississippian or Lower Carboniferous to the Permian, inclusive, whereas the third (*Knightoceras*) has been found in only the Pennsylvanian or Upper Carboniferous and the Permian.

Genus *Koninckioceras* Hyatt, 1884

Genotype: *Koninckioceras koninckı* Miller and Kemp

In the original description of this genus, Hyatt (1884, p. 295) stated: "Type, Kon. (Naut.) ingens sp. De Kon. Calc. Carbon. pl. 23, Mus. Comp. Zool. Camb.", meaning that he was basing the genus on the specimen from the Lower Carboniferous of Belgium which de Koninck had figured on his Plate 23 of 1878 as *Nautilus ingens* (Martin) and which had been deposited in the Harvard Museum of Comparative Zoology. According to Foord (1891, p. 176–178) this specimen is not conspecific with the type of *Conchyliolithus Nautilites* [*Nautilus*] *ingens* Martin, which came from England. Presumably, therefore, the specimen on which the genus rested was without a valid specific name, and accordingly Miller and Kemp (1947, p. 351) proposed to call it *Koninckioceras koninckı*. It is an internal mold of a phragmacone which is about 13½ cm. in diameter and which consists of about two and a half volutions in which the conch attains a maximum height and width of about 4 cm. and 6 cm., respectively.

Hyatt (1893, p. 439) stated that de Koninck's figures of this specimen (which we are reproducing as Figure 3 in the text and Figure 1 on Plate 9) are not accurate in certain details. Nevertheless, it is clear from them that this individual has a large subdiscoidal nautiliconic (but not deeply involute) conch in which the volutions are depressed and are elliptical in cross section (except for the slight dorsal impression), that the umbilicus is very large and perforate, that the external sutures are essentially straight and directly transverse, and that the siphuncle is small and is subcentral in position. When Hyatt (1893, p. 440) compared this genus with *Domatoceras*, he stressed the fact that at matur-

ity the ventral and lateral zones of the conch become flattened in that genus but remain rounded in *Koninckioceras* throughout ontogenetic development.

Hyatt regarded *Koninckioceras* as being exclusively Carboniferous but some ten years ago Newell (1936, p. 486) referred to it *Domatoceras militarum* Hyatt and *D. simplex* Hyatt from the Lower Per-

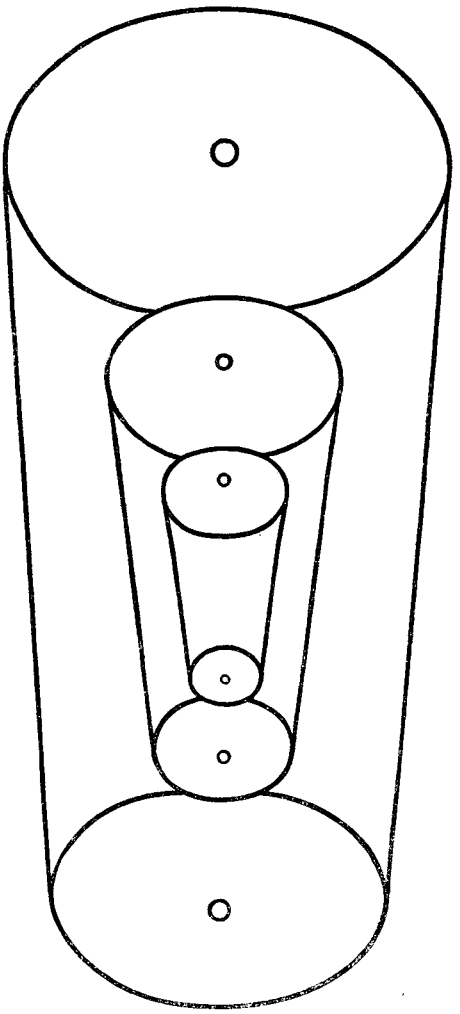

FIGURE 3.—*Koninckioceras koninckí* Miller and Kemp

The holotype of the type species of *Koninckioceras*, from Lower Carboniferous dense black limestone at Halloy, Belgium, × 1—same specimen as Pl. 9, fig. 1. After de Koninck.

mian Clyde formation of north-central Texas. As was noted by Hyatt (1893, p. 441), the generic affinities of these two species are uncertain. Their whorls are flattened laterally and ventrally and their lateral zones converge ventrad, as in typical *Domatoceras*; but the conch is depressed as in *Metacoceras*, rather than compressed as in *Domatoceras*. In our opinion these species are not very close to the genotype of *Koninckioceras*, and they should not be referred to that genus but to *Stearoceras*.

Nautilus subcariniferus Tzwetaev of the Upper Carboniferous of European Russia, which Hyatt

(1893, p. 439) referred to *Koninckioceras* has been assigned to *Knightoceras* by Miller and Owen (1934, p. 219). Also, we are inclined to eliminate from *Koninckioceras* the three forms from the Middle Pennsylvanian of Kansas that Newell (1936, p. 485–488, pls. 71, 72) described as *K. eliasi*, *K. jewetti*, and *K. wyandottense*—in all of them the conch is more or less flattened rather than rounded ventrally and the external sutures form broad rounded ventral lobes, rather than being essentially straight. However, we regard *Temnocheilus scottense* Worthen (1890, p. 151, pl. 27, figs. 3, 3a) from the Mississippian (Warsaw) of Illinois as a valid representative of *Koninckioceras*, and the paleontological collections of The University of Kansas contain a specimen from the Pennsylvanian Kansas City group at Westport, Missouri, that appears to be congeneric. *Nautilus implicatus* de Koninck (1878, p. 103, pl. 13, figs. 2, 3) of the Tournaician (Kinderhook equivalent) of Belgium, which was referred to *Koninckioceras* by Hyatt, has a sharp dorsolateral angle or keel but otherwise appears to possess the characters of the genus, and for the present, at least, it is probably best to retain it with *K. koninckı*. *Nautilus eccentricus* Meek and Hayden of the Lower Permian of Kansas, which we are referring with question to this genus, is of very uncertain affinities.

In summary it can be stated that representatives of *Koninckioceras* are now known from the Lower Carboniferous of Belgium and from the Mississippian, Pennsylvanian, and Permian of the United States.

Koninckioceras bibbi Miller and Kemp

(Plate 10, figures 1, 2)

1947. *Konickioceras bibbi* Miller and Kemp, Jour. Paleont., vol. 21, p. 353, pl. 51, figs. 1, 2.

The unique specimen on which this species is based is a well preserved internal mold. It represents almost all of the left side of the conch and a small part of the right side of the adapical volution. It is large, attaining a maximum diameter of approximately 250 mm., although it is not complete adorally. In shape it is thickly subdiscoidal, and in mode of growth nautiliconic but not deeply involute.

The conch expands orad rapidly. The holotype consists of less than two full volutions—its adapical portion is not well preserved and is of rather indefinite extent. The incomplete living chamber of this specimen is about a quarter of a volution in length. The whorls are subelliptical in cross section, being wider than high, very broadly rounded ventrally, rounded ventrolaterally, laterally, and dorsolaterally, and moderately impressed dorsally. Near the mid-length of the first volution, the conch is about 30 mm. wide and about 35 mm. high, but these measurements may not be very significant inasmuch as this portion of the specimen appears to have been distorted during preservation.

Both the umbilicus and the umbilical perforation are large. The umbilical shoulders are rounded and indefinite, but the maximum diameter of the area outlined by the umbilical seam measures about 97 mm.

No trace of ornamentation of the test is discernible on the specimen.

The camerae are numerous and comparatively short—there are 35 of them in the adoral volution. The length of the camerae increases gradually up to the adoral quarter volution and then decreases, suggesting that the specimen represents a fully mature, or possibly senile, individual. The external sutures are essentially straight and directly transverse, but on the umbilical walls they swing distinctly orad toward the dorsum. No trace of the siphuncle is retained but clearly it was not ventral (marginal) in position.

Remarks.—This species, although in general similar to the genotype, has a larger, more rapidly expanded, and more robust conch, which consists of fewer volutions. In the genotype the umbilical portions of the sutures do not swing orad toward the umbilical seams as they do in our species. The only known representative of *K. scottense* (Worthen) is relatively small, its whorls are almost as high as wide, and it has slightly but distinctly sinuous sutures which form ventral and lateral lobes; nevertheless, in general physiognomy it bears a striking resemblance to *K. bibbi*. The undescribed congeneric specimen from the Pennsylvanian of Missouri, mentioned in the discussion of the genus, is very incomplete and therefore detailed comparisons are not possible; it represents the left side of an outer half-volution of a mature conch, about 80 mm. in diameter, with whorls that are essentially elliptical in cross section and with sutures that appear to be straight and directly transverse.

OCCURRENCE.—In or just below the basal portion of the Lueders formation at the so-called "Alligator hole" in Miller Creek about 12 miles southwest of Seymour, Baylor County, Texas.

HOLOTYPE.—Private collection of Agusta Hasslock Kemp of Seymour, Texas.

Koninckioceras? eccentricum (Meek and Hayden)

(Plate 11, figures 7, 8)

1864. *Nautilis eccentricus* MEEK AND HAYDEN, Trans. Albany Inst., vol. 4, p. 83–84.
1865. *Nautilis eccentricus* MEEK AND HAYDEN, Smithsonian Contr. Knowledge, vol. 14, art. 5, p. 65, pl. 2, figs. 14a, 14b.

Meek and Hayden's final description of this species reads as follows:

"Shell small, somewhat compressed; volutions apparently not more than one and a half, not embracing, rounded excepting near the aperture, where the non-septate portion presents an oval transverse section. Umbilicus wide, shallow, and showing all of each whorl. Septa moderately concave; siphon small, placed about half way between the centre and the outer, or dorsal side. Aperture transversely oval. (Surface unknown.)

"Length, 0.70 inch; height, 0.53 inch; breadth at the aperture, 0.43 inch; small diameter of aperture, 0.25 inch.

"We [Meek and Hayden] have some doubts in regard to the propriety of retaining this species in the genus *Nautilus*, since it seems to consist of little more than one entire whorl, apparently surrounding an open central space. In this character (if it is not due to some accident), as well as in the eccentric position of the siphuncle, it would seem to present affinities to the genus *Gyroceras;* from which, however, it differs in having the whorls coiled so as to come in contact. Excepting in the rounded or nun-sulcate character of the whorls, it appears to approach the group *Trematodiscus*."

REMARKS.—We have not studied the only known representative of this species and are relying entirely on Meek and Hayden's illustrations and description, which we are reproducing. In our opinion, the holotype probably represents only the immature portion of the conch and its generic affinities are therefore very uncertain.

Attention should perhaps be called to the similarity of the specific name to *Nautilus excentricus* Eichwald of the Upper Carboniferous of Soviet Russia. That form should probably be placed in the genus *Liroceras*.

OCCURRENCE.—Lower Permian, "near the mouth of Smoky Hill fork of Kansas River" in central Kansas.

HOLOTYPE.—U. S. National Museum, 4185.

Genus *Knightoceras* Miller and Owen, 1934

GENOTYPE: *Knightoceras missouriense* Miller and Owen

The only known specimen of the type species of this genus is a rather small but well preserved fragment from the Cherokee shale of west-central Missouri, which represents only part of one volution of the conch (Pl. 11, figs. 4–6). However, the literature contains illustrations and descriptions of much more nearly complete congeneric forms: *K. subcariniferum* (Tzwataev) of the Upper Carboniferous (Dewiatowo oolite) of central European Soviet Russia, *K. tiltoni* (Miller, Dunbar, and Condra) of the Kansas City group (Bethany Falls limestone) of south-central Iowa, and *K. abundum* Miller and Unklesbay of the Kansas City group (Winterset limestone) of west-central Missouri. From a study of all of these and the congeneric Permian specimens illustrated on Plates 16, 55, and 58, we have drawn up the following generic diagnosis.

Conch nautiliconic, subglobular, and rapidly expanded orad. Whorls greatly depressed dorsoventrally and sublenticular or subelliptical in cross section as they are very broadly rounded ventrally and dorsally and are subangular or narrowly rounded laterally—the dorsal impressed zone is small and inconspucuous and the ventral concave zone developed in some forms is shallow and not prominent. Umbilicus broad, deep, and perforate. Growth lines indicate the presence of a broad deep rounded hyponomic sinus. Sutures form shallow ventral and dorsal lobes and corresponding lateral saddles (and in addition in some forms there are slight lobes on the umbilical walls and very low saddles that center on the umbilical seams). Siphuncle small, subcentral in position, and orthochoanitic in structure.

Miller and Owen (1934, p. 219) stated that this genus is closely related to *Vestianutilus* Ryckholt and should be associated with it in the Triboloceratidae. However, the material now available suggests that its affinities are rather with *Koninckioceras* Hyatt and *Endolobus* Meek and Worthen. Accordingly, we are placing it in the Koninckioceratidae.

All of the specimens that have been referred to this genus previously came from the Pennsylvanian of Missouri and Iowa and the Upper Carboniferous of European Soviet Russia. The new species discussed in the following paragraphs is from the Lower Permian of north-central Texas.

Knightoceras kempae, n. sp.

(Plate 16, figure 1; Plate 55, figure 1; Plate 58, figures 1, 2)

1891. *Nautilis* (*Temnocheilus*) *winslowi* [part] WHITE, U. S. Geol. Surv., Bull. 77, p. 16, 23, pl. 3, fig. 5 [not 1–4].

1948. *Temnocheilus winslowi* ("of White . . . not Meek and Worthen") [part] BRANSON, Geol. Soc. Am., Mem. 26, p. 837.

Half-a-dozen small fragmentary specimens that belong in *Knightoceras* were collected by Mrs. Augusta Hasslock Kemp at one horizon and locality in the Lower Permian of north-central Texas. They all seem to be conspecific and to represent a new species which we are naming in honor of the discoverer. This is the first time the genus has been recognized in the Permian, but as long ago as 1891 White illustrated and briefly described what appears to be a conspecific specimen from the same horizon at a nearby locality (Pl. 55, fig. 1).

The specimen illustrated by Figure 1 on Plate 58 is the best of the lot, and therefore we are designating it the holotype, though it is septate throughout and appears to represent only the adapical portion (two volutions) of the conch. Its maximum diameter, measured across the umbilicus, is about 32 mm., and near its adoral end the conch is about 19 mm. wide and 12 mm. high. The rather poorly preserved specimen illustrated by Figure 1 on Plate 16 shows that the conch of this species attained a diameter of at least 54 mm.

The extreme adapical part of the conch appears to be circular or nearly so in cross section, but before the conch had completed one full volution it had become distinctly wider than high. At the adoral end of the holotype the conch is asymmetrically sublenticular in cross section being depressed dorsoventrally, subangular laterally, and broadly rounded both ventrally and dorsally—however, the median portion of the dorsal side (which is much more highly arched than the ventral side) is slightly but distinctly impressed by the ventral part of the preceding volution.

The umbilicus is large, deep, and perforate, and the lateral zones of the conch are exposed in it. The umbilicus of the preserved part of the holotype attains a diameter of about 23 mm., and the maximum diameter of the umbilical perforation of this specimen measures some 5 mm.

The surface of the test appears to be essentially smooth. However, in testiferous specimens (not internal molds) there are lateral keels on which there is a suggestion of longitudinally elongate nodes.

In the adoral portion of the holotype, each suture forms a broad shallow ventral lobe and on either side of it a subangular lateral saddle, a slight lobe on the umbilical wall, and a very low saddle which centers on the umbilical seam and which extends to the shallow rounded dorsal lobe. The external sutures of the paratype illustrated on Plate 16 are almost straight and directly transverse, but that specimen has been somewhat distorted during preservation.

Siphuncle small, ventral but not marginal in position, and presumably orthochoanitic in structure. At the adoral end of the holotype, the siphuncle is about 1½ mm. in diameter, and it is some 2½ mm. from the venter and about 8 mm. from the dorsum (the bottom of the impressed zone).

REMARKS.—The four fragmentary paratypes that we are not illustrating represent only small portions of the phragmacone. They do not seem to differ materially from the figured specimens.

This species seems to resemble the genotype rather closely. However, its conch is more strongly depressed dorsoventrally, its siphuncle is more nearly marginal in position, and because of the great disparity in the age of these two species, it seems probable that their similarity is more apparent than real. Both are known from only small incomplete specimens.

OCCURRENCE.—Grape Creek limestone member of the Clyde formation at two localities in Baylor County, Texas: (1) about 1½ miles north of the England schoolhouse and 10 miles east of Seymour

(holotype and paratypes in Kemp Collection), and (2) the "Old Military Crossing" of the Big Wichita River (paratype illustrated by figure 1 on Plate 55).

TYPES.—Private collection of Augusta Hasslock Kemp of Seymour, Texas (holotype and 5 paratypes); and U. S. National Museum (Pl. 55, fig. 1).

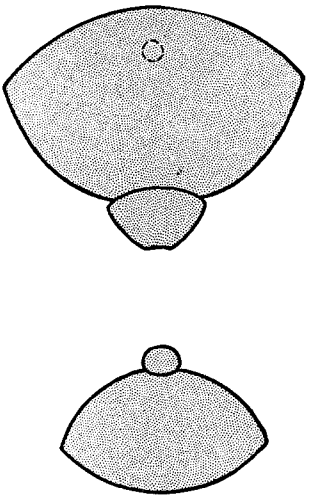

FIGURE 4.—*Knightoceras kempae*, n. sp.

Diagrammatic cross section of the holotype, from the Grape Creek limestone about 10 miles east of Seymour, Texas, × 2—same specimen as Pl. 58, fig. 1.

Genus ***Endolobus*** Meek and Worthen, 1865

GENOTYPE: *Nautilus spectabilis* Meek and Worthen

When Meek and Worthen established this genus, they referred to it only one species, *Nautilus* (*Endolobus*) *peramplus* Meek and Worthen of the Chester of Randolph County, Illinois. That species then became the genotype, but the following year, Meek and Worthen (1866, p. 309) concluded that the specimen on which it was based (see Pl. 12, figs. 1, 2) is conspecific with the holotype of *Nautilus spectabilis* Meek and Worthen of the same general horizon and locality. Presumably, therefore, that species is to be regarded as the genotype—its holotype has never been illustrated and we have not seen it.

As was emphasized by Miller, Dunbar, and Condra (1933, p. 193–194) *Endolobus* is not a synonym of such earlier generic terms as *Bisiphytes* Denys de Montfort, *Temnocheilus* M'Coy, and *Cryptoceras* d'Orbigny, as has been believed by some. That is, the type species of all four of these are sufficiently different from one another to be considered as generically distinct according to the present concepts of nautiloid genera.

It now seems to us that the chief characteristics of the genus can be briefly summarized as follows: Conch nautiliconic (but not deeply involute) and whorls are subelliptical in cross section, being broadly rounded ventrally, rather narrowly rounded laterally, and slightly impressed dorsally. Umbilicus wide, deep, and presumably perforate. Apparently there is a broad deep rather narrowly rounded hyponomic sinus. Lateral zones of conch bear low nodes. External sutures only slightly sinuous, but each internal suture forms a rather prominent dorsal lobe. Siphuncle small, subcentral, and orthochoanitic.

As thus interpreted, the genus is known to be of widespread occurrence in North America and to range here from the Upper Mississippian to the Lower Permian, inclusive. Miller, Dunbar, and Condra (1933, p. 195) stated that we should probably refer to *Endolobus* the forms described but not figured by Girty (1909, p. 114–115) as "*Temnocheilus* aff. *conchiferum* Hyatt" from the San Andres

and Yeso formations of New Mexico, and "*Temnocheilus* sp. *a*" from the Yeso, Abo, and San Andres formations of New Mexico. We have not seen these specimens, but Girty's description of them suggests to us that perhaps they can best be referred to *Stearoceras* with question. In Europe *Endolobus* may be represented by *Nautilus acanthicus* Tzwetaev of the Upper Carboniferous of central European Soviet Russia. *Endolobus* (*Solenocheilus*) *brouweri* Haniel of the Middle Permian Bitauni beds of Timor should be referred to *Liroceras*, rather than to *Endolobus*.

Endolobus renfroae, n. sp.

(Plate 46, figures 1, 2)

This species is based on two very similar internal molds from one horizon and locality. In both the preservation is only fair, the maximum diameter (measured across the umbilicus) is some 50 mm., the living chamber is about a quarter or a third of a volution in length, and the conch is expanded orad very gradually. The whorls are essentially elliptical in cross section, being depressed dorsoventrally, very narrowly rounded laterally, and broadly and about equally rounded ventrally and dorsally (except for a slight dorsal impressed zone). Near the adoral end of the figured specimen, the conch is about 26 mm. wide and 20 mm. high. The umbilicus is large, and its diameter is equal to about two-thirds that of the specimen. It is almost certainly perforate, but the inner volutions of the type specimens are not well preserved.

On each of the narrowly rounded lateral zones of the conch, there is a row of small longitudinally elongate nodes, of which there are about ten on the adoral half-volution of the phragmacone. They are not very prominent, however, and seem to become obsolete on the living chamber.

The camerae are short and there are about 20 of them in the adoral half-volution of the phragmacone. The external sutures are essentially straight and directly transverse, but they form slight ventral lobes and corresponding lateral saddles. The nature and position of the siphuncle could not be ascertained.

REMARKS.—One of the type specimens is considerably crushed and distorted, and the other, which is illustrated, is therefore being designated the holotype. Perhaps the most distinctive feature of the species is the slow rate of adoral expansion of the conch. The specific name is given in honor of Mrs. J. H. Renfro, who kindly loaned us the specimens on which the species is based.

OCCURRENCE.—Lueders formation about 4 miles south of Seymour, Baylor County, Texas, near east side of Highway 283 in a small creek tributary to Salt Fork of Brazos River, in association with fragmentary representatives of *Tainoceras*.

TYPES.—Renfro Collection, Fort Worth, Texas.

Endolobus? sp.

1893. *Temnocheilus coxanus* HYATT, Texas Geol. Surv., Ann. Rept. 4, p. 392.
1948. *Temnocheilus coxanus* ("of Hyatt . . . not Meek and Worthen") BRANSON, Geol. Soc. Am., Mem. 26, p. 836.

In 1893 under the heading *Temnocheilus coxanus*, Hyatt stated:

"Foord has pointed out that I [Hyatt] was incorrect in separating this species so widely from Temnocheilus and in placing it in the genus Kophinoceras. The study of several good specimens from Greencastle, Ind., in the collection of the Museum of Comparative Zoology has satisfied me that it possesses entirely distinct characteristics from Kophinoceras. The species of this genus has similar whorls and ridges, but the nodes are more ventral than lateral, and are due to the frilling of the more or less permanent apertures. That genus also has no true nautilian forms, and there are no dorsal or annular lobes in the sutures.

"There is an imperfect specimen from Ballinger in the new materials, but with the characteristic whorl, tubercles, and sutures of this species. No ridges are visible, but this may be due to the state of preservation."

REMARKS.—Almost certainly the specimen from Ballinger is of Lower Permian age. We have not seen it, but, like Branson, we are inclined to doubt that it is conspecific with the type specimens of *Nautilus* (*Temnocheilus*) *coxanus* Meek and Worthen, which came from the Mississippian of Illinois and Indiana. Nevertheless, it probably resembles them in general physiognomy and may well belong in the same genus, that is, in *Endolobus*.

OCCURRENCE.—Ballinger, Runnels County, Texas, where its age is almost certainly Lower Permian.

REPOSITORY.—University of Texas.

Family DOMATOCERATIDAE, n. fam.

Widely umbilicate more or less subdiscoidal nautiloids are not rare in the Late Paleozoic. In one group of these, the conch is flattened laterally and ventrally and slightly impressed dorsally, and typically the whorls are compressed laterally. The sutures form ventral, lateral, and dorsal lobes, and the siphuncle is orthochoanitic and is subcentral. At full maturity, many representatives of this group develop ventrolateral nodes. However, no such nodes are present during the early ontogenetic stages, and their late appearance suggests that they are a secondary development and are not to be homologized with the prominent ventrolateral nodes or spines that are so characteristic of the Tainoceratidae. In typical representatives of that family, the conch is depressed dorsoventrally, whereas in this one it tends to be compressed laterally. However, the difference in the development of the nodes is believed to be more fundamental than the shape of the cross section of the conch. Nevertheless, neither of these criteria is, by itself, infallible, and some specimens do not seem to fit readily into either family, though clearly they belong in the group represented by the two.

Altogether, we are placing in this family five genera: *Domatoceras, Pselioceras, Stearoceras, Stenopoceras*, and *Titanoceras*, all of Hyatt. In his final work on the classification of the nautiloids, Hyatt (1900 p. 523, 525) failed to mention *Titanoceras*; but he associated *Stearoceras* with *Coloceras* [= ? *Liroceras*], placed *Pselioceras* in the Pleuronautilidae (which otherwise included only Triassic forms), and assigned the other two of these genera to the Koninckioceratidae, for he believed that they evolved from *Koninckioceras*. We also think that most probably they arose from that genus (or some very similar form), but at the same time we are of the opinion that they are far enough removed from that ancestral type to be regarded as representing a distinct family. Presumably *Koninckioceras* also gave rise to *Stearoceras*, and *Stenopoceras* and *Titanoceras* are believed to have come from *Domatoceras*, with which they are connected by more or less intermediate forms. *Stearoceras* seems to be gradational with *Domatoceras*, but typical representatives of it have rather strongly depressed rather than compressed conchs. *Pselioceras* resembles *Domatoceras* but has a very large umbilical perforation.

Geographically this family is indeed widespread. Forms that belong in it are known from many localities in North America, and are recorded in the literature from Europe, Asia, and Australasia (including Australia). Stratigraphically they range from the Lower Carboniferous to the Permian, inclusive.

Genus *Domatoceras* Hyatt, 1891

GENOTYPE: *Domatoceras umbilicatum* Hyatt

A considerable variety of forms has been referred to this genus by various authors, and all of them are not to be regarded as congeneric. Miller, Dunbar, and Condra (1933, p. 216) designated *Domatoceras umbilicatum* as the genotype (Fig. 5), and from a study of it and very similar species, we have tried to summarize the more significant characters of the genus in a single paragraph.

Conch subdiscoidal and nautiliconic (but not deeply involute). Whorls flattened ventrally and laterally and only slightly impressed dorsally. The junctions of the flattened sides are narrowly rounded to subangular. Typically the lateral zones converge ventrad, and the maximum width of the conch is attained just outside (ventrad of) the umbilical shoulders (Fig. 6I). The surface of the test bears fine sinuous growth lines, which indicate the presence of a rather deep rounded hyponomic sinus. In at least some forms, during late maturity low ventrolateral and dorsolateral nodes are developed. The sutures form broad rounded ventral, lateral and dorsal lobes, which are separated by subangular saddles. Siphuncle subcentral and orthochoanitic.

Miller, Dunbar, and Condra (1933, p. 224–226) proposed the generic name *Pseudometacoceras* for forms like *Metacoceras sculptile* Girty (genotype—Pl. 9, figs. 2–5) that are "closely related to *Domatoceras*, though mimicking *Metacoceras*" in the development of ventrolateral nodes. It has since become clear that during late maturity ventrolateral and even dorsolateral nodes are formed on typical

representatives of *Domatoceras*, for example, *D. williamsi* Miller and Owen. Therefore, *Pseudometacoceras* should be suppressed as a synonym of *Domatoceras*, which has priority.

Both the Pennsylvanian and the Permian have yielded a good many specimens that resemble *Domatoceras* in many respects but have depressed rather than compressed whorls. These are being referred to *Stearoceras*, which, as we interpret it, seems to be more or less completely gradational with

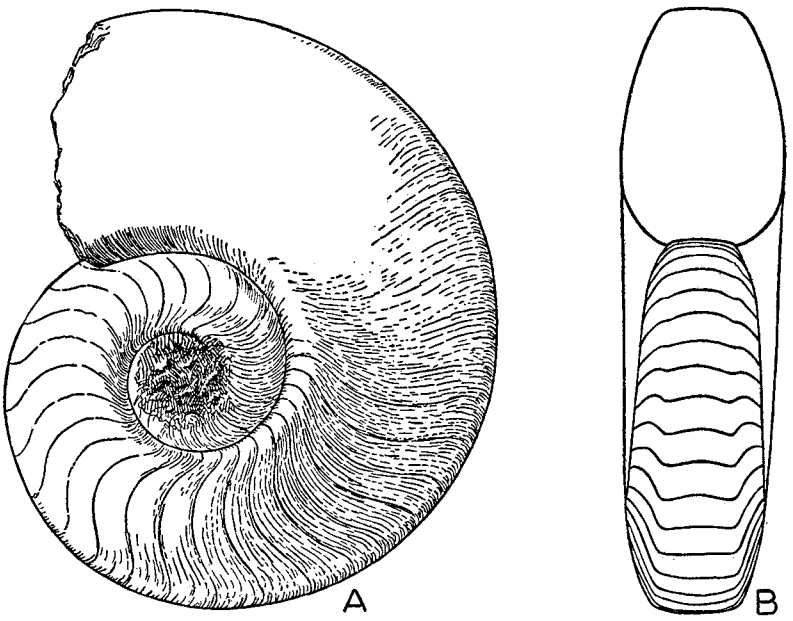

FIGURE 5.—*Domatoceras umbilicatum* Hyatt

The holotype of the type species of *Domatoceras*, from the Pennsylvanian Cherokee shale about 1½ miles southeast of Oswego, Kansas, × ⅔. After Hyatt. (*See aso* Fig. 61.)

Domatoceras. Presumably these two had a similar ancestry. *Pselioceras*, of which the only known representative is the genotype, *Nautilus ophioneus* Waagen of the Productus limestone of the Salt Range in India, resembles *Domatoceras* in general physiogonomy but has a very large umbilical perforation—it may possibly have had a different ancestry. *Domatoceras* is believed to have given rise to *Stenopoceras* and *Titanoceras*, with which again it is connected by intermediate forms. In *Stenopoceras* the sutures form large well developed dorsolateral saddles outside the umbilical seams, and in *Titanoceras* the ventral zone of the conch is prominently concave throughout maturity.

Locally this genus is not rare in the Pennsylvanian or Upper Carboniferous, and it seems to be

FIGURE 6.—*Aulametacoceras, Stearoceras, Stenopoceras, Domatoceras,* and *Titanoceras*

Cross sections of the fully mature portions of the conch of one species of *Aulametacoceras*, three of *Stearoceras*, one of *Stenopoceras*, three of *Domatoceras*, and one of *Titanoceras*. **A**, *Aulametacoceras mckeei* Miller and Unklesbay, the genotype of *Aulametacoceras*, based on the holotype at a diameter of about 185 mm., × ¾. **B**, *Stearoceras rotundatum* (Miller and Unklesbay), based on the largest of the syntypes at a diameter of some 150 mm., × ¾. **C**, *Stearoceras aberrans* (Miller and Unklesbay), based on the holotype at a diameter of about 165 mm. (near the adoral end of the phragmacone), × ¾. **D**, *Stearoceras sanandreasense* (Miller, Dunbar, and Condra)?, based on the specimen represented by Figure 15 (in the text) at a diameter of about 140 mm., × ¾. **E**, *Stenopoceras cooperi* Miller and Unklesbay, based on the holotype at a diameter of about 98 mm., × ¾. **F**, *Domatoceras walteri* Miller and Unklesbay, based on the holotype at a diameter of some 165 mm., × ¾. **G** and **H**, *Domatoceras bradyi* Miller and Unklesbay, based on the specimen represented by figures 5, 6 on Plate 14 at a diameter of about 115 mm. (G), and on that represented by figure 2 on Plate 13 at a diameter of about 150 mm. (H), both × ¾. **I**, *Domatoceras umbilicatum* Hyatt, the genotype of *Domatoceras*, based on the holotype at a diameter of some 115 mm. × 1 (after Hyatt—*see also* Fig. 5). **J**, *Titanoceras ponderosum* (Meek), the genotype of *Titanoceras*, constructed from Meek's measurements and illustrations of the holotype at a diameter of about 300 mm., × ⅜.

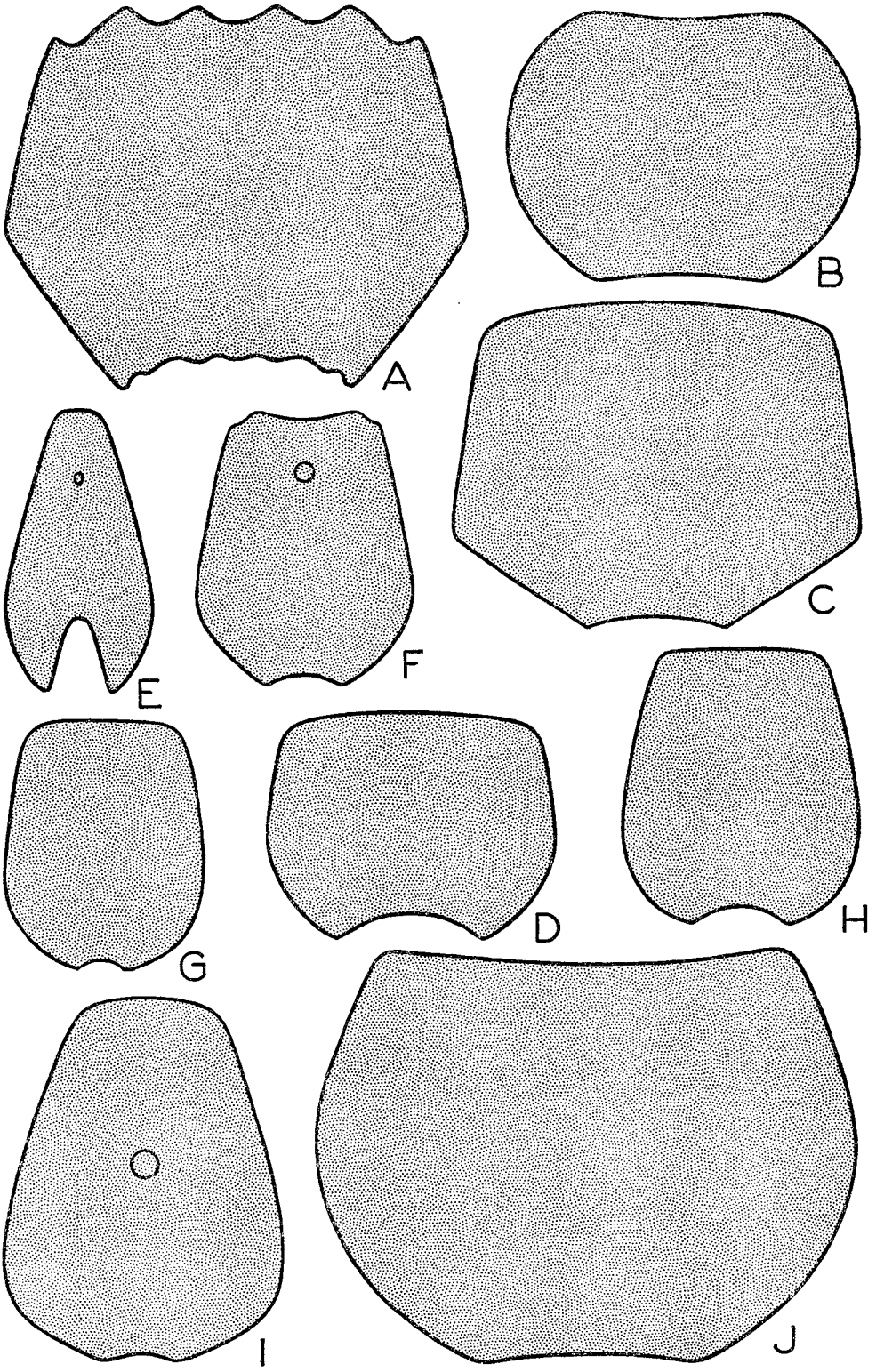

FIGURE 6 (A–J)

confined to that system and the Permian. Geographically, it has been found to occur in North America, Europe, Asia, the Malay Archipelago, and Australia.

Domatoceras bradyi Miller and Unklesbay

(Plate 13, figure 2; Plate 14, figures 5, 6)

1942. *Domatoceras bradyi* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721, 734–735, 737, pl. 116, figs. 5, 6; pl. 117, fig. 2.

The holotype of this species (Pl. 14, figs. 5, 6) is a fairly complete internal mold that is well preserved in very fossiliferous pink dolomite. Its maximum diameter, measured across the umbilicus, is about 155 mm. The adoral 50 mm. of this specimen represent the living chamber, which is not complete. The inner volutions of the conch are not preserved.

The whorls are considerably higher than wide, and their lateral and ventral sides are essentially flat. The ventrolateral zones are very narrowly rounded, whereas the dorsolateral ones are broadly rounded. The dorsal side appears to be slightly concave, that is, to be somewhat impressed by the preceding volution. In cross section the whorls are subrectangular (Fig. 6G) as the lateral zones are almost parallel (though they converge slightly ventrad) and are almost perpendicular to the ventral side. The maximum width of the holotype, which is attained at the rather indefinite umbilical shoulders, measures about 52 mm.; the corresponding height of conch is about 56 mm. The diameter of the umbilicus is approximately half that of the specimen.

There is a prominent raised line along the venter of the holotype, but otherwise there is no ornamentation on this specimen. The sutures form broad shallow ventral and lateral (and almost certainly dorsal) lobes, similar dorsolateral saddles, and relatively narrow ventrolateral saddles.

REMARKS.—The collections that we are studying contain five specimens that seem to be conspecific with the holotype, and can therefore be regarded as paratypes. The best of these (Pl. 13, fig. 2) is somewhat larger than the holotype, the cross section of its conch differs slightly (cf. Figs. 6G and H, in the text) and there are inconspicuous lateral nodes on its penultimate volution. The maximum diameter attained by the phragmacone of this specimen measures about 170 mm. (estimated). In another of the paratypes (Museum of Northern Arizona, 698/G2.1371), which is about 175 mm. in diameter, the preserved portion of the living chamber is at least a fourth of a volution in length.

This species, which was named in honor of Mr. L. F. Brady, has relatively low and broad whorls in comparison to those of the holotype of *Domatoceras*. Nevertheless, it clearly belongs in that genus and not in *Stearoceras*.

OCCURRENCE.—The holotype came from the Kaibab limestone (α member) at the Bottomless Pits, about 7 miles east of Flagstaff, Coconino County, Arizona. Two of the paratypes are from the same horizon (1) on the east side of Lake Mary (about 10 miles southeast of Flagstaff) and (2) near Grandeur Point in Grand Canyon. A third paratype was found near High Rolls, Otero County, New Mexico; and the other two were collected from the San Andres limestone (about 150–200 feet below the top) on the west side of the Penasco River Valley about 52 miles west of Artesia on the highway to Cloudcroft, Otero County, New Mexico. Also we are referring with question to this species a specimen from the Chupadera formation of the Cerrito Tularosa west of Tularosa, Otero County, New Mexico.

TYPES.—Museum of Northern Arizona, 811/G2.1517 (holotype) and 698/G2.1371 (unfigured paratype); Grand Canyon National Park Museum, Fk-287B (Grandeur Point specimen) and Fk-735 (unfigured paratype from High Rolls); Texas Technological College (unfigured paratype from Penasco River Valley); and State University of Iowa, 1088 (Pl. 13, fig. 2). The specimen from the Cerrito Tularosa, which we are referring with question to this species, is at The University of New Mexico.

Domatoceras northropi Miller and Unklesbay

(Plate 17, figures 4, 5)

1942. *Domatoceras northropi* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720, 735, 737, pl. 111, figs. 7, 8.

Three representatives of this species are available for study. The holotype, the figured specimen, represents most of the phragmacone and the adapical portion of the living chamber, whereas the para-

type represents most of the living chamber and the adoral portion of the phragmacone. The diameter of the holotype, measured across the umbilicus, is about 110 mm. The whorls are almost flat ventrally and laterally, are narrowly rounded ventrolaterally and more broadly rounded dorsolaterally, and are slightly impressed dorsally. The flattened lateral zones are almost parallel but converge slightly ventrad. Near the midlength of the outer volution of the holotype, the conch is about 26.5 mm. high and its maximum width, which is attained at the rounded umbilical shoulders, is about 25.5 mm. The diameter of the umbilicus is equal to almost half that of the specimen. The paratype shows that the living chamber is at least a third of a volution in length, and that it attains a maximum width of at least 62 mm.

The ventrolateral zones of the conch bear low rounded nodes of which there are three in the adoral half volution of the holotype. Such nodes are present on even the adoral portion of the living chamber of the paratype, and there appear to be about four of them on each ventrolateral zone of the adoral half volution of that specimen.

The sutures form very shallow broad rounded ventral, lateral, and dorsal lobes, and similar but somewhat narrower ventrolateral and dorsolateral saddles. The siphuncle is small and is located considerably ventrad of the center of the conch. Near the midlength of the outer volution of the holotype, where the conch is about 26.5 mm. high, the siphuncle is about 2.5 mm. in diameter and is about 6.5 mm. from the venter.

REMARKS.—The most distinctive feature of this species is the more or less square cross section of its conch. Also, the ventrolateral nodes help to differentiate it from similar congeneric forms. The specific name is in honor of Professor Stuart A. Northrop. The third specimen (the one from near Elk) does not differ materially from the primary types.

OCCURRENCE.—All three of the known representatives of this species came from the Chupadera formation of New Mexico. Both the holotype and the paratype are from near Bluewater Dam, about 16 miles northwest of Grants in Valencia County; the third specimen is from the eastern slope of the Sacramentos near Elk in Chaves County.

TYPES.—University of New Mexico, 316 (holotype) and 317 (paratype). The specimen from the Sacramentos near Elk is at the same institution.

Domatoceras walteri Miller and Unklesbay

(Plate 13, figure 1)

1942. *Domatoceras walteri* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721, 735–736, pl. 117, fig. 1.

(?) 1942. *Domatoceras* cf. *D. walteri* CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.

The holotype of this species is a moderately well preserved internal mold which is septate throughout. We estimate that the preserved part of this specimen attained a diameter of at least 165 mm. The adapical portions of the holotype are not well preserved, but the outer whorl is compressed laterally and is subrectangular in cross section (Fig. 6F). Its ventral side is slightly but distinctly concave, its lateral zones are almost flat and are slightly convergent ventrally, and its dorsal side is somewhat impressed. The dorsolateral zones (umbilical shoulders) are broadly rounded, whereas the ventrolateral zones are grooved. In the penultimate volution of the holotype, the cross section is similar but the ventrolateral zones are abruptly rounded rather than grooved. At the adoral end of the penultimate volution, the conch is about 35 mm. high and its maximum width, which is attained at the indefinite umbilical shoulders, is about 25 mm. Corresponding measurements at the adoral end of this specimen are about 66 mm. and 47 mm., respectively. The diameter of the umbilicus is equal to about half that of the specimen.

On at least the left lateral zone of the preserved portion of the penultimate volution of the holotype, there are two prominent rounded nodes which are longitudinally elongate and are about a third of a volution apart. These nodes are located slightly ventrad of the mid-height of the whorl.

The sutures form broad shallow rounded ventral, lateral, and presumably dorsal lobes, similar dorsolateral saddles, and narrower ventrolateral saddles which are flattened medianly in the adoral volution where the sutures cross the ventrolateral grooves. The siphuncle is small and is located approximately midway between the center and the venter. Where the conch is about 56 mm. high and about 43 mm. wide, the siphuncle is about 4.5 mm. in diameter and is about 8 mm. from the venter.

REMARKS.—By far the most distinctive features of this species are the lateral nodes and the ventrolateral grooves of its conch. Insofar as we have been able to ascertain, both of these are unique for the genus. The available collections contain a fragmentary specimen that we are referring to this species with question. It is of about the same size and shape as the penultimate volution of the holotype and, like it, bears lateral nodes.

OCCURRENCE.—Both the holotype and the fragmentary specimen we are associating with it were obtained by Dr. H. G. Walter, in whose honor the species was named, from the San Andres limestone (about 150–200 feet below the top) on the west side of the Penasco River Valley about 52 miles west of Artesia on the highway to Cloudcroft, Otero County, New Mexico. For the sake of completeness it should be mentioned that Clifton has listed "*Domatoceras* cf. *D. walteri*" from the Blaine and/or Dog Creek formations of north-central Texas—we have not seen his material.

REPOSITORY.—Texas Technological College.

Domatoceras sp. [of Colombia]

(Plate 58, figure 3)

1949. *Domatoceras* sp. THOMPSON AND MILLER, Jour. Paleont, vol. 23, p. 8, pl. 8, fig. 8.

J. Wyatt Durham sent us a testiferous specimen from the Sierra de Perijá in northern Colombia that is referable to *Domatoceras*. It is fragmentary and very incomplete, but shows that the conch attained a diameter of more than 75 mm. (estimated) and a maximum height and width of at least 38 mm. and some 35 mm. (estimated), respectively. The whorls are essentially flat laterally and particularly ventrally, subangular ventrolaterally, rounded dorsolaterally, and impressed dorsally. The maximum width of conch is attained just outside the umbilical shoulders as the lateral zones of the whorls are considerably converged ventrad. The umbilicus is small for this genus but nevertheless attains a diameter of at least 25 mm.

The surface of the test is marked by fine growth lines which form broad shallow rounded lateral salients and apparently deep rounded ventral sinuses. Each of the ventrolateral zones of the conch bears a single row of moderately large nodes which are considerably elongate longitudinally.

At least the adapical part of the outer volution of this specimen is septate, and the adapical camera in this portion of the conch is about 4½ mm. long. The precise shape of the sutures can not be ascertained, but it can be seen that they form ventral, lateral, and dorsal lobes. No trace of the siphuncle can be discerned, but presumably it resembles that of congeneric forms.

REMARKS.—Because of its moderately small umbilicus, this specimen can not be said to be a typical representative of *Domatoceras*. Insofar as size of umbilicus is concerned, it resembles *D. moorei* Miller, Dunbar, and Condra of the Middle Pennsylvanian Corbin City limestone of Kansas, but in that species the whorls are relatively high and narrow.

OCCURRENCE.—Middle Permian (Leonard equivalent) dark gray limestone on north side of Quebrada Manaure about 4½ km. east of village of Manaure, Departamento de Magdalena, Colombia; in association with the ammonoid genera *Medlicottia* and *Perrinites*.

REPOSITORY.—University of California, 32897.

Domatoceras sp. [of Colorado]

(Plate 15, figures 1–7)

Early in the fall of 1944, J. S. Williams and A. H. Koschmann of the U. S. Geological Survey collected some nautiloids from the Jacque Mountain limestone of Colorado. These specimens are preserved in a purplish oolitic micaceous metamorphosed limestone, and most of them are rather poor. A few seem to be referable to *Mooreoceras* and *Pseudorthoceras*, but the great majority (some 15 specimens) belong in *Domatoceras*. Only the last merit illustration and description.

The best specimen (Pl. 15, figs. 4–6) illustrates the general physiognomy of the conch and the shape of the growth lines and the sutures during early maturity. These features indicate clearly the generic affinities of the species. The maximum diameter of this specimen measures about 48 mm., and near its adoral end the conch is about 20 mm. wide and 26 mm. high. Other specimens in the collection

show that the phragmacone attained a maximum width and height of conch of at least 25 mm. and 34 mm., respectively. The shape of the cross section of the conch, the nature of the septa, and the size and position of the siphuncle are illustrated by Figure 7 on Plate 15.

The small immature individual represented by Figure 1 on the same plate shows that the umbilical perforation is oval in shape, that its two diameters are about 5 mm. and 4 mm., and that the extreme adapical portion of the conch is essentially circular in cross section. This specimen also shows that during early ontogenetic development, the conch expands orad rather rapidly, particularly in a dorsoventral direction, and the sutures develop lateral lobes. However, the conch does not become flattened ventrally until it has completed more than one full volution (see Pl. 15, fig. 5).

REMARKS.—Unfortunately, these specimens do not give much of a clue to the precise age of the containing beds, and about all that can be said is that they are Pennsylvanian or Permian. The associated fragmentary nautiloids (*Mooreoceras* and *Pseudorthoceras?*) likewise are not very diagnostic.

OCCURRENCE.—Jacque Mountain limestone "on slope between Searles Gulch and Jacque Peak, at saddle at top of Searles Gulch," near Kokomo, Summit County, Colorado.

FIGURED SPECIMENS.—U. S. Geological Survey, Carboniferous invertebrate type nos. 5207–5210, inclusive.

Domatoceras sp. [of Mexico]

(Plate 45, figure 8)

1942. *Titanoceras* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720.
1944. *Titanoceras* sp. KING, Geol. Soc. Am., Spec. Pap. 52, p. 14.
1944. *Titanoceras* sp. MILLER, Geol. Soc. Am., Spec. Pap. 52, p. 72, 80–81, pl. 21, fig. 7.

A single representative of *Domatoceras* is known from Mexico, but unfortunately it is so poorly preserved and incomplete that its specific affinities can not be ascertained. The adoral third of the outer volution of this specimen appears to represent living chamber, but the rest of it is septate and therefore represents phragmacone. The maximum diameter of this specimen, measured across the umbilicus, is about 12 cm., but the specimen has been slightly crushed during fossilization. The whorls are subtrapezoidal in cross section as they are flattened laterally and ventrally and slightly impressed dorsally, and the lateral zones converge slightly ventrad. The maximum width of the conch, which is approximately equal to the height, is attained just outside (ventrad of) the umbilical shoulders. Along each of the ventrolateral zones of the conch is a single row of low longitudinally elongate nodes which are quite distinct on the internal mold. The umbilicus is large and its diameter is equal to slightly more than one-third that of the specimen. The umbilical shoulders are rounded but rather abrupt. The umbilical walls are at almost right angles to the nearly flat lateral zones of the conch.

The camerae are rather short. The sutures form shallow rounded ventral, lateral, and presumably dorsal lobes, and these are separated by shallow ventrolateral and dorsolateral saddles—the dorsolateral saddles center on or near the umbilical shoulders and the ventrolateral saddles center on the subangular ventrolateral zones of the conch. The siphuncle is subcentral but is located distinctly ventrad of the center of the conch. Its diameter is equal to about a tenth the height of the conch.

REMARKS.—This specimen appears to resemble *Domatoceras umbilicatum* Hyatt more closely than any other valid genotype. It differs from that species particularly in that its whorls are lower and wider (though they are not depressed dorsoventrally as in typical *Stearoceras*).

OCCURRENCE.—Middle Permian (zone of *Waagenoceras*) shale or graywacke (King's bed 17) about 60 meters N. 35° E. of La Difunta in the Valle de Las Delicias, Coahuila, Mexico.

REPOSITORY.—Yale Peabody Museum, 16276.

Domatoceras? spp. [New Mexico]

1909. *Domatoceras* sp. GIRTY, U. S. Geol. Surv., Bull. 389, p. 49, 115.
1933. *Domatoceras* sp. MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 216.
1942. *Domatoceras?* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721.
1942. *Domatoceras* spp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 737.
1942. *Titanoceras* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 737.

In his study of the paleontology of the Manzano group of the Rio Grande Valley, New Mexico, under the heading "*Domatoceras?* sp." Girty stated:

"This form is represented in our collection by the merest fragments, but nevertheless seems of sufficient interest to warrant a brief mention. The shell was probably rather small and the shape flat, discoidal, with large umbilicus (?). The section was tetragonal, with nearly flat sides and ventral surface. The sides converged toward the latter, and their abrupt junction with it is emphasized in the best fragments by a strong carina. The septa are closely arranged, the height of the chambers being 2 mm."

We have not had an opportunity to study these specimens. However, in so far as we can tell from the quoted description, Girty's generic assignment is most probably correct.

Miller and Unklesbay (1942, p. 737) mention that C. E. Needham had sent them "a fragment of a fairly large *Domatoceras*" from the Yeso formation in the Sacramento Mountains of New Mexico, and that S. A. Northrop had loaned them for study specimens from the Chupadera formation of the same state that they had identified as *Titanoceras* sp. and *Domatoceras* sp. All three of these most probably belong in *Domatoceras*, but their affinities may possibly be with *Stearoceras*, as we interpret that genus.

OCCURRENCE.—The specimens discussed by Girty came from the Yeso formation ("lime between massive part of base of red beds and upper or gypsum series"), south of Mesa del Yeso, near Socorro, Socorro County, New Mexico. Miller and Unklesbay's specimens are from a limestone in the mid-portion of the Yeso formation (about 725 feet below the top) in the Sacramento Mountains near Bent, Otero County, New Mexico; and from the Chupadera formation near Bluewater Dam about 16 miles northwest of Grants in Valencia County of New Mexico, and in the Cerrito Tularosa west of Tularosa in Otero County of the same state.

REPOSITORIES.—U. S. National Museum (Girty's specimens), New Mexico School of Mines (Miller and Unklesbay's specimen from the Yeso), and University of New Mexico (Miller and Unklesbay's specimens from the Chupadera).

Domatoceras spp. [of Texas]

(Plate 16, figure 2)

1942. *Domatoceras* sp. CLIFTON, Jour. Paleont., vol. 16, p. 688, 696.
1944. *Domatoceras* sp. CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.

In 1942, under the heading "*Domatoceras* sp." Clifton, while discussing the invertebrate faunas of the Blaine and the Dog Creek formations of north-central Texas, stated: "In the collections there are several specimens, which no doubt are properly assigned to the genus *Domatoceras*. The specimens may represent a new species. They are hardly to be confused with *Stenopoceras*, which is also present at the same localities." This quotation contains all of the information available in regard to this form (except the "occurrence" which is given below), and we have not seen the specimens on which it is based.

The specimen represented by Figure 2 on Plate 16 is also referable to *Domatoceras*. The maximum height of conch attained by the preserved portion of it measures about 43 mm. The corresponding width cannot be ascertained. The sutures form broad shallow rounded ventral, lateral, and presumably dorsal lobes. No trace of the siphuncle or the surface ornamentation of the test can be discerned on this internal mold.

REMARKS.—The figured specimen is only moderately well preserved, and the side of it that is not illustrated is crushed. Its conch may well have been wider than high, and therefore it may belong in *Stearoceras* rather than *Domatoceras*. However, its inner volution suggests that its affinities are with the latter genus.

OCCURRENCE.—Clifton states that the specimens to which he referred are "scarce to common" and that they came from the Acme member of the Blaine formation and the Guthrie member of the Dog Creek formation. Furthermore, he indicates that the Acme individuals are from the following two localities: (1) "an extensive area, including sections 148, 168, 169, 173, 198 and adjacent sections, north and northwest of Quanah, in Block H, of the Waco and NW. R. R. Company Survey, Hardeman County, Texas"; and (2) "northeast Nolan County and Southeast Fisher County in Texas.

Chiefly, Sec. 289, B. H. Stribling Survey, and Sec. 290, R. Cochran Survey." Finally, Clifton adds that his Guthrie specimens came from the following locality: "section 139 and areas northeast, in Block F, of the H. & T. C. R. R. Co. Survey, Stonewall County, Texas". The ammonoid genus *Perrinites* (as well as the nautiloid genus *Stenopoceras*) occurs at all three of Clifton's localities.

The specimen we are figuring is from the Grape Creek limestone member of the Clyde formation about 1½ miles north of the England schoolhouse and about 10 miles east of Seymour, Baylor County, Texas.

FIGURED SPECIMEN.—Private collection of Augusta Hasslock, Kemp of Seymour, Texas.

Genus *Stearoceras* Hyatt, 1893

GENOTYPE: *Endolobus gibbosus* Hyatt

Very little has been added to our knowledge of this genus since it was established. However, in 1900 Hyatt (p. 523) listed it as a member of the Triboloceratidae; in 1933 Miller, Dunbar, and Condra (p. 131–132) stated that it may be synonymous with *Coloceras* Hyatt [= ? *Liroceras* Teichert] but that tentatively both generic names should be retained; in 1940 Teichert (p. 590) stated that *Stearoceras* can be differentiated from *Liroceras* inasmuch as in that genus the external sutures are "straight or almost straight" and the internal sutures do not form an annular lobe; and in 1941 this last author, Teichert (p. 377, 383), listed *Stearoceras* as occurring in the Middle Permian of Western Australia.

When Hyatt (1893, p. 422–424) established this genus, he stated that the specimen represented by Figure 7 of the present publication "will have to be considered as the original of the generic description". However, presumably it is not one of the original types of the genotype though it came from the same general locality (near Bend, Texas) and probably from about the same horizon as the syntypes, that is, from the Lower Pennsylvanian. Figure 8 elucidates the shape of the cross section of the conch.

In so far as we can tell from Hyatt's published illustrations and descriptions of the type species, the more significant characters of this genus are as follows:

Conch nautiliconic, and being rapidly expanded orad completes only a few volutions. Whorls are subtrapezoidal in cross section (impressed zone disregarded) as they are depressed dorsoventrally, are flattened laterally and ventrally, and the lateral zones converge ventrad—the ventral zone becomes very slightly concave medianly in the adoral portion of the type specimen of the genus. The impressed zone is relatively small. The umbilicus is moderate in size, is deep, and presumably is perforate. The umbilical shoulders are fairly distinct, and the umbilical walls are steep. Apparently the test is essentially smooth and the genotype does not bear ribs, nodes, or spines. Hyponomic sinus deep and rounded. Sutures form slight ventral, lateral, and dorsal lobes, and there is a small V-shaped annular lobe in the center of the dorsal lobe of the genotype. The siphuncle is "above [presumably ventrad of] the center" and is almost certainly orthochoanitic in structure.

It seems to us that such species as *Domatoceras simplex* Hyatt and *D. militarium* Hyatt, both of the Lower Permian of north-central Texas, and the form from the Middle Permian of west Texas that we are describing as *S. hesperium*, n. sp., differ materially from the genotype only in that they have relatively wide umbilici and more abrupt umbilical shoulders. Unlike typical *Domatoceras*, they have depressed rather than compressed whorls. Accordingly, we are referring all of them to *Stearoceras*, though we regard them as being somewhat more advanced than *S. gibbosum*. Teichert gives no information in regard to the morphology of the forms from the Permian of Western Australia which he placed in this genus.

Stearoceras resembles such genera as *Metacoceras* Hyatt, *Domatoceras* Hyatt, and *Liroceras* Teichert. In typical *Metacoceras* the whorls are concave laterally and are prominently nodose ventrolaterally. In *Domatoceras* the whorls are higher than wide and the test forms ventrolateral nodes; and in *Liroceras* the conch is not flattened ventrally and laterally and the external sutures are essentially straight.

It should also be mentioned that in our opinion most of the forms that in 1933 Kruglov placed in his genus *Permonautilus* belong in *Stearoceras*. However, the genotype of *Permonautilus*, *Nautilus cornutus* Golovkinsky (Pl. 54, figs. 1–3) of the Permian of Soviet Russia, is most probably congeneric

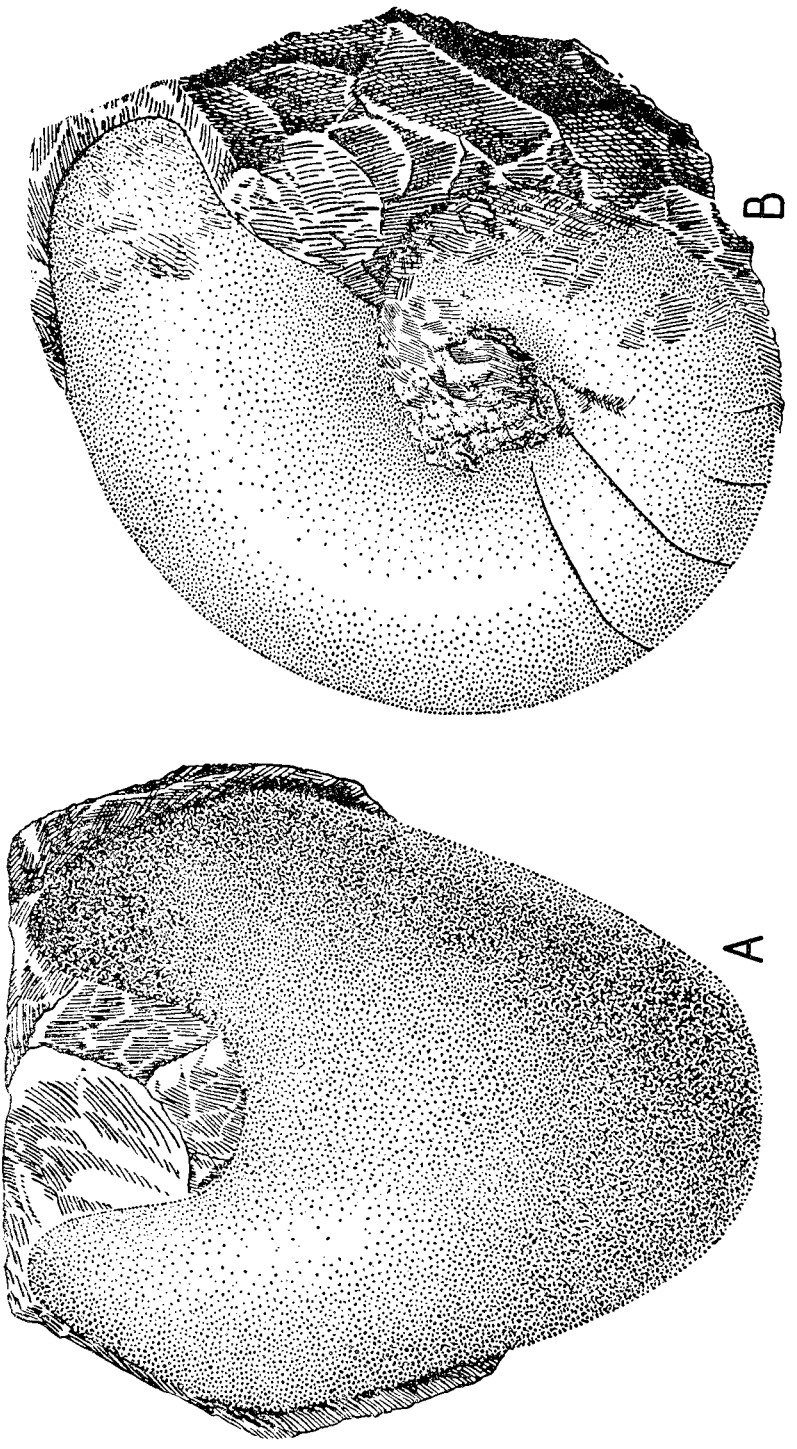

FIGURE 7.—*Stearoceras gibbosum* (Hyatt)

Two views of the type specimen of the genus *Stearoceras*, from the Lower Pennsylvanian near Bend, Texas, × ⅓. After Hyatt.

with *Acanthonautilus bispinosus* Foord, the type species of *Acanthonautilus* Foord, which has priority and which we are tentatively placing in the Liroceratidae.

Stearoceras, as interpreted by us, is now known to range from the Lower Pennsylvanian to the Middle Permian. Geographically it has been found to be represented in north-central and west Texas and in Western Australia.

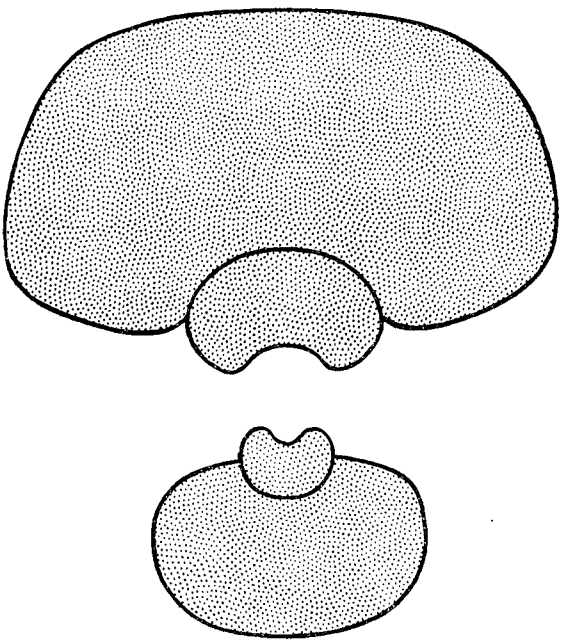

FIGURE 8.—*Stearoceras gibbosum* (Hyatt)

Cross section of one of the syntypes, from the Lower Pennsylvanian near Bend, Texas, × 1. After Hyatt.

Stearoceras aberrans (Miller and Unklesbay)

(Plate 16, figure 3; Plate 17, figure 3)

1942. *Metacoceras? aberrans* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720, 725–726, pl. 113, fig. 4; pl. 114, fig. 4.

This species is based on the figured specimen, but a small incomplete specimen, which may be conspecific, is also available for study. The holotype is only moderately well preserved, and it represents only the right lateral half of the conch. Its maximum diameter, measured across the umbilicus, is about 235 mm. The preserved portion of the living chamber is about half a volution in length.

The whorls are depressed dorsoventrally and are subrectangular in cross section (Fig. 6C). Their ventral and lateral zones and the umbilical walls are almost flat, but the dorsal zone is slightly impressed. Both the umbilical and the ventrolateral shoulders are abrupt and are slightly nodose. The rather poor preservation of the holotype precludes an accurate description of the nodes, but those on the umbilical shoulders seem to be relatively small and to be somewhat longitudinally elongate. Near the midlength of the outer volution of the holotype, the conch is about 65 mm. high and its width (at the umbilical shoulders) is estimated to be about 80 mm. The diameter of the umbilicus is slightly more than half that of the specimen.

The sutures form rather deep broad rounded ventral lobes, high narrowly rounded ventrolateral saddles, relatively shallow lateral lobes, low narrowly rounded dorsolateral saddles, very small lobes on the umbilical walls, and presumably shallow saddles on the umbilical seams and a dorsal lobe. The nature and position of the siphuncle are not known.

REMARKS.—The small specimen that we are referring with question to this species is about 100 mm. in diameter. It is fragmentary, but it seems to resemble the holotype rather closely but to have somewhat more prominent ventrolateral nodes.

This species resembles *Stearoceras ingens* (Miller, Dunbar, and Condra) of the Middle Pennsylvanian of Nebraska and *S. militarium* (Hyatt) and *S. simplex* (Hyatt) of the Lower Permian of Texas. These four forms are not very similar to the type species of *Stearoceras*, but they seem to be closer to it than to any other genotype.

OCCURRENCE.—Both the holotype and the specimen we are referring with question to this species came from the Chupadera formation near Bluewater Dam, about 16 miles northwest of Grants, Valencia County, New Mexico.

REPOSITORY.—University of New Mexico, 315 (holotype) and 318 (specimen referred with question to this species).

Stearoceras conchiferum (Hyatt)

(Plate 18, figures 1, 2; Plate 19, figure 2)

1891. *Temnocheilus Conchiferous* [part?] HYATT, Texas Geol. Surv., Ann. Rept. 2, p. 329–330, text figs. 23, 24.
1891. *Temnocheilus conchiferus* [part?] HYATT, Texas Geol. Surv., Ann. Rept. 2, p. 332.
1893. *Temnocheilus conchiferus* [part?] HYATT, Texas Geol. Surv., Ann. Rept. 4, p. 391.
1933. *Endolobus conchiferus* [part?] MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 194.
1942. *Endolobus conchiferous* [part?] MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720.
1947. *Endolobus?* sp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.
1948. *Endolobus conchiferous* [part?] BRANSON, Geol. Soc. Am., Mem. 26, p. 775.

Hyatt's original description of this species reads as follows:

"This is a small species having an exceedingly thick shell. The sides are decidedly convex and ornamented with short, thick, heavy-looking, fold-like pilae, which are prolongations of the thick, heavy, but not very prominent nodes on the edges of the abdomen. The shell is so thick that in some casts of the interior, as in the figure given above [reproduced as Fig. 9A] these nodes are not visible, and in others they are only slightly indicated. The surface appears to have been smooth with the exception of these nodes and pilae, but this could not be observed satisfactorily. The increase by growth in the transverse diameters is exceedingly rapid, whereas the vertical diameters increase slowly by growth. The abdomen is much depressed, almost flattened along the centre, becoming strongly convex only near the outer edges or sides. The sides, as in all the species of this genus, converge very rapidly towards the umbilici.

"The living chamber expands very rapidly and continuously outwards to the aperture in its transverse diameters, and varies from somewhat more than one-fourth to somewhat less than half of a volution in length. The aperture had a very shallow broad ventral, and lateral sinuses. The impressed zone on the dorsum is well marked, but the involution covers only the central part of the abdomen, leaving the whole area of the sides and the edges of the abdomen exposed.

"The sutures have broad and very short ventral and lateral lobes, and corresponding saddles at the angles of junction of the abdomen and sides; dorsal sutures were not observed. The siphuncle is of medium size and somewhat above the centre. The figure is approximately natural size."

Two years after this species was established Hyatt referred some additional specimens to it and briefly commented on them as follows:

"The new materials show living chambers having prominent and subangular lateral aspects and very broad abdomens, which indicate that this species probably belongs to Temnocheilus, as previously stated, and the exact locality has also been ascertained. Figure 24 of a transverse section of the whorl in the Second Annual Report [Fig. 9B of the present publication], as quoted above, is that of a young whorl, and the lateral aspects are probably somewhat rounded by compression."

REMARKS.—In the original description of this species, the specific name is spelled "*Conchiferous*", presumably as a result of a typographical error, for on a succeeding page of the same publication (Hyatt, 1891, p. 332) it appears three times and is invariably spelled "*conchiferus*." Furthermore two years later, its author (Hyatt, 1893, p. 391) wrote it twice and both times spelled it "*conchiferus*."

We have not seen any of the specimens studied by Hyatt, and therefore are reproducing his illustrations and descriptions. The original description seems to us to have been based on specimens that

were probably not all conspecific or even congeneric. That is, Hyatt's figures appear to represent a non-nodose form which is fairly close to the genotype of *Stearoceras*. However, some of the original types are stated to have convex lateral zones which are "ornamented with short, thick, heavy-looking, fold-like pilae, which are prolongations of the thick, heavy, but not very prominent nodes on the edges of the abdomen", and presumably these should be referred to *Foordioceras*. To clarify this situation, we are designating the individual that Hyatt figured as the holotype of the species. Unfortunately the exact horizon and locality (or horizons and localities) in the Late Paleozoic of Texas from which all of the original types came are not known.

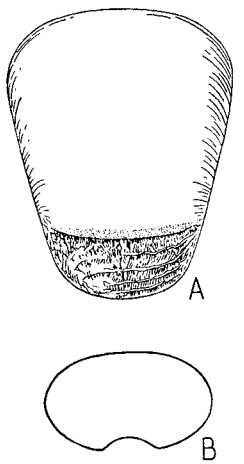

FIGURE 9.—*Stearoceras conchiferum* (Hyatt)

The holotype, from some unrecorded horizon and locality in the Late Paleozoic of Texas, approximately × 1. After Hyatt.

Recently Mrs. Augusta Hasslock Kemp loaned us several rather poorly preserved and somewhat crushed internal molds which are considerably larger than the holotype of this species, but otherwise seem to resemble it rather closely (Pl. 18, figs. 1, 2; Pl. 19, fig. 2). They have rather rapidly expanded low broad whorls, moderately small umbilici, and essentially straight external sutures. The ventral zone of the one illustrated on Plate 18 is distinctly concave, possibly in part, at least, as a result of distortion.

In general physiognomy this form is similar to *Stearoceras phosphoriense* (Branson). However, the conch of that species is less rapidly expanded orad and its sutures appear to be somewhat more sinuous.

OCCURRENCE.—The holotype of this species is from some unrecorded horizon and locality in the Late Paleozoic of Texas. The specimens which Hyatt referred to it in 1893 came from the Grape Creek limestone of the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas. Mrs. Kemp's material was collected from the lower portion of the Lueders formation about 8 miles south of Seymour near the Throckmorton highway along Self School Creek and adjacent parts of the Brazos bluff east of the highway in Baylor County, Texas.

TYPES.—All of the specimens studied by Hyatt (including the holotype) are stated to be at The University of Texas. Those we are studying are in the private collection of Mrs. Augusta Hasslock Kemp of Seymour, Texas.

Stearoceras hesperium, n. sp.

(Plate 20, figures 1, 2)

The only known representative of this species is a well preserved but fragmentary silicified replacement of a moderately large conch which consisted of at least two and a half volutions. All but

the adoral quarter-volution of this specimen is septate and presumably therefore represents phragmacone. The maximum diameter of the preserved part of the holotype measures about 125 mm., and near its adoral end the conch was about 50 mm. high and 75 mm. wide. The whorls are subrectangular in cross section as they are flattened laterally and ventrally and only slightly impressed dorsally, and the lateral zones are almost parallel though they converge slightly ventrad.

The umbilicus is large, open, and apparently perforate—that of the holotype attains a maximum diameter of about 55 mm. The umbilical shoulders are abrupt, and the umbilical walls, which are slightly concave exteriorly, are steep, being inclined to the lateral zones of the conch at an angle of some 120 degrees.

The surface of the test is smooth, or essentially so. The camerae are moderate in length. The sutures are almost straight and directly transverse, but they form broad shallow rounded ventral, lateral, and dorsal lobes. A structure that probably represents the siphuncle is small in cross section and is subcentral in position but is distinctly closer to the venter than the dorsum.

REMARKS.—The conch of this species is expanded orad more rapidly than is that of *S. militarium* (Hyatt), and it can be readily differentiated from *S. simplex* (Hyatt) and *S. gibbosum* (Hyatt) by means of its relatively large umbilicus. Its umbilical shoulders are much more nearly abrupt than those of the genotype, and it is perhaps closest to *S. simplex*.

OCCURRENCE.—Lower part of the Leonard formation "on the south side of the road between the road fork and the Sheep Tank at the Old Word Ranch" house in the Glass Mountain region of Brewster County, Texas.

HOLOTYPE.—U. S. National Museum.

Stearoceras militarium (Hyatt)

1893. *Domatoceras militarium* HYATT, Texas Geol. Surv., Ann. Rept. 4, p. 441, 444, 445–446, text figs. 22–24.
1933. *Domatoceras militarium* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 216.
1936. *Koninckioceras? militarium* NEWELL, Jour. Paleont., vol. 10, p. 486.
1947. *Domatoceras? militarium* MILLER AND KEMP, Jour. Paleont., vol. 21, p. 351–352.
1948. *Domatoceras (Metacoceras?) militarium* BRANSON, Geol. Soc. Am., Mem. 26, p. 775.

Hyatt's description of this species reads as follows:

"In the metanepionic sub-stage, shown in the inner lower outline of figure 22 [10A of the present publication], the whorl changes more rapidly than in *D.* [*Stearoceras*] *simplex*, the transverse diameter is longer than the ventro-dorsal, the form and sutures about the same as in *D. simplex* at a much larger size and later time in the same stage. There is also perhaps a slight flattening of the sides beginning in this sub-stage, and the sutures appear also to be tending towards the formation of lobes on the venter, these lateral zones, and dorsum, but these facts were not determined with absolute precision on account of the condition of the specimen. One thing is, however, certain, this stage is more accelerated in the development of the same characteristics than in *D. simplex*. The siphuncle is about half way between the center and the venter.

"In the ananeanic sub-stage, after the first whorl is completed and the zone of impression is formed, the whorl is smaller than in *D. simplex* at the same stage, the lateral zones perhaps broader and the abdomen narrower; the lateral zones also become very quickly convergent. The umbilical shoulders are consequently more prominent than in *D. simplex*, the zone of impression deeper and wider. The sutures also change more quickly and are more sinuous than in *D. simplex*. All of these characteristics correlated with the smaller umbilical perforation and the closer coiling and involution of the whorls. The siphuncle is slightly nearer the center in this sub-stage than in the preceding stages. The whorls at all stages observed are more numerous and broader transversely than in *D. simplex*, and the lobes are narrower, owing to the lesser breadth of the sides. Besides these differences and those given in the description of *D. simplex*, the two species are very similar. The shell is unknown; the cast is smooth. There are no annular lobes, although there are deep dorsal lobes, as shown in figure 23 [10B]. The section of the older whorl of figure 24 [10C] does not differ materially from that of the outer whorl as given in the younger stage represented in figure 22 [10A]."

REMARKS.—All of the information in regard to this species that is available to us is contained in the description and illustrations that we are reproducing. These indicate that the generic affinities of this form are with *Stearoceras*, rather than *Domatoceras* or *Koninckioceras*, to which it has been referred by other authors.

OCCURRENCE.—Grape Creek limestone of the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas.

HOLOTYPE.—Stated by Hyatt to be in the collections of the "Geol. Surv. of Texas," but not seen by us.

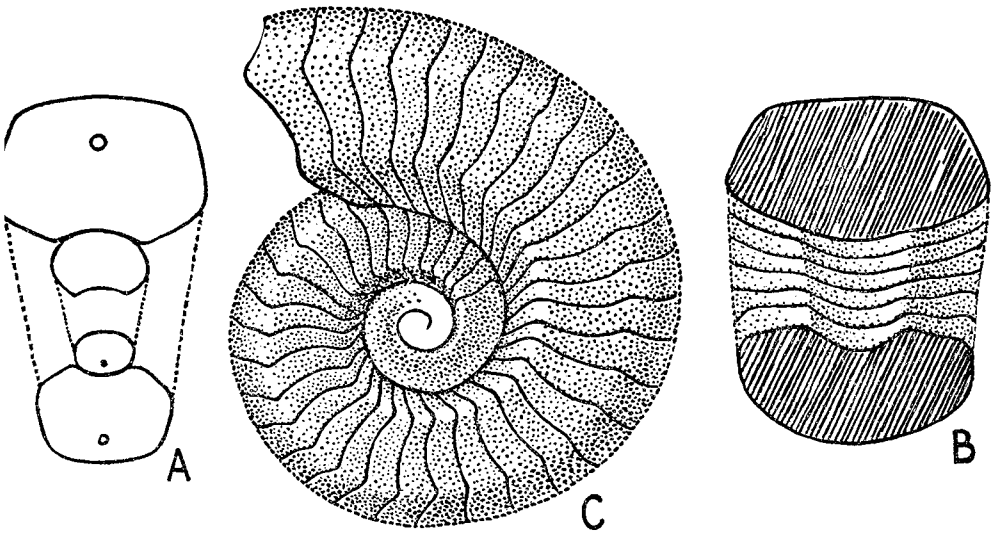

FIGURE 10.—*Stearoceras militarium* (Hyatt)

The holotype, from the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas, × 1. After Hyatt.

Stearoceras? permianum (Swallow)

1858. *Nautilus Permianus* SWALLOW, Acad. Sci. St. Louis, Trans., vol. 1, p. 178, 196.
1948. *Nautilus (Metacoceras?) permianus* BRANSON, Geol. Soc. Am., Mem. 26, p. 797.

All of the available information in regard to this species is contained in the original description, which reads as follows:

"*Shell* of medium size, discoidal; *spire* formed of two or three rapidly increasing sub-hexagonal volutions; *dorsal* [ventral] *margin* broad, flattened, slightly concave along the middle of some specimens; *sides* flattened; *interior lateral slopes* convex; *internal margin* concave, as modified by the succeeding whorl; *umbilicus* large, showing all the volutions; septa convex, sub-reniform, curved forward from the centre of the dorsal and ventral margins to the lateral, direct on the lateral; *siphuncle* large, sub-central, a little nearer the dorsal margin; *last chamber* large, enlarging rapidly toward the aperture, and becoming less angular; *aperture* transverse, reniform, slightly modified by the succeeding whorl. Surface markings not seen.

"Diameter, 2.68 [inches]; width of aperture, 2.25 [inches]; length of aperture in middle, 1.64 [inches].

"Major Hawn's collection from the Permian Rocks, near the Smoky-Hill Fork, K. T."

REMARKS.—The type specimen of this species was never illustrated, and if it is extant its whereabouts is not known. The shape of the conch and the position of the siphuncle suggest a relationship to *Stearoceras*, to which genus the species is accordingly referred. It is, however, so poorly known that even its generic affinities are uncertain, and it is not possible to place specimens in it with a reasonable degree of assurance.

OCCURRENCE.—Some unknown horizon in the Permian near the Smoky Hill River in central Kansas.

HOLOTYPE.—Probably lost in the fire at the University of Missouri in 1892.

Stearoceras phosphoriense (Branson)

(Plate 30, figures 1, 2)

1930. *Asymptoceras phosphoriense* BRANSON, Missouri Univ. Studies, vol. 5, no. 2, p. 59, pl. 12, fig. 11; pl. 15, figs. 4, 5.
1933. *Coloceras phosphoriense* MILLER, Paleont. Zentralblatt, Bd. 2, p. 349.
1933. *Coloceras phosphoriense* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 131.
1934. *Stearoceras phosphoriense* MILLER AND CLINE, Jour. Paleont., vol. 8, p. 288–289.
1948. *Stearoceras phosphoriense* BRANSON, Geol. Soc. Am., Mem. 26, p. 832.

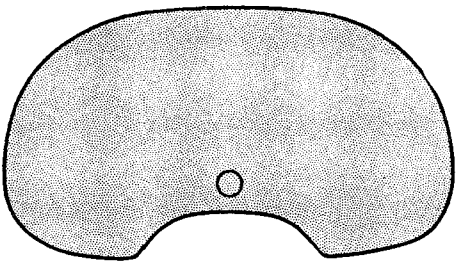

FIGURE 11.—*Stearoceras phosphoriense* (Branson)

Cross section of the adoral portion of the phragmacone of the holotype, × 1.

The holotype of this species consists of about half a volution of a rather poorly preserved internal mold representing much of the living chamber and the adoral six camerae of the phragmacone. Its maximum overall length measures about 105 mm. The conch is rather gradually expanded orad, and the whorls are reniform in cross section being greatly depressed dorsoventrally, somewhat flattened ventrally and laterally, and impressed dorsally. In the adoral portion of the holotype the ventral zone of the conch is slightly concave, possibly as a result of distortion during preservation. Near the junction of the phragmacone and the living chamber the conch is some 65 mm. wide and 35 mm. high.

The umbilicus is moderate in size for this genus, and that of the preserved part of the holotype attained a diameter of some 40 mm. The umbilical shoulders are rounded and rather indefinite, and the umbilical walls are steep.

Faint traces of the growth lines are discernible on the adoral portion of the holotype. They indicate that the conch is marked ventrally by a large, deep, U-shaped hyponomic sinus, much like that of *S. gibbosum* (Hyatt), the genotype.

The camerae are of about average length. The sutures are essentially straight and directly transverse, but they are slightly sinuous. Each forms a broad, very shallow, evenly rounded ventral lobe and on either side of it a similar but narrower ventrolateral saddle and lateral lobe, and a similar but still narrower dorsolateral saddle. The internal sutures of the holotype are not visible, but very shallow lobes are formed on the broad steep umbilical walls.

At a break along a septum near the mid-length of the preserved part of the holotype, there is exposed a structure that is believed to represent the siphuncle. It is small in size and is located fairly close to the dorsum (the bottom of the impressed zone).

REMARKS.—The only known representative of this species is incomplete and somewhat distorted, and therefore detailed comparisons are not possible. However, it seems to be fairly close to *S. gibbosum* but to have a less rapidly expanded conch and shorter camerae.

OCCURRENCE.—"Top limestone member" of Phosphoria formation in Bighorn Canyon in the Owl Creek Mountains near Thermopolis, Hot Springs County, Wyoming.

HOLOTYPE.—University of Missouri, 5326.

Stearoceras rotundatum (Miller and Unklesbay)

(Plate 7, figure 3)

(?) 1938. . . . McKee, Carnegie Inst. Washington Publ. 492, pl. 18, (unnumbered figure).
1942. *Titanoceras rotundatum* Miller and Unklesbay, Jour. Paleont., vol. 16, p. 721, 730, 731, 732–733, 737.

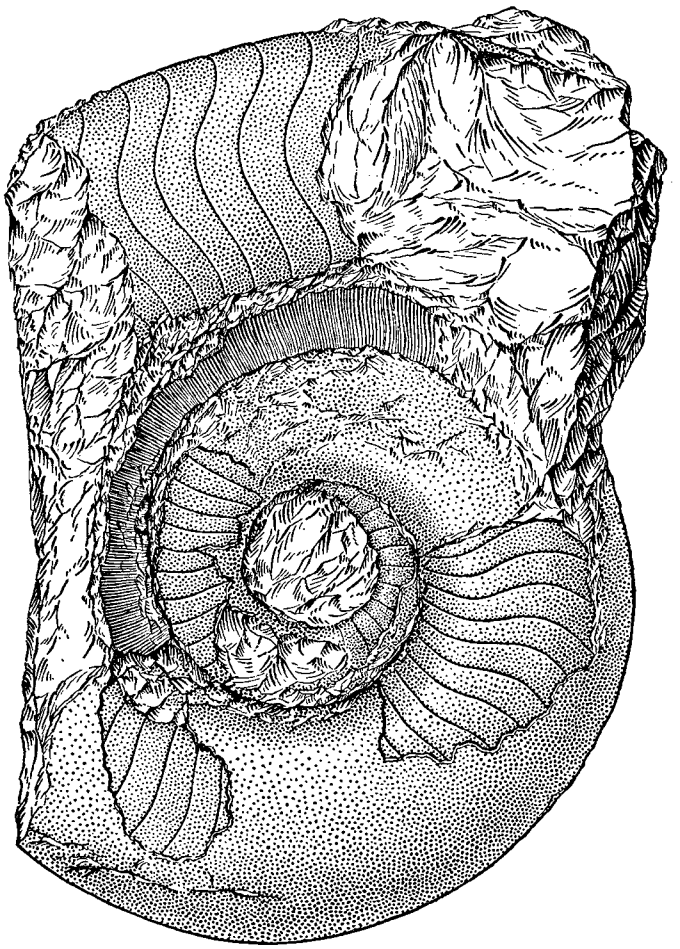

FIGURE 12.—*Stearoceras rotundatum* (Miller and Unklesbay)

A syntype, from the San Andres limestone along the Cloudcroft-Artesia highway in the Penasco River Valley of southeastern New Mexico, × 1. Same specmen as Figure 13A, in the text.

This species is based on several specimens, syntypes. The one represented by Figures 12 and 13A (in the text) consists of two completely septate volutions, and it is about 130 mm. in diameter. At least the outer whorl of this specimen is depressed dorsoventrally, is flattened ventrally and laterally, and is impressed dorsally. Its lateral zones (which converge ventrad), its ventral zone, and its umbilical walls are all broadly rounded. Both the umbilical and ventrolateral shoulders are rounded. The maximum width of the conch is attained just ventrad of the umbilical shoulders. Both the umbilicus and the umbilical perforation are large; the diameter of the umbilicus is equal to about half

that of the specimen. The test is thick, and near the umbilical shoulders of the adoral portion of the specimen, its thickness measures about 3 mm. The growth lines are rather prominent on the exterior of the test. On the adapical half of the inner volution of this specimen, there are low inconspicuous lateral nodes. The sutures form broad shallow rounded ventral, lateral, and presumably dorsal lobes, and rather narrowly rounded saddles on the ventrolateral and umbilical shoulders—they are essentially straight on the umbilical wall.

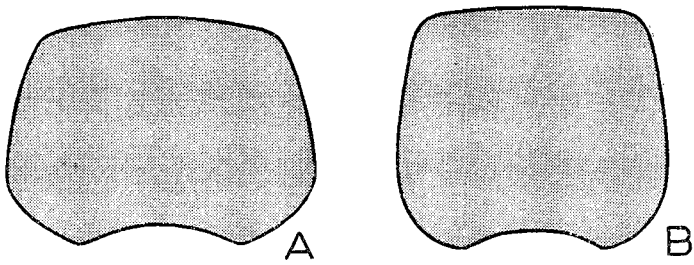

FIGURE 13.—*Stearoceras*

Cross sections of early mature portions of the conchs of (A) *Stearoceras rotundatum* (Miller and Unklesbay) and (B) *S. sanandreasense* (Miller, Dunbar, and Condra), both from the San Andres limestone of southeastern New Mexico and both × 1. The first is based on the same specimen as Figure 12 (in the text) at a diameter of about 80 mm.; the second on a topotype at the State University of Iowa (no. 1089) at a diameter of about 78 mm.

No trace of the siphuncle is visible in this specimen. However, in one of the fragmentary syntypes from the same horizon and locality, the siphuncle is moderately large and is subcentral in position but is slightly nearer the dorsum than the venter. Its diameter is about 3.7 mm. where the conch is about 42 mm. high and about 55 mm. wide.

The specimen on which Figure 6B is based represents the adapical third of a volution of the living chamber and the inner one and a half volutions of the phragmacone. The maximum diameter of the preserved portion of the conch of this specimen is estimated to have been about 160 mm. The inner volutions of this individual seem to resemble very closely equal-sized portions of the septate specimen represented by Figure 12. The outer volution, however, differs in cross section from the inner volutions; it is broadly rounded laterally, ventrolaterally, and dorsolaterally, and is slightly concave both dorsally and ventrally. Nevertheless, the sutures on this outer volution are essentially the same as on the preceding one.

REMARKS.—The Kaibab specimen figured by McKee in 1938 (see Pl. 7, fig. 3 of the present publication) seems to resemble this form but to be somewhat more closely coiled and to have a smaller umbilical perforation. Nevertheless, we are doubtfully placing it in this species and are associating with it several less nearly complete specimens from the same formation. The collections of the Museum of Northern Arizona contain a specimen (no. 1063/G2.1299) from a road-cut at the Canyon Padre bridge that resembles very closely the one figured by McKee, and these two may represent a distinct species.

S. sanandreasense Miller, Dunbar, and Condra, which occurs in association with this species, differs from it in that its whorls are relatively narrower and higher. Also the lateral and particularly the ventrolateral zones of its conch are much rounder at full maturity.

OCCURRENCE.—All five of the syntypes came from the San Andres limestone (150–200 feet below the top) on the west side of the Penasco River Valley about 52 miles west of Artesia on the highway to Cloudcroft, New Mexico. Professor S. A. Northrop loaned us for study a conspecific specimen from the Chupadera formation near Bluewater Dam, about 16 miles northwest of Grants, Valencia County, New Mexico. Several specimens that we are referring to this species with question came from the Kaibab limestone (α member) at the following localities in Arizona: (1) Grand Canyon Village (4 specimens including the one figured by McKee in 1938), (2) Grandeur Point in Grand Canyon (2 specimens), (3) Bottomless Pits about 7 miles east of Flagstaff (1 specimen), and (4) road-cut at Canyon Padre bridge about 20 miles east of Flagstaff.

REPOSITORIES.—Texas Technological College (all 5 syntypes); University of New Mexico (specimen from Bluewater Dam); Museum of Northern Arizona (2 questionable representatives of species numbered 811/G.598 and 1063/G2.1299); and Grand Canyon National Park Museum (3 questionable representatives of species numbered Fk-236, 1 numbered Fk-237, and 2 numbered Fk-287).

Stearoceras sanandreasense (Miller, Dunbar, and Condra)

(Plate 21, figures 1, 2)

1933. *Titanoceras sanandreasense* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 204–206, 207, 211, pl. 13, fig. 7; pl. 17, figs. 1, 2.
(?) 1942. *Titanoceras sanandreasense* CLIFTON, Jour. Paleont., vol. 16, p. 688, 696.
1942. *Titanoceras sanandreasense* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721, 733–734.
(?) 1944. *Titanoceras sanandreasense* CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.

Conch moderately large, subdiscoidal, and nautiliconic (but not deeply involute). Whorls are depressed dorsoventrally and are subrectangular in cross section but are slightly convex laterally, concave dorsally and (in late maturity) ventrally, and rather narrowly rounded ventrolaterally and dorsolaterally (see Fig. 13B, in the text). The extreme adapical part of the conch appears to be essentially circular in cross section; but during early ontogenetic development it was rapidly flattened laterally and all of it but the first volution is impressed dorsally. The ventral side of the earlier volutions of the conch is convex; but the amount of convexity decreases adorally so that in the adapical half of the outer volution of the holotype (Pl. 21, figs. 1, 2), the ventral zone is essentially flat and in the adoral half of that volution it is slightly but distinctly concave. Living chamber moderately long and expanded orad at same rate as phragmacone; it is at least a quarter of a volution in extent. Growth lines indicate the presence of a broad, moderately deep, narrowly rounded hyponomic sinus. Umbilicus large, shallow, and perforate—all of the inner volutions of the conch are exposed in it. Umbilical shoulders rounded.

Holotype is a moderately small but nevertheless mature individual consisting of about two and a half volutions. It is fairly complete and well preserved but has been crushed laterally. Its maximum diameter, measured from the adoral end of the preserved part of the venter across the umbilicus to the opposite side of the conch, is about 175 mm.; the diameter at right angles to this one measures about 150 mm. Maximum height of whorl attained by preserved part of holotype is about 55 mm.; maximum width about 71 mm. In the largest of the paratypes, the outer whorl attains a maximum height of at least 65 mm., and the preserved part of the living chamber of this specimen, which is not complete orad, is about 145 mm. long (measured along the center of the lateral zone of the conch). Surface of test marked by numerous, very fine, regular growth lines; these appear to be nearly straight and essentially transverse to the long axis of the conch on the dorsal and lateral sides of the specimen, but they bend strongly apicad as they cross the ventral side and indicate the presence of a broad, moderately deep, narrowly rounded hyponomic sinus. Surface of internal mold marked by a very small longitudinal ridge or raised line along the venter and a single row of large, low, rounded, inconspicuous nodes on each ventrolateral zone—it is estimated that about twelve nodes occur on each side of the outer whorl of the holotype. The borders of these nodes are very indefinite, and they rise only about $\frac{1}{2}$ mm. above the rest of the surface. As a matter of fact, they are so low and broad that they can be easily overlooked.

Camerae rather short, and from six to eight of them occupy a distance (measured along the center of the lateral zone of the phragmacone) equal to the width of the conch. Septa moderately convex apicad. Sutures approximately transverse but sinuous. They form broad, shallow, broadly rounded lobes as they cross the broad flattened ventral, lateral, and dorsal sides of the conch, and broad narrowly rounded saddles as they cross the ventrolateral and dorsolateral zones of the phragmacone. In the outer whorl of the fully mature conch, the dorsal lobe is divided by a very shallow median saddle.

Siphuncle rather large and central or nearly so in position. Septal necks moderately short and essentially straight and segments of siphuncle only very slightly expanded within camerae. In the illustrated paratype (Fig. 14, in the text) where width of conch measures about 45 mm., siphuncle

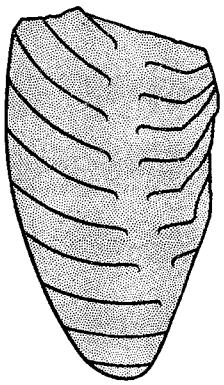

FIGURE 14.—*Stearoceras sanandreasense* (Miller, Dunbar, and Condra)

Longitudinal dorsoventral section of a fragmentary topoparatype showing the nature of the siphuncle, from the San Andres limestone along the Cloudcroft-Artesia highway in the Penasco River Valley of sotheastern New Mexico, × 1. The dorsal part of this specimen has been crushed and therefore the siphuncle does not appear to be central in position.

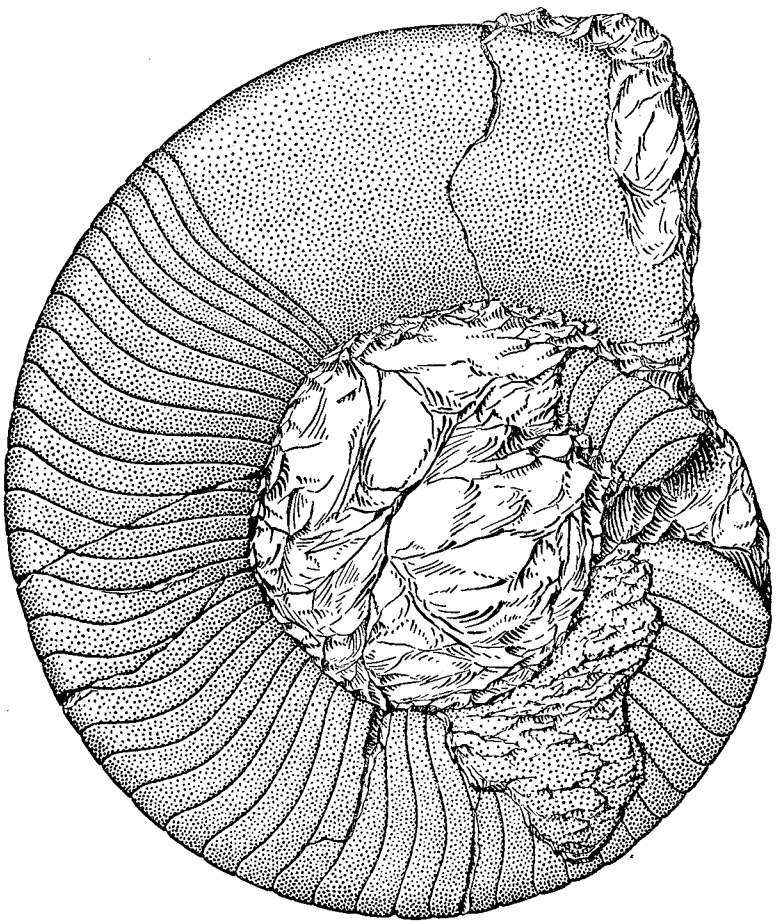

FIGURE 15.—*Stearoceras sanandreasense* (Miller, Dunbar, and Condra)?

Lateral view of a specimen from the α member of the Kaibab limestone at the Canyon Padre bridge about 20 miles east of Flagstaff, Arizona, × ¾. Same specimen as Figure 6D in the text.

is about 4½ mm. in diameter at its passage through a septum, and septal necks are only about 1 mm. long.

REMARKS.—The preceding specific description is based almost entirely on the holotype, but eleven additional specimens from the same horizon and locality are available for comparisons—ten of them are paratypes. Also the collections of Kaibab nautiloids that have been loaned to us for study contain six specimens that do not seem to differ materially from the holotype. However, five of them are only fragments of the internal mold of the chambered portion of the conch, and the sixth (Figs. 6D and 15, in the text) does not retain the inner volutions. Therefore we are somewhat uncertain in regard to their affinities, and we are referring them to this species with question. The best of our Kaibab specimens attains a maximum diameter, measured across the umbilicus, of about 170 mm. The adoral camerae of this specimen are relatively short, indicating that it represents a fully mature individual. The portion of the living chamber that is preserved is only about a fourth of a volution in length. The cross section of the conch is represented by Figure 6D, in the text.

OCCURRENCE.—The original type specimens of this species came from the San Andres limestone (about 150–200 feet below the top) on the west side of the Penasco River Valley about 52 miles west of Artesia on the highway to Cloudcroft, Otero County, New Mexico. Six specimens that we are referring to the species with question are from the α member of the Kaibab limestone of Arizona—four of these came from Grand Canyon Village, one is from Grandeur Point in Grand Canyon, and the sixth was found at the Canyon Padre bridge which is about 20 miles east of Flagstaff, in Coconino County.

In 1942 Clifton studied some specimens (which we have not seen) from the Permian of north-central Texas and stated that "this species is common to the Blaine and Dog Creek formations at several localities, and at the locality near Quanah, Texas, some specimens attain a larger size, being more than 240 millimeters in diameter." He adds that it occurs in the Acme member of the Blaine at the following localities: (1) "an extensive area, including sections 148, 168, 169, 173, 198 and adjacent sections, north and northwest of Quanah, in Block H, of the Waco and NW. R. R. Company Survey, Hardeman County, Texas"; and (2) "northeast Nolan County and Southeast Fisher County in Texas. Chiefly, Sec. 289, B. H. Stribling Survey, and Sec. 290, R. Cochran Survey." Also, he indicates that conspecific specimens occur in the Guthrie member of the Dog Creek formation at the following localities: (1) "sections 410, 411, 420, and 421, northeast and southeast of Kirkland, in Childress County, Texas"; (2) "section 139 and areas northeast, in Block F of the H. & T. C. R. R. Co. Survey, Stonewall County, Texas"; and (3) "about two miles south of Sylvester, Fisher County, Texas." The ammonoid genus *Perrinites* is known to be represented at all five of these localities.

REPOSITORIES.—Yale Peabody Museum, 13998 (holotype and paratypes); Museum of Northern Arizona 1033/G2.1109 (Figs. 6D and 15, in the text); State University of Iowa, 1089 (Fig. 13B, in the text); and Grand Canyon National Park Museum, Fk-8, Fk-236A, Fk-236B, Fk-287A, and Fk-515.

Stearoceras simplex (Hyatt)

1893. *Domatoceras simplex* HYATT, Texas Geol. Surv., Ann. Rept. 4, p. 441–444, 445, 446, text figs. 16–21.
1933. *Domatoceras simplex* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 216.
1936. *Koninckioceras? simplex* NEWELL, Jour. Paleont., vol. 10, p. 486.
1947. *Domatoceras? simplex* MILLER AND KEMP, Jour. Paleont., vol. 21, p. 351–352.
1948. *Domatoceras* (*Metacoceras?*) *simplex* BRANSON, Geol. Soc. Am., Mem. 26, p. 775.

Hyatt's description of this species reads as follows:

"The young of this form in the nepionic stage has evidently, as seen from the side in figure 17 [16D of the present publication], a rounded whorl, larger than in young of *D.* [*Stearoceras*] *militarium*, but with similar sutures. The increase in size is more rapid, but the form and sutures change little until the first whorl is completed. The lateral zones of the whorl make their appearance in the beginning of the anaeanic sub-stage, together with umbilical shoulders and zones and a zone of impression. Later in the paraneanic sub-stage—shown in the outer fragment of a whorl in figure 17 [16D], all of these characteristics are more decided and the lateral zones converge slightly. The siphuncle appears in the drawings to be below the center in the earlier stages, and to be above that point in the paraneanic sub-stage, but this is probably due to compression which has slightly distorted the whorls of the specimen figured, since it is plainly above the center in the last septum, figure 18

[16B], of the paraneanic sub-stage. There is no annular lobe at any stage observed. There is also a specimen from Military Crossing, Baylor county, which is only provisionally referred to this species on account of the absence of the later stages, but it has evidently very similar young whorls, and these may be described as follows: During the nepionic stage the whorl is stout, rapidly increasing in size and rounded. The venter is rounded and gibbous, and the ventro-dorsal diameters a little longer than

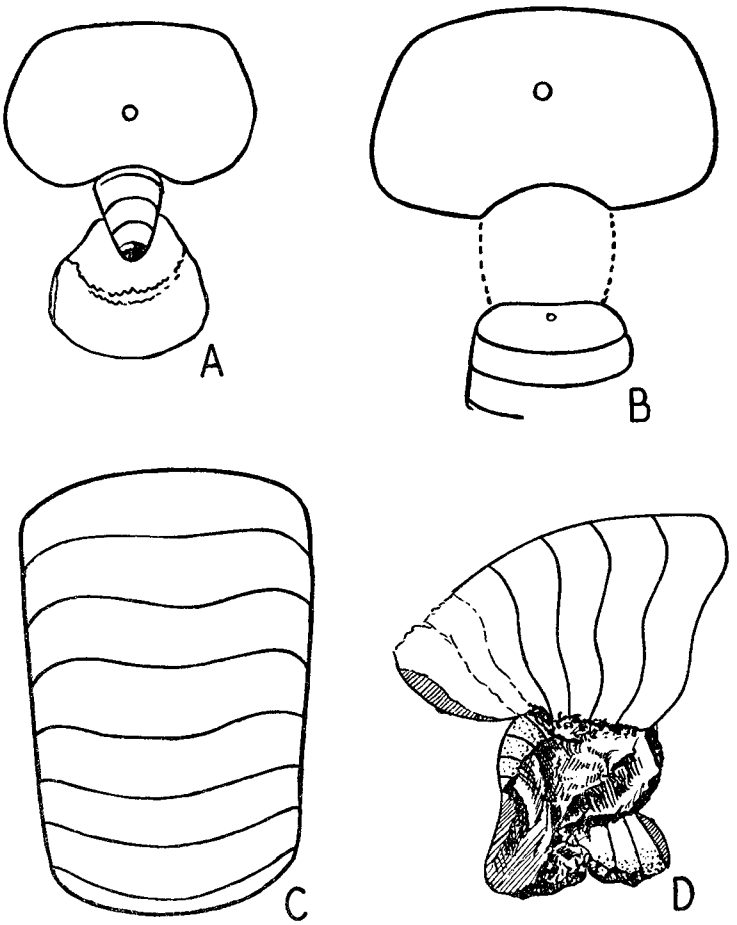

FIGURE 16.—*Stearoceras simplex* (Hyatt)

A specimen "provisionally referred to this species", from the Lower Permian near Ballinger, Texas, × 1. After Hyatt.

the transverse. The sutures, straight at first, have finally a slight curvature, with ventral and dorsal saddles and slight lateral lobes. The siphuncle is quite close to the venter, but not decidedly ventral. In the paranepionic sub-stage the gyroceran curvature begins, and the transverse becomes longer than the ventro-dorsal diameters, but the rounded, depressed, elliptical outline of the whorl in section is maintained and the sutures remain unchanged. The siphuncle is evidently, however, slightly shifted in position towards the center, judging from the place it occupies in the next sub-stage. When the first whorl is completed and the neanic stage begins, there is a decided tendency to form umbilical shoulders, but the abdominal angles are so slight that unless one knew the affinities of the form for *D. simplex* he would consider it a digonal whorl, and probably lose the significance of the slight umbilical angles and the very slight saddles in the sutures that accompany them. The sutures have slight lateral and dorsal lobes, but are straight across the venter. Later in this stage these characters especially the prominence of the umbilical shoulders, increases and well defined lateral and umbilical zones are formed. The siphuncle is but just above the center. Later stages did not exist in this specimen. There was no annular lobe in any of the septa observed in the stages described.

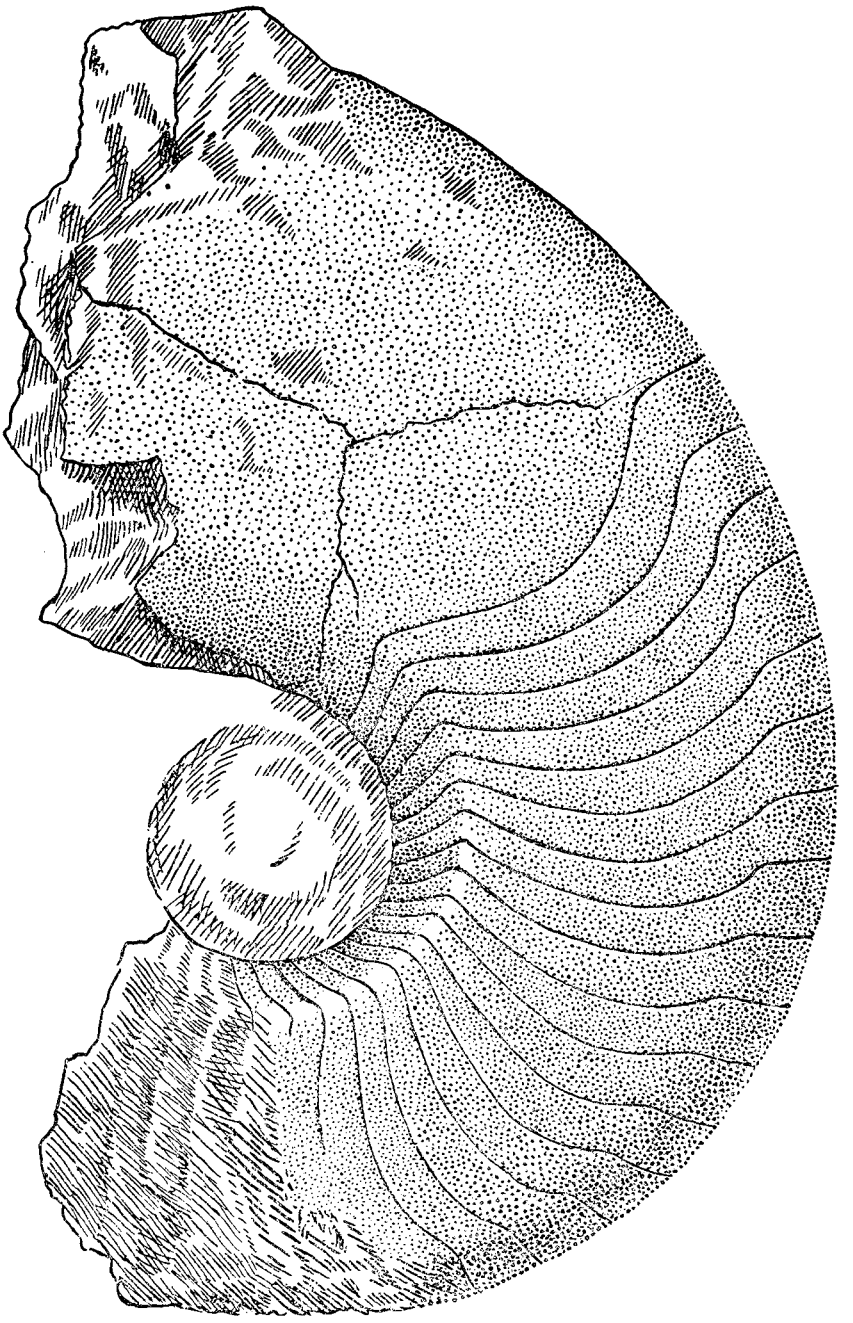

FIGURE 17.—*Stearoceras simplex* (*Hyatt*)

The holotype, from the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas, × 1. After Hyatt.

"This species has a much larger umbilical perforation, grows more quickly in bulk, and attains probably a much larger size than in *D. militarium*. The whorl increases faster at all stages of growth, so that the umbilici become rapidly much deeper than in *D. militarium*. The siphuncle is a little below the center in the full grown shell. The specimen figure 20 [17] is about 173 mm. in diameter, with part of the living chamber preserved. The full grown shell has a flattened abdomen and a more hexagonal whorl than in the neanic stage. The shell is unknown, but the cast is smooth at all stages."

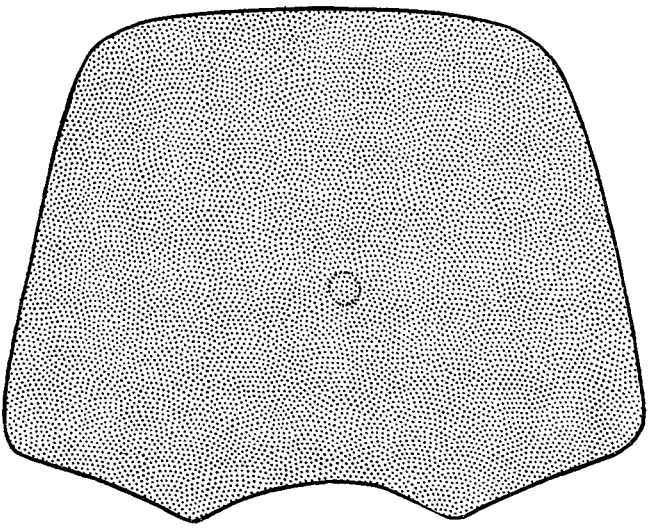

FIGURE 18.—*Stearoceras simplex* (Hyatt)

Cross section of the holotype, from the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas, × 1. After Hyatt.

REMARKS.—All of the information in regard to this species that is available to us is contained in the description and illustrations which we are reproducing. These indicate that the generic affinities of this form are with *Stearoceras*, rather than *Domatoceras*, *Koninckioceras*, or *Metacoceras*, to which it has been referred by other authors.

OCCURRENCE.—Lower Permian of north-central Texas. The holotype came from the Grape Creek limestone of the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County; and the small specimen that Hyatt "provisionally referred to this species" was found at or near Ballinger, in Runnels County, presumably in either the Clear Fork or Wichita group.

REPOSITORY.—Both specimens are stated by Hyatt to be in the collections of the "Geol. Surv. of Texas," but neither has been seen by us.

Stearoceras sublaeve (Miller, Dunbar, and Condra)

(Plate 57, figures 3, 4)

1933. *Metacoceras sublaeve* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 190–193, pl. 7, figs. 1–3.
1948. *Metacoceras sublaeve* BRANSON, Geol. Soc. Am., Mem. 26, p. 792.

The conch at maturity consists of some two to three slightly depressed volutions, and it is nautiliconic but is not deeply impressed dorsally. The first volution is elliptical in cross section, but the rest are irregularly hexagonal (being flattened ventrally, laterally, and dorsolaterally) and only moderately concave dorsally; and the junctions of these flattened sides are rather narrowly rounded or subangular. The broad ventral side of the conch is in general slightly convex, but on the adoral half of the outer volution it is very slightly concave along the median zone. The lateral zones, which converge somewhat toward the venter, and the dorsolateral zones (that is, the umbilical walls)

also are slightly but very distinctly convex exteriorly; and the junctions of the ventral, lateral, and dorsolateral zones are rather narrowly rounded though on the adoral portion of the conch they become more broadly rounded. The dorsolateral zones are inclined to the lateral zones at about 115 degrees. The dorsal zone is concave as it is impressed by the preceding volution. The junctions of the dorsolateral and the dorsal zones of the conch are subacute.

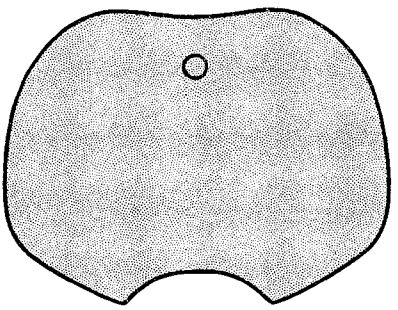

FIGURE 19.—*Stearoceras sublaeve* (Miller, Dunbar, and Condra)

Diagrammatic cross section of the adapical end of the holotype, from the Neva limestone about 1¼ miles northeast of Roca, Nebraska, × 2.

The umbilicus is moderately large and deep; its width is equal to about a third of the diameter of the specimen. The umbilical shoulders are smooth and rounded, and the umbilical walls are fairly steep. Presumably the umbilicus is perforate, but this character can not be ascertained from the type material.

The conch is marked ventrally by a broad deep rounded hyponomic sinus, but no lateral sinuses. The hyponomic sinus is as broad as the flattened ventral zone of the conch and is about a third as deep as wide. The internal mold at first sight appears to be entirely non-nodose, but when the ventrolateral zones are viewed in profile, very low broad nodes can be readily detected; it is estimated that there are about 16 of these nodes on the outer volution of the conch, and they appear to be just as inconspicuous on the earlier volutions as on the later ones.

About five camerae occur in a distance (measured along the center of the lateral zones of the conch) equal to the width of the conch. Each suture forms a broad shallow rounded lobe on the ventral, the lateral, and the dorsal zones of the conch, and these are separated by subacute saddles. The part of the suture forming the dorsal side of the lateral lobe continues to curve orad across the umbilical wall, and the subacute dorsolateral saddle centers on the umbilical seam rather than on the umbilical shoulder; there is, however, a marked decrease in the amount of adoral curvature of the sutures on the umbilical shoulder, and a secondary saddle can be said to occur there.

The siphuncle is small, is neither ventral nor central but intermediate in position, and is orthochoanitic in structure. Where the conch is about 30 mm. wide, the siphuncle is approximately 2 mm. in diameter.

REMARKS.—This specific description is based on five incomplete internal molds, all of which came from a block of limestone no more than 6 inches square and 2 inches thick. The holotype is an internal mold representing only the adoral portion of what appears to be a mature specimen; it is essentially complete adorally and is bordered adapically by the impression of the adoral septum of the phragmacone, so it represents all of the living chamber which is about a third of a volution in length. Traces of growth lines are very clear and distinct on the holotype; presumably they were impressed on this internal mold from the external mold.

At the adapical end of this specimen, the conch is about 30 mm. wide and 20 mm. high; the ventral zone is about 19 mm. wide, the lateral about 13 mm., the dorsolateral about 10 mm., and the dorsal about 10 mm.; and the impressed zone is about 2 mm. deep. At the adoral end of this specimen, which apparently represents the aperture, the conch attains a maximum width of about 40 mm. and a maximum height of about 30 mm.

This species is readily distinguished from all other described representatives of the genus by means of its general physiognomy and particularly its slight ventrolateral nodes. These nodes indicate a relationship to *Metacoceras*, but the similarity to the genotype of *Stearoceras* is greater than to that of *Metacoceras*.

OCCURRENCE.—Neva limestone about 1¼ miles northeast of Roca, Lancaster County, Nebraska.

TYPES.—Yale Peabody Museum, 13995 (holotype) and 13996 (paratypes).

Stearoceras? sp. [of Colombia]

1945. *Titanoceras?* sp. MILLER AND WILLIAMS, Jour. Paleont., vol. 19, p. 347.
1949. *Pseudometacoceras?* sp. THOMPSON AND MILLER, Jour. Paleont., vol. 23, p. 7.

One of the two coiled nautiloids known from the Permian of Colombia is only a fragment of a septate whorl of a large form, and it does not merit illustration. The volution represented was at least 60 mm. wide. The septa are moderately convex apicad, and the lateral walls of the conch are essentially flat. The general appearance of this specimen suggests a relationship to *Stearoceras* of the type of *S. sanandreasense* Miller, Dunbar, and Condra, but so small a portion of the conch is represented that even a generic determination can not be made satisfactorily.

OCCURRENCE.—Middle Permian (Leonard equivalent) gray dolomitic limestone on the western side of the Sierra de Perijá east of Manaure, Departamento de Magdalena, northern Colombia.

REPOSITORY.—Compañía de Petróleo Shell de Colombia.

Stearoceras sp. [of Mexico]

1942. *Stearoceras* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720.
1944. *Stearoceras* sp. KING, Geol. Soc. Am., Spec. Pap. 52, p. 14.
1944. *Stearoceras* sp. MILLER, Geol. Soc. Am., Spec. Pap. 52, p. 79.

One horizon and locality in northern Mexico yielded three specimens that appear to be referable to *Stearoceras*, but unfortunately are not sufficiently complete to merit illustration. All three seem to be conspecific. The conch, which consists of at least two and a half volutions is subglobular in shape and nautiliconic in mode of growth. The whorls are reniform in cross section as they are broadly rounded ventrally, somewhat more narrowly rounded laterally, and impressed dorsally. The preserved portion of the conch attained a width of at least 35 mm. and a corresponding height of at least 20 mm. The diameter of the umbilicus is equal to about a third that of the specimen. The umbilical shoulders are rounded. The surface of the internal mold is smooth, but there is a small indistinct rounded ridge along the venter.

The camerae are moderate in length, and the septa are moderately convex apicad. The sutures are in general directly transverse to the long axis of the conch, but each of them forms slight ventral, lateral, and dorsal lobes, and similar ventrolateral and dorsolateral saddles—the dorsolateral saddles center on the umbilical walls and they are more prominent than the ventrolateral saddles. There is no annular lobe on the dorsum.

The siphuncle is small and is subcentral in position, but it is distinctly nearer the dorsum than the venter. The septal necks are very short and straight. The connecting rings are almost cylindrical but are slightly expanded within the camerae, possibly in part at least because of distortion during fossilization.

REMARKS.—These specimens seem to be closer to the type species of *Stearoceras* than to any other genotype. However, they are considerably smaller than that form and their similarity to it may be more apparent than real.

OCCURRENCE.—Concretionary shales in the zone of *Timorites* along the strike from Cerro Wencelao on the south to 300 meters west of El Indio on the north, in the Valle de Las Delicias, Coahuila.

REPOSITORY.—Yale Peabody Museum, 16275.

Stearoceras? spp. [of New Mexico]

1909. *Temnocheilus* aff. *winslowi* GIRTY, U. S. Geol. Surv., Bull. 389, p. 47, 49, 113–114.
1909. *Temnocheilus* aff. *conchiferum* GIRTY, U. S. Geol. Surv., Bull. 389, p. 47, 49, 114.
1909. *Temnocheilus* sp. *a* GIRTY, U. S. Geol. Surv., Bull. 389, p. 47, 49, 114–115.
1933. *Endolobus?* spp. MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 195.
1942. *Endolobus* aff. *E. conchiferous* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721.

In his study of the paleontology of the Manzano group of the Rio Grande Valley, New Mexico, Girty described but did not illustrate some fragmentary material under the headings "*Temnocheilus* aff. *winslowi* Meek and Worthen," "*Temnocheilus* aff. *conchiferum* Hyatt," and "*Temnocheilus* sp. *a*." Miller, Dunbar, and Condra did not discuss the first of these, but they stated that the last two should "probably" be referred to *Endolobus*. We have not had an opportunity to study the specimens, but in so far as we can tell from the published descriptions of them, it seems likely that their affinities are with *Stearoceras*.

Girty's description of his "*Temnocheilus* aff. *winslowi*" reads as follows:

"The subject of this description is a single fragment having a closely quadrate section 35 mm. in both directions. The sides are straight and parallel. The ventral surface is gently convex. The dorsal side is concave for an undetermined distance, and runs upward rather strongly at the sides, making this surface on the whorl more convex than the other. The umbilical shoulder probably not well defined. While the ventral and lateral surfaces are fairly distinct, they apparently do not meet in an angle. This line, however, is marked by a row of very large nodes, which are subcircular, somewhat elongate, basally at least, in the direction of revolution, and are probably 20 mm. or more apart. The siphuncle is of medium size and is about 7 mm. from the ventral border. The sutures are very nearly straight and very nearly transverse. There is perhaps a faint ventral lobe. The chambers are low, about 4 mm. in height along the ventral surface.

"This form appears to be related to *T. winslowi*, but is with little question distinct, one difference being the less transverse shape of the cross-section. The Manzano form is too incompletely known, however, to determine its relationship to other species. More perfect material would probably verify the foregoing description in the main."

Girty described the specimens he termed "*Temnocheilus* aff. *conchiferum*" in the following words:

"This form, like the other ['*Temnocheilus* aff. *winslowi*'], is represented by very fragmentary specimens, the following notes being taken from one of them:

"The volutions appear to have been rather gradually enlarging, and but slightly embracing, so that the shape of the whorl was discoidal, with wide umbilicus. The shape of the section is transversely elliptical, with a barely perceptible flattening of the sides. The width is 34 mm. and the height 24 mm. The dorsal surface is impressed for about one-third the entire width. Indistinct traces of nodes have been observed along the obscure ventrilateral shoulder.

"The character of the suture is not shown by the specimen furnishing the above data, and other examples too doubtfully belong to the same species to make it desirable to include here data derived from them.

"This form suggests *T. conchiferum* in its section, but is a less rapidly enlarging species."

The specimens called "*Temnocheilus* sp. *a*" were described by Girty in the following two paragraphs:

"The form included under this title appears to be closely related to the last ['*Temnocheilus* aff. *conchiferum*'], and may prove even identical with it when both come to be better known. The chief reason for distinguishing them has to do with the septa. In the best and most characteristic specimen referred to this division the height of the chambers is about 6 mm., or considerably more than in the other. The sutures are also more strongly curved. There is a distinct ventral lobe or sinus and a distinct lateral lobe, with saddles more or less well marked upon the ventrilateral and unbilical shoulders.

"Not all of the specimens referred here show nodes upon the ventrilateral shoulder, but, especially in the older whorls, those structures are largely taken up by the thickness of the shell, leaving often very indistinct elevations upon the internal mold, the condition in which most of our specimens are found."

OCCURRENCE.—All of the specimens just discussed came from the Yeso, Abo, and San Andres formations of south-central New Mexico. Although Girty described only a single specimen as "*Temnocheilus* aff. *winslowi*," he listed this form as occurring in the Yeso formation at two localities and horizons: (1) "near C. F. Blackinton's ranch, about 15 miles east of Socorro. Lime near top of gypsum series of red beds"; and (2) south of Mesa del Yeso, near Socorro, Socorro County, in "lime between massive part of base of red beds and upper or gypsum series."

Girty's "*Temnocheilus* aff. *conchiferum*" also is stated to be from two horizons and localities: (1) "about midway of 300 feet of lime, above pink and red sandstones" in the San Andres formation in Nogal Creek, west of Paraja, Sierra County; and (2) the Yeso formation 2 miles east of river near Alamillo, Socorro County. The specimens that Girty included in his "*Temnocheilus* sp. *a*" are from three formations: (1) the Yeso "lime between massive part of base of red beds and upper or gypsum series" south of Mesa del Yeso, near Socorro; (2) questionably the Abo sandstone ("lime

near base of red beds") south of Mesa del Yeso; and (3) questionably from the San Andres formation ("lime above the gypsum of the red beds"), Mesa del Yeso.

REPOSITORY.—U. S. National Museum.

Stearoceras sp. [of north-central Texas]

(Plate 22, figures 1, 2; Plate 48, figures 1, 2; Plate 58, figures 8, 9)

1947. *Domatoceras?* sp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.

Mrs. Augusta Hasslock Kemp loaned us three specimens from one horizon and locality in the Lower Permian of north-central Texas, which seem to be conspecific and to represent an unnamed species of *Stearoceras*. Unfortunately none of them is sufficiently complete or free from distortion to serve satisfactorily as a holotype, and therefore we are refraining from proposing a name for the species.

The largest of the three (Pl. 22, figs. 1, 2) appears to be essentially complete adorally, and the portion of it that represents living chamber is a little less than half a volution in length. The maximum diameter of this specimen in its present slightly crushed incomplete state measures about 110 mm., and near its adoral end its conch is about 40 mm. high and 70 mm. wide. Slightly apicad of what appears to be the apertural margins, there is a broad shallow rounded constriction in the lateral but not the ventral zones of the internal mold. The whorls are flattened laterally and ventrally, with the lateral zones converging slightly ventrad. The ventrolateral and dorsolateral zones are rather narrowly rounded, and presumably the dorsal zone is slightly impressed by the preceding volution. The umbilicus is wide, and the maximum width of that of the specimen under consideration measures about 50 mm. The test is thick, and just inside the umbilical shoulders of the adoral portion of this specimen its thickness measures some 2 mm. The surface of the test bears fine growth lines which on at least the lateral zones of the conch are essentially straight and directly transverse. The camerae are rather short, and along the venter the length of each of the adoral two camerae of this large specimen measures about 6 mm. The sutures form very slight lateral, ventral, and presumably dorsal lobes.

The smaller specimens do not appear to differ materially from the larger one except in size. The individual illustrated on Plate 58 shows that the umbilicus is most probably perforate, and that the extreme adapical portion of the conch is subcircular or subelliptical in cross section. The specimen figured on Plate 48 shows that during early maturity the sutures form distinct lateral and ventral lobes, the lateral zones of the conch are considerably converged ventrad, and the siphuncle is located about midway between the center and the venter.

REMARKS.—This form is not particularly close to the genotype of *Stearoceras*, but it resembles other species which we are referring to that genus. Because of the nature of the specimens we are studying, detailed specific comparisons are difficult.

OCCURRENCE.—Elm Creek limestone member of the Admiral formation along Godwin Creek about 17 miles east of Seymour, Baylor County, Texas.

FIGURED SPECIMENS.—Private collection of Augusta Hasslock Kemp of Seymour, Texas.

Stearoceras? sp. [of west Texas]

(Plate 6, figures 1, 2)

1945. *Domatoceras?* sp. MILLER, Jour. Paleont., vol. 19, p. 283, 284–285, pl. 44, figs. 1, 2.

The collections under consideration contain a moderately small silicified nautilicone of uncertain generic affinities. The size of this specimen and the fact that the shape of its conch changes fairly rapidly throughout its entire length indicate that it is immature. It seems to resemble early ontogenetic stages of *Stearoceras*, and accordingly we are referring it with question to that genus.

This specimen, which consists of some one and a half volutions, is about 25 mm. in diameter, and all but the extreme adoral portion of it is septate. The living chamber, when complete, appears to have been about two-fifths of a volution in length. The conch is expanded orad rapidly, and at the adoral end of the specimen is about 21.5 mm. wide, and 13 mm. high. Corresponding measurements at the adapical end of the outer volution are about 10 mm. and 5 mm., respectively. At the latter

place, the conch appears to be subelliptical in cross section, being more broadly rounded dorsally than ventrally. However, throughout the length of the outer volution of this specimen, the conch becomes progressively more flattened ventrally and laterally and the umbilical shoulders become higher and higher. The lateral zones converge ventrally, and at the adoral end of this specimen the conch is unequally hexagonal in cross section, with the dorsal side slightly concave and all of the other sides slightly convex.

The umbilicus attains a diameter of about 10 mm. The umbilical shoulders are abrupt, and the umbilical walls are steep. If an umbilical perforation existed, it was very small.

The camerae are moderate in length. In the adapical part of the specimen the sutures are essentially straight and directly transverse, but in the adoral portion of it they form slight lateral and ventral lobes. No trace of the siphuncle is visible.

REMARKS.—Superficially, at least, this specimen resembles the adapical portion of large representatives of *Stearoceras*. If, however, as is now believed, it is immature, its generic affinities can not be determined with certainty.

OCCURRENCE.—Near the top of the slope on the northwest side of the road about 0.5 mile southwest of the old Word Ranch house, some 17 miles north-northwest of Marathon, Brewster County, Texas. G. A. Cooper, who collected this specimen, is inclined to believe that the limestone from which it came is the first limestone of the Word formation, but he states that in the field he "felt that there was quite an overlap between the base of the Word and the top of the Leonard." Inasmuch as he found typical representatives of *Perrinites hilli* (Smith) in association with this specimen, we are of the opinion that the beds which yielded it are part of the Leonard formation.

REPOSITORY.—U. S. National Museum, 111611.

Stearoceras? sp. [of Wyoming]

(Plate 31, figure 6)

1930. *Coloceras* sp. BRANSON, Missouri Univ. Studies, vol. 5, no. 2, p. 59, pl. 15, fig. 3.
1934. *Stearoceras* sp. MILLER AND CLINE, Jour. Paleont., vol. 8, p. 289.

Branson gives only the following information in regard to this form:

"No specimen in good condition was found. The diameter of the best specimen is about 70 mm. and the width of the umbilicus 10 mm. The chambers are from 6 to 7 mm. in height. The sutures are slightly lobed on the sides, and distinctly lobed on the venter; the greatest lobation is next to the iving chamber."

REMARKS.—The specimens to which this description refers have been misplaced. The physiognomy of the figured individual (Pl. 31, fig. 6, of the present publication) and particularly the sinuosity of the sutures suggest a relationship to *Stearoceras* rather than to *Liroceras* [= ? *Coloceras*].

OCCURRENCE.—Uppermost limestone member of the Phosphoria formation ni the Wind River and Owl Creek mountains of west-central Wyoming.

Genus *Titanoceras* Hyatt, 1884

GENOTYPE: *Nautilus ponderosus* White

When Hyatt (1884, p. 289–290) established this genus, he stated: "Type, Titan. (Naut.) ponderosum, sp. White, U. S. Geol. Surv. Final. Rep. on Nebr. Hayden, p. 236, pl. 3. Nat. Mus." At first sight, this designation of the genotype seems quite satisfactory. However, the description and illustration to which Hyatt referred are by Meek and not by White, and they are not based on White's specimen. That is, Meek's study is of a nautiloid from the Plattsmouth limestone of Nebraska, which he believed to be conspecific with "Dr. White's type specimen, now in the Iowa State collection . . . from the Upper Coal-Measures of Iowa"; but the individual for which White had coined the specific name was never illustrated or described in print, and presumably it is lost. Meek stated that White's specimen was "much larger" than his, but gave no further information in regard to it. The collections of the State University of Iowa contain a large only moderately well preserved nautiloid that appears to resemble superficially the one illustrated by Meek, and it may well be White's specimen. However, it bears no label, and therefore a great deal of uncertainty will always exist in regard

to it. Accordingly, this unlabelled individual should most probably be ignored, and the one studied by Meek should be regarded as the type of the species and therefore of Hyatt's genus *Titanoceras*—see Pl. 23, figs. 1, 2; and Fig. 6J, in the text).

If Meek's drawings are accurate, this genus should include forms in which the conch is thickly subdiscoidal and is coiled but not deeply involute. The whorls are subquadrate in cross section, being distinctly wider than high, slightly impressed dorsally, rounded dorsolaterally, flattened but nevertheless convex laterally, subangular ventrolaterally, and concave ventrally. The umbilicus is large, open, and perforate. At full maturity each of the ventrolateral shoulders of the conch bears a row of relatively small longitudinally elongate nodes. The mature sutures form broad rounded ventral, lateral, and almost certainly dorsal lobes. No information is available in regard to the siphuncle.

Specimens from the Lower Carboniferous of England, the Upper Carboniferous of European Russia, and the Pennsylvanian and Permian of North America have been referred to this genus. However, none of them bear small ventrolateral nodes, and only one (*Nautilus tuberosus* McCoy) is prominently concave ventrally. Most of them should probably be referred to *Domatoceras* and *Stearoceras*, but we are very uncertain in regard to the generic affinities of *N. tuberosus* of the Lower Carboniferous of Derbyshire—it is not very well known and its similarity to the genotype of *Titanoceras* is almost certainly more apparent than real. Anyhow, we are not referring any of the numerous Late Paleozoic nautiloids in the collections under consideration to this genus.

Genus ***Stenopoceras*** Hyatt, 1893

GENOTYPE: *Phacoceras dumbli* Hyatt

In 1893 Hyatt (p. 446–447) recognized that the forms he had previously referred to *Phacoceras* are not all congeneric, and he established the genus *Stenopoceras* for one group of them. *Phacoceras dumbli* Hyatt of the Late Paleozoic of Texas and Kansas was designated as the genotype (see Fig. 20, in the text); and one other species was referred to the genus, *Nautilus rouillieri* de Koninck of the early Upper Carboniferous of central European Soviet Russia. At that time, Hyatt also discussed this genus briefly, contrasted it with *Phacoceras*, and placed it in the Koninckioceratidae where he associated it with *Domatoceras*. In 1900 he (p. 525) reaffirmed his opinion in regard to the taxonomic position of *Stenopoceras* but gave no additional information in regard to it. This genus is also listed in the Zittel-Broili and the Zittel-Rjabinin Grundzüge der Paläontologie.

During the last 25 years or so, the senior author of the present report and certain of his associates have added to the knowledge of *Stenopoceras*, and it can now be diagnosed as follows: Form subdiscoidal, as conch is rapidly expanded orad, strongly compressed, flattened laterally, and deeply involute. Ventral zone is very narrow—in immature individuals it is flattened and is approximately normal to the lateral zones of the conch; but in at least one species (not the genotype) the venter of mature specimens is angular, and in others it is slightly concave. Whorls of immature representatives are therefore subrectangular in cross section (impressed zone disregarded), whereas those of mature specimens are either subrectangular or subtriangular. Umbilicus small and, though perforate during early growth stages, closed or nearly so at maturity. Umbilical shoulders low and broadly rounded. Surface of internal mold smooth, and there are no longitudinal ridges on the lateral zones of the conch as there are in *Phacoceras*. However, sinuous growth lines are rather prominent, and these curve strongly apicad as they approach the ventral zone, indicating the presence of a deep hyponomic sinus. Each suture forms a deep ventral saddle (which may be slightly divided medianly) and on either side of it a broad rounded lateral lobe, a smaller rounded dorsolateral saddle in the region of the umbilical shoulder, a similar lobe that centers near the umbilical seam, and a similar internal lateral saddle which extends to a moderately deep depressed-V-shaped truncated dorsal lobe. Siphuncle small, orthochoanitic, and located ventrad of the center of the conch.

Clearly this genus is related to *Domatoceras*, from which it almost certainly arose. It differs from *Domatoceras* particularly in that its umbilicus is much smaller and its sutures form dorsolateral saddles that center outside the umbilical shoulders.

S. rouillieri (de Koninck) differs considerably from the other known representatives of the genus and may be generically distinct from them. That is, its ventral zone is very narrow during adoles-

cence and becomes angular at maturity. The holotype of this species was originally described by Trautschold (1874, p. 304–305, pl. 30, figs. 7a, 7b) and incorrectly referred to *Nautilus oxystomus* Phillips. De Koninck (1878, p. 124) recognized this fact and proposed the name "*N. Rouillieri*" (not "*N. Rouilleri*" as stated by Tzwetaev and Hyatt) for the Russian form. The specimen described by Trautschold appears to be a mature individual; a small, immature representative showing the earlier stages of growth has since been described by Tzwetaev (1888, p. 21, 53, pl. 6, figs. 33, 34). The holotype came from the Fusulina limestone at Mjatschkowo (which is equivalent to part of our Lower Pennsylvanian). Specimens that are stated to be conspecific have been found elsewhere in the same general area, that is, in the Carboniferous limestone of the Matkosersky Canal and the oolite of the village of Dewiatowo on the Desna River, where their age is presumably about the same as at Mjatschkowo.

Altogether, this genus is now known to be represented in Nebraska, Kansas, Texas, New Mexico, Wyoming, and central European Soviet Russia. Stratigraphically, it has been found to range from the lower part of the Upper Carboniferous up into the Middle Permian (Leonard). It should also be mentioned in this connection that possibly the form from the Middle Permian Wandagee series of Western Australia which Teichert (1941, p. 383) placed in *Phacoceras* may also be referable to this genus as we interpret it.

Stenopoceras dumbli (Hyatt)

1891. *Phacoceras Dumbli* HYATT, Texas Geol. Surv., Ann. Rept. 2, p. 347–349, text figs. 50, 51.
1893. *Phacoceras Dumbli* HAY, Kansas Acad. Sci., Trans., vol. 13, p. 38, 45–47.
1893. *Stenopoceras dumbli* HYATT, Texas Geol. Surv., Ann. Rept. 4, p. 446, 447.
1924. *Stenopoceras dumbi* KRUGLOV, Zittel-Rjabinin Grundzüge der Paläontologie (Paläozoologie), I. Abt., Invertebrata, p. 741.
1932. *Stenopoceras dumbli* MILLER, Jour. Paleont., vol. 6, p. 66, 68, 69.
1933. *Stenopoceras dumbli* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 218, 223.
1936. *Stenopoceras dumbli* MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 736.
1942. *Stenopoceras* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 736, 737.
1944. *Stenopoceras dumbli* SHIMER AND SHROCK, Index fossils of North America, p. 549.
1948. *Stenopoceras dumblei* BRANSON, Geol. Soc. Am., Mem. 26, p. 832.

When Hyatt established this species, he referred it to *Phacoceras* and described it as follows:

"The extraordinarily large size of this shell, its involute form, its compressed whorls, and the attenuated character of the outer part of the whorls in proportion to their transverse diameters, combined with the comparatively smooth and ribless shell, makes this species interesting.

"The umbilici are very narrow and small, the involution being almost complete. The increase of the vertical diameters by growth is extremely rapid, whereas the transverse diameters have increased very slowly, leaving whorls very much compressed or axe-shaped. The broadest transverse diameters are near the umbilici, and from this part the whorl is slightly concave on both sides towards the periphery or abdomen. This although very narrow is flattened or slightly convex, even in the largest specimens.

"The living chamber in one specimen was about one-half of a volution in length. The lines of growth[1] indicate that the aperture probably had very broad lateral saddles and a single deep, narrow median abdominal lobe.

"The sutures are near each other or slightly crowded in aspect. They have a narrow abdominal saddle, deep, broad lateral lobes, comparatively narrow lateral saddles near the umbilici, and a pair of shallow lateral lobes internally on the shoulders of the whorls.

"The shell is thin and is marked by fine lines of growth. The siphuncle is probably situated near the abdomen, but was not clearly seen.

"A specimen sent me [Hyatt] by Mr. Hay from Fort Riley is the most perfect specimen of this remarkable species that I have yet seen. It has an almost entire living chamber about one-half of a volution in length, the sutures show well, and it is not as much compressed as specimens from Texas. All the specimens are reported as coming from Carboniferous, as do all species of the genus so far found.

"The sutures may have a slight lobe on the hollow of the narrow abdomen, where compression has affected them; where they are unaffected by compression they are absolutely straight or very faintly

[1] "The lines of growth in the drawing [Fig. 20A] have the first lateral saddles or inflections too prominent and the second pair not prominent enough, the lobe between being too deep."

concave. In Mr. Hay's cast, the outer part of the living chamber presents the abdomen as slightly convex, and leads one to think that the slight hollowness of the abdomen often present in younger whorls is due to compression. In fact the whorl is broken along a line parallel with and near to the edge of the abdomen and is concave from compression on the right hand (morphologically left) side until near the end of the living chamber. Here, where the abdomen presents a very flat convex surface, both sides of the whorl are unbroken and have the normal proportions. Figure 28 [misprint for 50 = Fig. 20B of the present publication] is therefore in part a restoration.

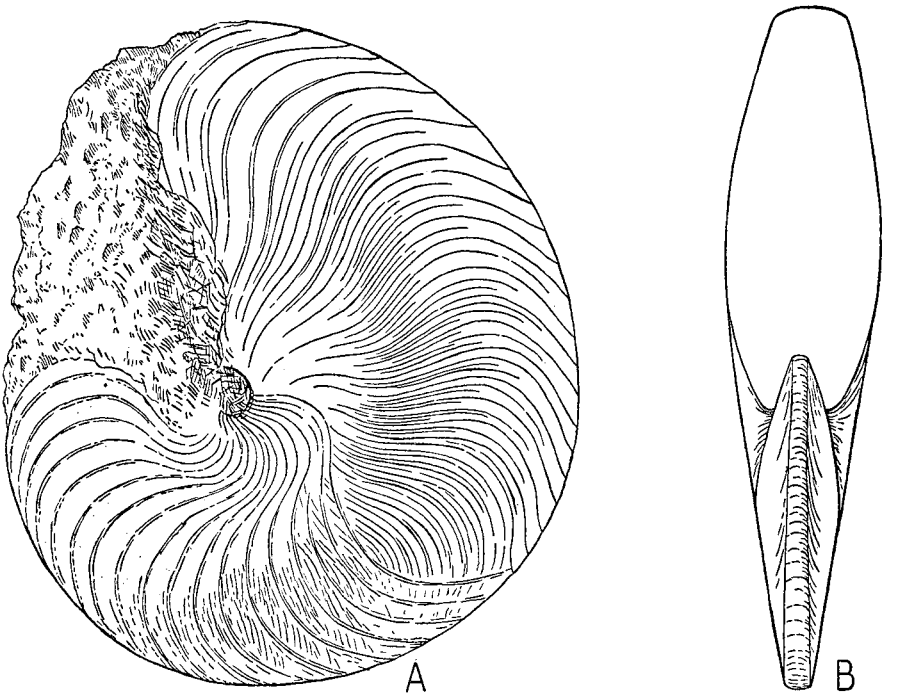

FIGURE 20.—*Stenopoceras dumbli* (Hyatt)

The holotype, from the Fort Riley limestone? near Junction City, Kansas, × ⅔. The apertural view is "in part a restoration." After Hyatt.

"This is the largest and finest species of the involute shells of this group yet found in the Carboniferous. The principal difference between it and *Nautilus Rouilleri*, the adult of which was described and figured by Trautschold [1874, p. 28, pl. 3, fig. 7] under the name of Oxystomus and the young by Marie Tzwetaev [1888, p. 53, pl. 6, figs. 33, 34], consist in its size. The principal difference between the European and American is, that the former retains throughout life—that is to say, on all parts of its largest whorl, which is much larger than that of the European species—the peculiar but flattened abdomen which is found only in the young of *Phacoceras Rouilleri*. This character is of genetic importance, and, together with the longitudinal ridges and form of the young in this species, and in *P. oxystomum*, shows that these acute involute shells were derived by descent from more discoidal shells like those of the genus Discitoceras. This also serves the purpose of explaining the occurrence in the Carboniferous of their apparently anachronic forms and structural characteristics. The aspect of the adults and the sutures in this genus are like Triassic species such as *Grypoceras* (*Nautilus*) *galeatus*, Mojsisovics, and at first they appear to have occurred before their proper geologic period. When, however, their young are studied, it is plain that their shells at early stages have the ordinary characteristics of normal members of the Carboniferous faunas, and that the peculiarities of later stages were evolved from purely Carboniferous forms. Their mimicry of Triassic shells in later stages must therefore be regarded simply as good examples of parallel progressive complications arising independently in different genetic series during different periods of time. In *Rouilleri* the flattened aspect of the crest of the abdomen is retained much longer in the course of the growth than in *Phacoceras oxystomum*. The American species, with its truncated abdomen existing in the adult, is therefore the most immature form of the group yet discovered, and although it is as yet impossible to come to any conclusion, this fact at present points to the fauna of this country as the place of origin or aldainic

fauna of this series. *Rouilleri* is probably genetically connected with *P. Dumbli*, or some equivalent species, and *P. oxystomum* is similarly connected with *P. Rouilleri*. In both of these, however, it is superseded in its subsequent stages of shell growth by an acute abdomen."

REMARKS.—We have not seen the type specimens of this species and therefore are reproducing the only illustrations and detailed description of them that are available. In view of the fact that neither the horizon nor the locality of the syntypes from Texas is known, we are designating the syntype from Kansas as the holotype. It is the only one of the original type specimens that has ever been illustrated. Hyatt gives its locality as Fort Riley, whereas Hay states that it came from Junction City, which is nearby. Presumably it is from the Fort Riley limestone.

According to Hyatt, Figure 20B is "in part a restoration." This drawing indicates that the ventral zone of the conch increases in width very rapidly for this genus, and therefore we are inclined to doubt that it is accurate in detail. Nevertheless, this species may be rather close to *Stenopoceras inexpectans* Miller, in which the ventral zone is rather narrow during early maturity.

OCCURRENCE.—The holotype came from near Fort Riley or Junction City, both in Geary County, Kansas, presumably from the Fort Riley limestone. The paratypes are from some unrecorded horizon and locality in Texas.

TYPES.—Presumably at least some of the original type specimens are at The University of Texas, but the holotype is stated to be in the Robert Hay Collection, the whereabouts of which is not known to us.

Stenopoceras abundum Miller and Thomas

(Plates 24, figures 1, 2; Plate 25, figures 7–10)

1908. Ammonoid indet. GIRTY, Geol. Soc. Am., Bull., vol. 19, p. 429.
1936. *Stenopoceras abundum* MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 722, 723, 734–736, pl. 98, figs. 7–10; pl. 99, figs. 1, 2.
1944. *Stenopoceras abundum* SHIMER AND SHROCK, Index fossils of North America, p. 549, pl. 224, figs. 16, 17.

This species was based on about 45 specimens. Most of them are rather incomplete and fragmentary, but they supplement one another very well and a great deal of detailed information can be gleaned from them.

Conch, which forms at least three volutions, at maturity is sublenticular in shape, nautiliconic in its mode of growth, and large, attaining a maximum diameter (measured across the umbilicus) of more than 125 mm., and a maximum height and width of conch of at least 70 mm. and 35 mm., respectively. Extreme adapical portion of conch is circular (or essentially so) in cross section, but dorsoventral diameter of conch is increased much more rapidly than lateral diameter, and very early in its ontogenetic development conch becomes oval in cross section being much more narrowly rounded ventrally than dorsally. Following this state of development, dorsal side of conch becomes flat, and before conch has completed the first half-volution its dorsal side is distinctly concave (see Fig. 21A, in the text). At first the dorsal concave zone is broad, shallow, and broadly rounded, but it becomes progressively deeper and relatively narrower, and by the time the conch has completed one and a half volutions it is impressed dorsally to almost two-fifths its height (Pl. 25, fig. 8). It should be stated unambiguously that a dorsal concave zone is developed long before the conch completes one volution and becomes involute; that is, it almost seems as though an impressed zone is developed before it is needed. After the conch has completed about one volution, its broad lateral walls become noticeably more and more flattened; and its ventral side, which has become very narrow, is also gradually flattened and ultimately (after the conch has reached a height of about 35 mm.) it becomes concave. The lateral walls of the conch converge ventrally and the cross section of the whorls is cordate during adolescence but subsagittate (though slightly concave ventrally) at maturity. Apertural margins are not preserved on any of the type specimens, but living chamber is at least a fourth of a volution in length.

At maturity umbilicus is small and closed, and umbilical shoulders are broadly rounded and very indistinct. During early growth stages the umbilicus is small but perforate, the umbilical perforation being oval in shape and, after the conch has completed one volution, about 4 mm. long and 3 mm. wide. During the next half-volution the umbilicus appears to become smaller; then it seems to

become larger, only to be closed rather abruptly after the conch has completed a little more than two volutions (Pl. 25, fig. 7).

Test thin, and even on large mature specimens it does not seem to have been more than 1 mm. thick. Surface of test smooth and marked only by growth-lines, which are fine and though very distinct are not particularly prominent. At full maturity each growth-line forms a deep rounded

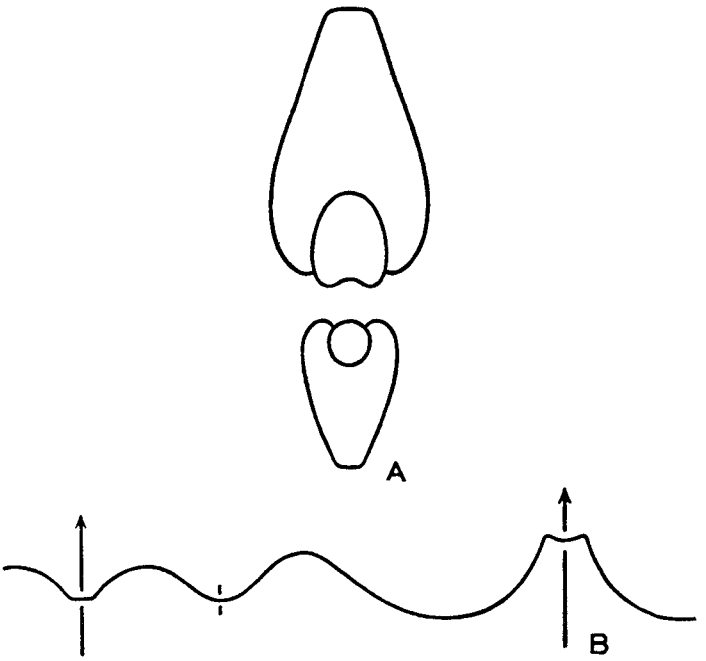

FIGURE 21.—*Stenopoceras abundum* Miller and Thomas

Diagrammatic cross section of early volutions of conch, × 1½, and diagrammatic representation of a mature suture, × 1, both based on syntypes from the Casper formation in Gilmore Canyon about 8 miles southeast of Laramie, Wyoming

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ventral sinus, and on either side of it a shallow rounded ventrolateral salient (which centers on thl ventral portion of the flattened lateral zone of the conch), a broad shallow broadly rounded lateral sinus, and a similar but smaller dorsolateral salient which centers slightly dorsad of the umbilical shoulder (Pl. 24, figs. 1, 2). On the penultimate volution of the conch the growth-lines are in genera_ similar to those on the ultimate volution but the lateral sinus is relatively narrow and the ventro lateral salient is relatively broad.

Septa rather close together and camerae therefore numerous and rather short (Pl. 24, fig. 2). At maturity each suture forms a high rather narrow ventral saddle in the center of which there is a shallow broadly rounded lobe which results from the concavity of the ventral side of the conch, and on each side of it there is a wide deep broadly rounded lateral lobe, a much smaller rounded dorsolateral saddle which centers on the umbilical wall, a similar but slightly smaller lobe which centers on the umbilical seam, and a similar internal lateral saddle which extends to the dorsal lobe. The dorsal lobe is moderate in size and it is depressed-V-shaped but truncated.

Siphuncle small, circular in cross section, and intermediate in position. Where the conch is about 35 mm. high the siphuncle is about 1 mm. in diameter and is located about 1 mm. from the venter. Unfortunately, its structure could not be determined, but it is almost certainly orthochoanitic.

REMARKS.—The specimen which in 1908 Girty identified as "Ammonoid indet." was kindly loaned for study. It is a small fragment of a *Stenopoceras*, apparently conspecific with the specimens

just described, though preserved in a different type of matrix. Traces of its sutures are discernible and the shape of the ventral and ventrolateral portions of its conch can be determined quite accurately. The block of limestone in which it is imbedded contains small fragmentary specimens which appear to represent the genera *Pseudorthoceras* and *Metacoceras*.

S. abundum seems to be rather close to *S. dumbli* (Hyatt) and *S. tularosense* Miller, and it may be closer to the latter than the former. The nature of the umbilicus of *S. tularosense* at full maturity is not known; however, inasmuch as the umbilicus of the holotype of that species, a moderate-sized specimen "becomes relatively smaller in the later stages of growth," it may be closed during late maturity as is that of the species under consideration.

OCCURRENCE.—Abundant in *Stenopoceras* beds of Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Albany County, Wyoming; and occurs at the same locality in the *Meekella* beds of the same formation, about 20 feet above the horizon in the *Stenopoceras* beds at which cephalopods are so abundant. Girty's specimen also came from "Gilmore canyon, 8 miles southeast of Laramie . . . [in an] 8-foot bed of limestone."

SYNTYPES.—State University of Iowa, 1164–1170.

Stenopoceras cooperi Miller and Unklesbay

(Plate 17, figures 1, 2)

1942. *Stenopoceras cooperi* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 719, 736–737, pl. 113, figs. 2, 3.

The holotype of this species is a well preserved internal mold which is septate throughout. Its maximum diameter measures about 98 mm. At least the outer whorl is flattened (but nevertheless is distinctly convex) laterally and ventrally, subangular ventrolaterally, and impressed dorsally (Fig. 6E, in the text). The maximum width of the conch is attained somewhat dorsad of the mid-height of the whorl. At the adoral end of the holotype, the conch attains a maximum width of about 28 mm., the whorl is about 57 mm. high, and the impressed zone is about 20 mm. deep. The umbilicus is inconspicuous, and the umbilical shoulders are broadly rounded and indefinite. On the internal mold the umbilicus is not closed, and the umbilical perforation in the outer volution of the holotype is about 7 mm. in diameter. At maturity the test may, of course, have been thick enough in the umbilical region to close this perforation.

The sutures form a high blunt ventral saddle, broad deep rounded lateral lobes, high rather narrowly rounded saddles centering just inside the umbilical shoulders, and apparently lobes centering on the umbilical seams. The siphuncle is small, is elliptical in cross section (as compressed laterally), and is subventral in position. At the adoral end of the holotype, the siphuncle is about 1.5 mm. wide and about 2 mm. high, and it is located about 6 mm. from the venter.

REMARKS.—Of the various species of *Stenopoceras* that have been described, the one under consideration seems to resemble closely only *S. tularosense* Miller of the Upper Pennsylvanian of New Mexico. Unfortunately the mature portions of the phragmacone of that species are very poorly known.

OCCURRENCE.—Upper shaly beds of the Neva limestone (upper Grenola limestone) near the Cowley-Elk county-line along U. S. Highway 160 close to Grand Summit, Kansas.

HOLOTYPE.—State University of Iowa, 2120.

Stenopoceras inexpectans Miller

(Plate 6, figures 5, 6; Plate 26, figures 1–10; Plate 40, figure 5)

1945. *Stenopoceras inexpectans* MILLER, Jour. Paleont., vol. 19, p. 283, 292–293, pl. 44, figs. 5, 6.

Five representatives of this species are now known. The largest of them, which retains part of the apertural margins, is illustrated by Figures 1–3 on Plate 26 and Figure 5 on Plate 40.

The small specimen represented by Figures 9 and 10 on Plate 26 shows that the extreme adapical part of the conch is circular or nearly so in cross section and is very rapidly expanded orad. However, during early ontogenetic development the conch becomes relatively higher and narrower, the ventral portion of it becomes somewhat acuminate, and along the venter there is developed a flattened

zone. At first the umbilicus is perforate, but it soon becomes closed. However, it is rather small and inconspicuous throughout ontogenetic development, and the umbilical shoulders are rounded and more or less indefinite.

All but the extreme adoral portion of the largest specimen known (Pl. 26, figs. 1–3; Pl. 40, fig. 5) is septate and therefore represents phragmacone. Slightly apicad of the junction of the phragmacone and the living chamber, the diameter of this specimen measures about 61 mm., and the corresponding width and height of conch are about 24 mm. and 41 mm., respectively. At this place the flattened ventral zone of the conch is only about 2 mm. wide, whereas that of the smaller specimen represented by Figures 5–8 on Plate 26 is about 3 mm. wide at a diameter of some 35 mm.

The apertural margins form lateral crests, but the nature of their ventral portions is not known. The test is essentially smooth and devoid of ornamentation.

At maturity, each suture forms a high more or less truncated V-shaped ventral saddle and on either side of it a broad rounded lateral lobe, a small rounded saddle centering just outside the umbilical shoulder, a low umbilical lobe, and a rounded internal lateral saddle that extends to a rather narrow blunt dorsal lobe. The siphuncle is small. During adolescence it is located fairly close to the venter (Pl. 26, fig. 9), but at maturity it is considerably removed from the ventral side of the conch (Pl. 26, fig. 2).

REMARKS.—In general, the early stages of this form resemble those of *Stenopoceras abundum* Miller and Thomas of the Casper sandstone of Wyoming, described elsewhere in this report. The apparent migration of the siphuncle to a somewhat more nearly central position during maturity and the variation in the width of the flattened ventral zone of two of the specimens illustrated on Plate 26, might be taken to suggest that all of the specimens we are referring to this species are not conspecific.

OCCURRENCE.—Middle portion of upper Leonard formation at two localities in the vicinity of Split Tank near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas. The holotype came from 0.2–0.5 mile east of Split Tank, whereas all of the hypotypes are from about half a mile west of Split Tank.

TYPES.—U. S. National Museum, where the holotype is numbered 111622.

Stenopoceras whitei, n. sp.

(Plate 5, figure 2; Plate 27, figures 1–7; Plate 28, figures 1, 2)

1891. *Nautilus* ——? WHITE, U. S. Geol. Surv., Bull. 77, p. 24, pl. 2, figs. 4–6.
1945. *Stenopoceras* sp. MILLER, Jour. Paleont., vol. 19, p. 293.
1947. *Stenopoceras* sp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.

Long ago, White (1891, pl. 2, figs. 4–6) illustrated some "fragments" from the Lower Permian Grape Creek limestone of north-central Texas which belong in *Stenopoceras* (Fig. 22, in the text). Recently Mrs. Augusta Hasslock Kemp loaned us for study about a dozen similar specimens from the same horizon at a nearby locality and two apparently conspecific individuals from the Lueders formation, a little higher in the section in the same area. We are proposing the name *S. whitei* for all of these specimens.

The individual represented by Figures 1, 2 on Plate 27 is designated the holotype. It is an internal mold of a few chambers of a phragmacone. Nevertheless, it is quite a satisfactory "study specimen" for it is essentially free from distortion and it elucidates the shape of the cross section of the conch during early and full maturity, the nature of the sutures, and the size and position of the siphuncle. The maximum height and width of conch attained by the preserved part of this specimen measure about 75 mm. and 40 mm., respectively. The large specimen illustrated on Plate 5 shows that in this species the conch attains a maximum diameter of at least 200 mm., that the living chamber is more than half a volution in length, and that the umbilicus is small, inconspicuous, and closed at maturity.

Figures 3 and 4 on Plate 27 represent a small specimen which shows that during early ontogenetic development the conch is about as wide as high and is rounded ventrally. However, it increases in height much more rapidly than in width and soon becomes very narrowly rounded (Pl. 27, fig. 7) and then subangular ventrally. Figure 2 on Plate 27 makes it clear that in the holotype the conch remains subangular ventrally until it attains a height of more than 75 mm. After that it becomes

narrowly rounded ventrally and then rapidly develops a flattened ventral zone (Pl. 28, fig. 2). Near the junction of the phragmacone and the living chamber of the large specimen figured on Plate 5, the flat ventral zone is some 12 mm. wide. Although the ventral surface of the test may be slightly concave at full maturity, that of the internal mold apparently is not.

With the possible exception of the smallest of the figured specimens, none of the material we are studying retains any of the surface markings of the test. The shape of the sutures and the size and position of the siphuncle are elucidated by the accompanying illustrations, and little would be gained by describing them in detail. It should, however, be stated that the siphuncle is composed of segments that are almost cylindrical in shape.

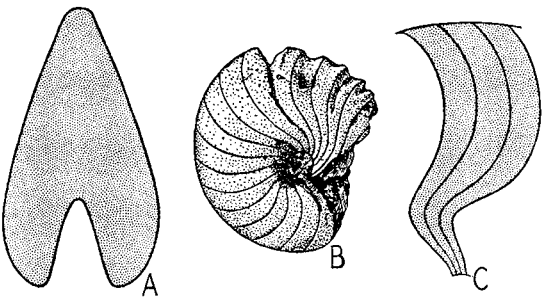

FIGURE 22.—*Stenopoceras whitei*, n. sp.

Three drawings based on specimens from the Grape Creek limestone at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas, presumably × 1. **A**, Diagrammatic cross section "restored from imperfect examples;" **B**, lateral view of a small incomplete specimen; and **C**, diagrammatic representation of the lateral portions of the sutures of a fragment. All after White.

REMARKS.—The early development of this form appears to be quite comparable to that of *S. abundum* Miller and Thomas, which is described in detail elsewhere in this report. However, at no stage does the ventral zone of that form become subangular, and one of the most distinctive features of this species is the fact that typically the subangularity of the ventral zone is continued to a rather late stage of ontogenetic development. In this respect *S. whitei* resembles *S. rouillieri* (de Koninck) of the early Upper Carboniferous of central European Soviet Russia, in which however the ventral zone first becomes flat and then angular. It should be mentioned that on one of the fragmentary specimens which we are referring to this species, there is a well developed flat ventral zone where the conch is only some 55 mm. high.

OCCURRENCE.—The holotype and 10 of the paratypes (including both of those figured on Plate 27) came from the Grape Creek limestone of the Clyde formation about 1½ miles north of the England schoolhouse and about 10 miles east of Seymour, Baylor County, Texas. White's specimens came from the same horizon at the "Old Military Crossing" of the Big Wichita River, also in Baylor County. The large specimen figured on Plate 5 is from near the base of the Lueders formation in Rock Creek about 1 mile southeast of Seymour. The individual illustrated on Plate 28 was found in a boulder probably from the upper part of the Lueders formation at the Lake Kemp dam in Baylor County. The form that Miller and Kemp (1947, p. 352) list from the Elm Creek limestone of the Admiral formation (some 500 feet stratigraphically below the Grape Creek limestone) of Baylor County may well belong in this species.

TYPES.—Private collection of Augusta Hasslock Kemp of Seymour, Texas. White's specimens, which we have not seen, are presumably at the U. S. National Museum.

Stenopoceras sp. [of Kansas]

1936. *Stenopoceras* sp. MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 736.

In 1936 Miller and Thomas mentioned that N. D. Newell had sent them for comparison an undescribed representative of *Stenopoceras* from the Lower Permian Florena shale of Cowley County, Kansas. They add that in general physiognomy this specimen is closely similar to *S. abundum*

Miller and Thomas, "but apparently it is not conspecific with it. The umbilicus of the Florena specimen is quite small, but although the part of the conch (phragmacone) represented apparently attained a diameter of at least 45 mm., the umbilicus is not closed, and there is no good reason to assume that it was ever closed during ontogenetic development."

REMARKS.—Unfortunately, this specimen seems to have been mislaid. The above paragraph contains all of the information that is available in regard to it. It may, of course, be referable to *S. cooperi* Miller and Unklesbay, the holotype of which came from the same general area but from slightly lower in the section, that is, from the Neva limestone.

OCCURRENCE.—Florena shale of Cowley County, Kansas.

REPOSITORY.—University of Kansas.

Stenopoceras spp. [of north-central Texas]

(Plate 45, figures 5, 6)

1942. *Stenopoceras* sp. CLIFTON, Jour. Paleont., vol. 16, p. 688, 696.
1944. *Stenopoceras* sp. CLIFTON, Am. Assoc. Petrol. Geol. Bull., vol. 28, p. 1026.
1947. *Stenopoceras* sp. MILLER AND YOUNGQUIST, Kansas Univ. Paleont. Contr., Mollusca, art. 1, p. 1, 2, 3, 6–7, pl. 1, figs. 13, 14.

Clifton has stated that the genus *Stenopoceras* is represented in both the Blaine and the Dog Creek formations of north-central Texas. However, he gives no morphological data in regard to the specimens, and we have not seen them. The horizons and localities from which they came are given in our paragraph, headed "Occurrence."

The collections from the Admiral formation that we are studying contain two fragments that belong in *Stenopoceras*. One of them is being illustrated. Near the mid-length of this specimen the conch is about 18 mm. high and 11 mm. wide, and the flat ventral zone is about 3 mm. wide and the dorsal impressed zone about 5 mm. deep. The growth-lines form deep rounded ventral sinuses, broad rounded lateral salients, small shallow sinuses on or near the umbilical shoulders, and similar salients on the umbilical walls. The siphuncle is small and is subcentral in position but is distinctly closer to the venter than the dorsum—at the adapical end of the specimen the siphuncle is of the order 1 mm. in diameter, and it is about 4½ mm. from the venter and 7 mm. from the dorsum.

The preserved part of the other specimen, which is not being illustrated, attains a maximum height and width of conch of some 23 mm. and 13 mm., respectively. In so far as general form of conch, depth of impressed zone, shape of growth-lines, and size and position of siphuncle are concerned, this specimen resembles the figured one very closely. Its umbilicus is small and inconspicuous, and the umbilical shoulders are low and rounded. The sutures form a ventral saddle, and on either side of it a broad rounded lateral lobe, and a small saddle in the vicinity of the umbilical shoulder.

REMARKS.—Both of the specimens just described represent such small portions of the conch that satisfactory comparisons can not be made. Their whorls seem to be rather low and broad for *Stenopoceras*, but this feature may be due in part at least to the fact that they represent only small volutions of the conch.

OCCURRENCE.—Clifton states that the specimens to which he referred came from the Acme member of the Blaine formation and the Guthrie member of the Dog Creek formation. Furthermore, he indicates that the Acme individuals are from the following two localities: (1) "an extensive area, including sections 148, 168, 169, 173, 198 and adjacent sections, north and northwest of Quanah, in Block H, of the Waco and NW. R. R. Company Survey, Hardeman County, Texas"; and (2) "northeast Nolan County and Southeast Fisher County in Texas. Chiefly, Sec. 289, B. H. Stribling Survey, and Sec. 290, R. Cochran Survey." Also Clifton indicates that his Guthrie specimens came from the following locality: "section 139 and areas northeast, in Block F, of the H. & T. C. R. R. Co. Survey, Stonewall County, Texas." The ammonoid genus *Perrinites* (as well as the nautiloid genus *Domatoceras*) occurs at all three of Clifton's localities.

The two specimens which we are studying came from the Wildcat Creek shale member of the Admiral formation about 4½ miles south-southwest of Coleman, Coleman County, Texas.

FIGURED SPECIMEN.—U. S. National Museum. The specimen which we are studying but not illustrating is in the Renfro Collection at Fort Worth, Texas.

Stenopoceras sp. [of west Texas]

(Plate 44, figure 2)

1945. *Stenopoceras* sp. MILLER, Jour. Paleont., vol. 19, p. 283, 293–294, text figs. 2A, 2B.

The Lower Permian Hueco formation of west Texas has yielded two large fragments that are clearly referable to *Stenopoceras*. However, both of them are so incomplete that we can not determine their specific affinities satisfactorily.

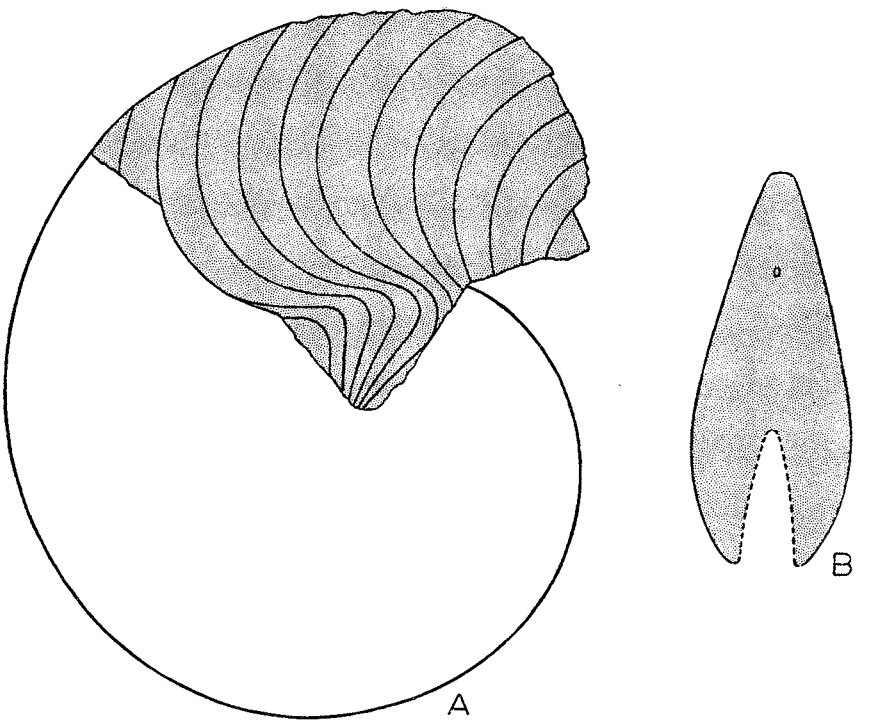

FIGURE 23.—*Stenopoceras* sp.

Lateral view and cross section of a specimen from the Hueco formation in Apache Springs Canyon of the Sierra Diablo, west Texas, × 1.

One of these, which is somewhat distorted, was secured by Stanislaus Kříž. It represents about a fourth of a volution of a phragmacone. Near its adapical end its conch is about 53 mm. high and about 21 mm. wide, and the flattened ventral zone is about 5 mm. wide. The maximum width of conch is attained in the vicinity of the umbilical shoulders, which are indefinite. The shape of the sutures, the cross section of the conch, and the size and position of the siphuncle are shown by the accompanying illustrations (Fig. 23, in the text).

The second Hueco specimen was found by C. C. Branson. It represents much of a living chamber and the adjacent portion of the phragmacone. Unfortunately it is broken in such a way that the width of its ventral zone can not be determined. The cross section exposed at the adapical end of this individual suggests that it was somewhat crushed laterally during preservation, but where its conch was about 70 mm. high, it was at least 25 mm. wide. The nature of the umbilicus and the shape of the sutures are elucidated by Figure 2 on Plate 44. In so far as we are able to ascertain, this specimen does not differ materially from the one obtained by Kříž, but satisfactory comparisons are not possible

REMARKS.—Both of the specimens under consideration are preserved in fine-grained light-gray limestone. They seem to resemble *Stenopoceras cooperi* Miller and Unklesbay but to have a narrower ventral zone, and perhaps are closer to *S. inexpectans* Miller.

OCCURRENCE.—Kříž's specimens came from the basal limestones and shales of the lower part of a down-faulted block of the Hueco formation on the south branch of Apache Springs Canyon in the Sierra Diablo of Hudspeth County, Texas. Branson's specimen is from the same formation (gray limestone about 20 feet below the Deer Mountain shale) in the saddle at the north end of Alecran Mountain of the Hueco Mountains, also in Hudspeth County, Texas.

REPOSITORY.—Princeton University (Kříž's specimen) and U. S. National Museum (Branson's specimen).

Family TAINOCERATIDAE Hyatt, 1883

Perhaps the most conspicuous nautiloids in the Late Paleozoic sediments are those which bear prominent ribs, nodes, and spines. Most of these have thickly subdiscoidal conchs in which the volutions are somewhat wider than high and are only slightly impressed dorsally, the umbilici are wide and open, the sutures are sinuous, and the siphuncles are subcentral and are orthochoanitic. The "ornamentation" is developed during early adolescence and typically persists throughout ontogenetic development.

These forms, which we are placing in Hyatt's family Tainoceratidae, are divisible into six genera: *Tainoceras* Hyatt, *Aulametacoceras* Miller and Unklesbay, *Temnocheilus* M'Coy, *Foordiceras* Hyatt, *Metacoceras* Hyatt, and *Cooperoceras* Miller. *Tainoceras* is the only one of the group that possesses ventral as well as ventrolateral nodes. In *Aulametacoceras* the ventral zone of the conch bears several longitudinal grooves and ridges. *Temnocheilus* has strongly depressed whorls which are somewhat triangular in shape as they have a broad flattened ventral zone and similar lateral zones that are strongly converged dorsally. *Foordiceras* is characterized by lateral ribs, *Metacoceras* by ventrolateral (and in some cases dorsolateral) nodes, and *Cooperoceras* by ventrolateral spines—the first two of these are somewhat gradational.

In his final work on the classification of the nautiloids, Hyatt (1900, p. 524) placed in this family the four of these genera known at that time: *Tainoceras*, *Temnocheilus*, *Foordiceras*, and *Metacoceras*. He also included *Endolobus* Meek and Worthen and *Cryptoceras* d'Orbigny, both of which he regarded as synonyms of *Temnocheilus*. In our opinion *Endolobus* is a valid independent genus which should be associated with *Koninckioceras* in the Koninckioceratidae; and *Cryptoceras* d'Orbigny (not Barrande, which has priority) is a synonym of *Solenochilus* Meek and Worthen of the Solenochilidae (see Miller, Dunbar, and Condra, 1933, p. 44–45). Hyatt also referred to the Tainoceratidae his Late Paleozoic genus *Coelogasteroceras* (which we are placing in the Liroceratidae) and his Devonian genus *Diadiploceras*, the status of which is uncertain (see Flower, 1936, p. 54 [324]).

All of the forms that have been referred to *Tirolonautilus* Mojsisovics came from the Upper Permian Bellerophon limestone of the southern part of the eastern Alps. We have not had an opportunity to examine any of these specimens, but in so far as we can tell from the published illustrations and descriptions of them, it seems rather doubtful if they differ sufficiently from typical *Tainoceras* *Foordiceras*, and *Metacoceras* to be regarded as generically distinct.

Geographically the Tainoceratidae are world-wide in their occurrence. Stratigraphically they range at least from the Mississippian (or Lower Carboniferous) to the Permian, inclusive.

Genus ***Tainoceras*** Hyatt, 1883

GENOTYPE: *Nautilus quadrangulus* McChesney

In 1933 Miller, Dunbar, and Condra showed that the type specimen of the type species of this genus is the individual from the Pennsylvanian of Illinois that is represented by Figure 5 on McChesney's Plate 3 of 1868, which is reproduced as Figure 11 on our Plate 11. From the published data in regard to this specimen and from a study of numerous very similar ones in the collections available to us, we believe the genus should be diagnosed as follows:

Conch nautiliconic but not deeply involute, and typically whorls are subrectangular in cross section as they are depressed dorsoventrally, flattened laterally and ventrally, and only slightly impressed

dorsally. The volutions are few in number. The umbilicus is large and open, the umbilical shoulders are abrupt, and the umbilical walls are steep. On each of the ventrolateral zones of the conch there is a single row of nodes, and the flattened ventral zone bears an additional pair of rows of nodes that border a median sulcus or flattened zone. Growth lines indicate that the aperture bears a broad rounded hyponomic sinus. Each mature suture forms a broad shallow lobe on the ventral, lateral, and dorsal sides of the conch—these are separated by very narrowly rounded or subangular saddles that center on the ventrolateral zones of the conch and the umbilical seams. As a result of the ventral nodes, the sutures are sinuous and commonly asymmetrical as they cross the ventral zone. At the umbilical shoulders (which in some cases are nodose), there is a marked change in the adoral curvature of the sutures. The siphuncle is orthochoanitic in structure and is more or less subcentral in position but typically is located much closer to the venter than the dorsum. The septal necks are short but straight, the connecting rings are not expanded appreciably within the camerae, and the segments of the siphuncle are therefore essentially cylindrical in shape.

The ventral nodes on the conch differentiate members of this genus from representatives of such similar genera as *Metacoceras*, *Stearoceras*, etc. In the genotype, these nodes are larger than the ventrolateral nodes, but in many congeneric species the reverse is the case. It should also be noted that both the ventrolateral and the lateral nodes display a marked sequence of ontogenetic changes.

The genus *Tainoceras* is now known to range from the Middle Pennsylvanian to the Upper Permian, inclusive, and to be widespread geographically in the northern hemisphere. That is, representatives of it have been described from the Pennsylvanian of Illinois, Missouri, Nebraska, Kansas, Texas, and European Soviet Russia (Moscow region); and from the Permian of Nebraska, Kansas, Texas, New Mexico, Arizona, Wyoming, Sicily, Tirol, Serbia, Asiatic Soviet Russia (Ussuri region near Vladivostok, and possibly Armenia), and India.

Tainoceras cavatum Hyatt

1891. *Tainoceras cavatum* HYATT, Texas Geol. Surv., Ann. Rept. 2, p. 341–342, text figs. 42–44.
1893. *Tainoceras cavatum* HYATT, Texas Geol. Surv., Ann. Rept. 4, p. 398–399, 402, 403.
1898. *Tainoceras cavatum* WELLER, U. S. Geol. Surv., Bull. 153, p. 623.
1933. *Tainoceras cavatum* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 146.
1948. *Tainoceras cavatum* BRANSON, Geol. Soc. Am., Mem. 26, p. 834.

When Hyatt established this species, he described it as follows:

"The cast [internal mold] of this shell has distinctly marked lines of nodes, two on each side and two on the abdomen (outer side). The umbilical shoulders of the whorls are very broad but slightly convex and divergent. The umbilici are consequently deep and broadly coniform. The sides are flat, narrow, and not as broad as the umbilical shoulders of the whorl. The abdomen is very much broader than the dorsum and consists of three longitudinal divisions, a smooth zone on either side lying between the outer lateral and the proximate abdominal row of nodes. These two internodal zones are only very slightly convex, have no ribs, and the median zone lying between them is also free of ribs and decidedly concave. No shell was seen. The sutures are moderately closely set. The living chamber, of which the larger part is preserved, was probably, judging from markings on the cast, not less than half a volution in length. The increase by growth in the lateral transverse diameters is much more rapid than in the dorso-ventral diameters of the whorl, and the last whorl therefore grows broader quite rapidly. Siphuncle was not seen.

"The smaller specimen of the two under examination is also a cast, but it shows the umbilicus quite plainly. This is deep, and the narrow, flattened sides of the later stages arise on the latter part of the second or the first quarter of the third volution.[2] The second volution has a very broad abdomen and convex sides dipping steeply towards the funnel-shaped umbilici as in Temnocheilus. Whether the sides had one row of tubercles along the crests at the junctions of the abdomen and sides before these began to spread out to form the flattened sides of the latter stages could not be determined—none were present on the cast. (Fig. 44 [25 of the present publication].) But it is probable that the other row appeared before the inner lateral row during the Temnocheilus-like stage. The side view (Fig. 44 [25]) has the lower part or the outer whorl much too broad, and the umbilicus consequently too narrow, but the depth is better shown than in the other figure (Fig. 43 [24A]), where it is a restoration. The notable fact is the late stage at which the Temnocheilus form still characterizes the whorl and the rapidity with which the sides become flattened and assume the Tainoceran outline.

"This species differs from *Tainoceras quadrangulum*, McChesney, in having a stouter whorl in all

[2] "Number of volutions are estimated; the beginning of the first volution is destroyed in the fossil."

its diameters and in the sutures, especially on the abdomen (outer side). The abdominal lobe is as broad as the outer side in *quadrangulum*, whereas in this species it occupies only the longitudinal concave zone between the two rows of abdominal tubercles. It is more closely allied to *Nautilus tuberculatus*, Sow., as figured by Trautschold [1874, pl. 30, figs. 3a–3c], from the Upper Carboniferous of Russia, but the shell has whorls broader in proportion to the abdomino-dorsal diameter, and the nodes of the outer lateral ridges are closer together and larger. *Nautilus tuberculatus* as figured by Sowerby apparently differs in the same characteristics, but the figure is poorly executed, and I [Hyatt] have no English specimens of this species for comparison.

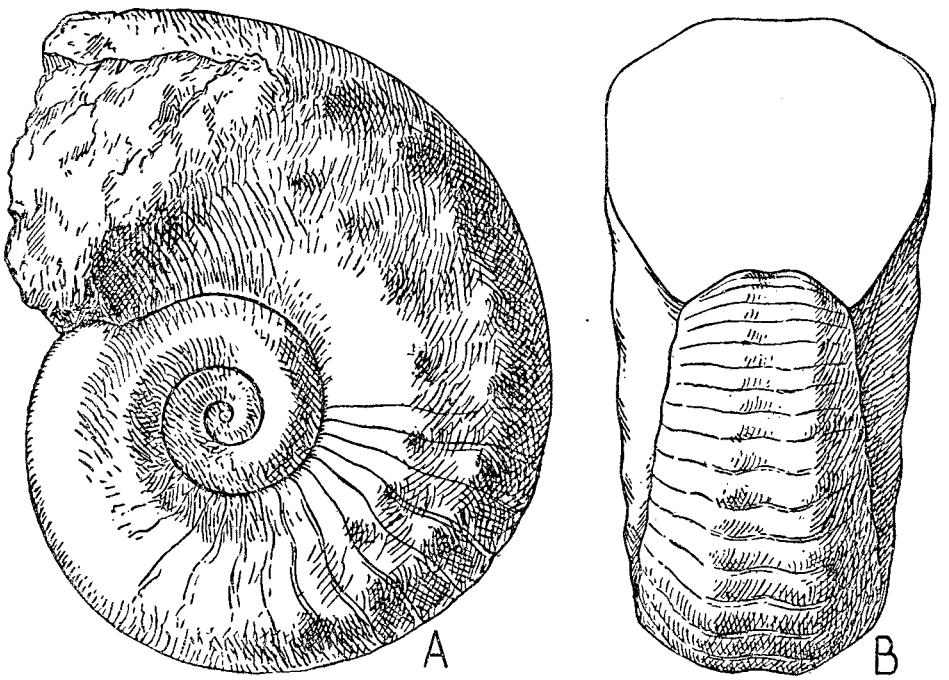

FIGURE 24.—*Tainoceras cavatum* Hyatt

Two views of the larger syntype, from some unrecorded horizon and locality in Texas, × ⅔. After Hyatt.

"This species might be supposed to be a close ally of *Solenoceros* (*Nautilus*) *Canaliculatus* as figured in the Kentucky Geological Survey [Cox, 1857, pl. 10, figs. 3, 3a], but the sutures and all characteristics differ essentially in the adult stage, although the young are quite similar. The *Nautilus decoratus* of the Kentucky Survey [Cox, 1857, pl. 9 figs. 4–4b] may also be the young of an allied species of this genus, but is evidently not very closely allied, since the abdominal depression is not very well marked in the drawing."

Two years later Hyatt described some additional specimens as follows:

"The new material from Ballinger shows the position of the siphuncle in a full grown whorl to be central, and also that in larger specimens the whorl has broader transverse diameters than in the smaller and younger specimens figured in the Second Annual Report of the Geological Survey of Texas, p. 341. In old whorls, as growth ceases, the air chambers become more closely approximated in the latter part of the ephebic stage, and in the anageron tic stage the abdominal tubercles disappear. The inner tubercles disappear about the same time, but on the abdominal angles they are apparently quite as prominent as at any previous stage. The newly collected specimens show that this species attains considerable dimensions. One cast measures about 160 mm. in diameter and has an imcomplete living chamber.

"There is also a young specimen of this species from Ballinger which is very imperfect, but so far as it is preserved confirms previous description and enables us to separate *cavatum* from *quadrangulum*. The ventral lines of tubercles and the ventral lobe of the sutures are just beginning to appear at the diameter of 45 mm. I [Hyatt] was not able to detect any signs of the presence of an annular lobe in the dorsal sutures. I expected to find in the middle of the dorsal lobe some inflection to correspond

to the dorsal face which runs along the center of the zone of impression corresponding to the concave ventral zone of the abdomen, but the dorsal lobe was found to be entire as in other species of this genus. This young specimen shows also that the large rows of tubercles on the abdominal angles appear before the ventral rows, and also before those on the umbilical shoulders in precise accordance with the theory that this genus is the descendant of forms like Temnocheilus, having nodes only on the corresponding angles of the whorl.

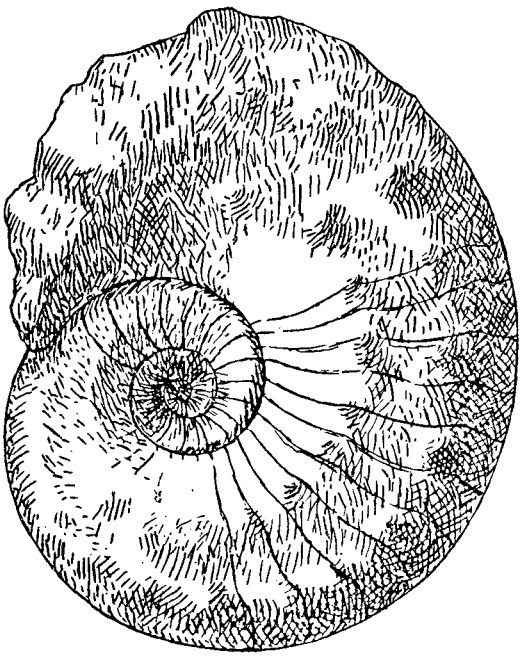

FIGURE 25.—*Tainoceras cavatum* Hyatt

The smaller syntype, from some unrecorded horizon and locality in Texas, × 1. After Hyatt.

"The markings of the shell on the umbilical zone at the diameter of 45 mm. are preserved, and show that the outer surface had fine transverse striae crossed by equally fine longitudinal striations, visible only under a magnifier. The increase in size by growth is very rapid in the ventro-dorsal as well as the transverse diameters of the whorls up to 34 mm., but after that the increase in the transverse diameters becomes the marked characteristic of the stages of growth in the whorl. The lateral zones of the young at the diameter of about 30 mm. are smooth, and, if the ventral rows of tubercles are present, they are just beginning to appear.

"This specimen is marked in the collection of the [Texas Geological] Survey as No. 289B, (20)a. The aspect of this fossil would lead one to expect that the external shell at this stage was very similar to that of *Metacoceras cavatiformis* as given on page 34 of Second Annual Report Texas Geological Survey, F. 30. Position of siphuncle was above the center at the diameter for the whole shell of about 19 mm."

REMARKS.—We have not seen any representatives of this species and hence are reproducing Hyatt's descriptions and illustrations of the types. In so far as we can judge from them, this form is quite distinct from all of the other known representatives of *Tainoceras*. Superficially, it seems to resemble *T. clydense* Miller and Kemp, but its conch is much less strongly depressed. As a matter of fact, the shape of the cross section of the conch and the small size and lack of prominence of the nodes are perhaps the most distinctive characters of this species.

OCCURRENCE.—The syntypes came from some unrecorded horizon and locality in Texas. The specimens discussed by Hyatt in 1893 were found near Ballinger, Runnels County, Texas, so they almost certainly came from the Lower Permian. Weller gives their age as "Carboniferous", Branson as "Leuders?."

TYPES.—The University of Texas.

Tainoceras clydense Miller and Kemp

(Plate 29, figures 1-4; Plate 55, figures 12-14)

1891. *Nautilis occidentalis* WHITE, U. S. Geol. Surv., Bull. 77, p. 16, 23, pl. 2, figs. 11, 12.
(?) 1891. *Nautilis (Endolobus)* ——? WHITE, U. S. Geol. Surv., Bull. 77, p. 16, 24, pl. 2, fig. 13.
1893. *Tainoceras quadrangulum* HYATT, Texas Geol. Surv., Ann. Rept. 4, p. 402–404, text figs. 5–7.
1933. *Tainoceras* n. sp. MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 146.
1942. *Tainoceras* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 731.
1947. *Tainoceras* spp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.
1947. *Tainoceras clydense* MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.

As was noted by Miller and Kemp, in 1933 Miller, Dunbar, and Condra pointed out that the specimens from the Clyde formation at the "Old Military Crossing" of the Big Wichita River in north-central Texas, which Hyatt referred to *Tainoceras quadrangulum* (McChesney), are not conspecific with the figured type of that species, which came from the Pennsylvanian of Illinois; and they were without a valid specific name. In 1891 White had illustrated as "*Nautilus* [*Tainoceras*] *occidentalis* Swallow" a fragmentary specimen from the "Old Military Crossing" that is almost certainly conspecific with those from this locality which Hyatt studied; but it does not seem to be referable to Swallow's species, which is very poorly known. Furthermore, the collections available to Miller and Kemp (Kemp Collection) contained a number of specimens from the Clyde formation, which showed a certain amount of variation in the nodes but which seemed to be conspecific with the individuals illustrated by Hyatt and White from the same formation. Accordingly, Miller and Kemp proposed the name *Tainoceras clydense* for this species.

White's figured specimen is poorly preserved and represents only a small portion of the conch (phragmacone)—see Pl. 55, figs. 13, 14, of the present publication. Hyatt's figures are being reproduced as Figures 26A–C in the text of the present publication. Also, we are illustrating the best two of the conspecific specimens in the Kemp Collection (Pl. 29, figs. 1–4)—both of these came from the Lueders formation, which immediately overlies the Clyde.

From the specimens now available to us for study and the published illustrations and descriptions by White and Hyatt, it can be stated that in this species the conch attains a diameter of at least 105 mm. and that the living chamber is at least two-fifths of a volution in length. At the junction of the living chamber and the phragmacone of the large specimen illustrated by Figures 3 and 4 on Plate 29, the conch is about 37 mm. high and the corresponding width is estimated to be some 45 mm. The whorls of the specimen represented by figures 1 and 2 on the same plate seems to be somewhat narrower, possibly in part at least as a result of distortion during preservation. The shape of the cross section of the conch in this species is elucidated by Figure 26B, in the text.

The umbilicus is large and open, and its diameter is equal to a little more than half that of the specimen. The umbilical walls are steep and the umbilical shoulders are abrupt and at least on the internal mold are essentially non-nodose.

Each of the ventrolateral zones of the conch bears a single row of prominent large rounded nodes of which at full maturity there are about a dozen to the volution. Also, on the ventral zone of the conch there is a pair of rows of similar but slightly smaller nodes—the nodes in these two ventral rows are staggered. The ventral nodes are much more closely spaced than are the ventrolateral nodes and they are about twice as numerous. The specimen represented by Figures 1 and 2 on Plate 29 has smaller ventral nodes (as well as a narrower conch) than that illustrated by Figures 3 and 4 on the same plate, but the differences between these two individuals may well be a matter of preservation.

The sutures are similar to those of other congeneric forms described in this report, for example, *T. wyomingense* Miller and Thomas. The siphuncle is located somewhat ventrad of the center of the conch (Pl. 55, fig. 13).

REMARKS.—The more distinctive characters of this species seem to be the shape of the cross section of the conch and particularly the size, shape, and arrangement of its nodes. That is, its umbilical shoulders are essentially non-nodose, and both the ventrolateral and the dorsolateral nodes are rounded. The ventrolateral nodes are larger and less numerous than the ventral nodes, which

are staggered. We are very uncertain in regard to the affinities of the small fragment represented by Figure 13 on White's Plate 2 of 1891 (reproduced as Figure 12 on our Plate 55). However, the published illustration of it seems to suggest that it belongs in this genus or in one with a somewhat similar conch, like *Metacoceras* or *Foordiceras*.

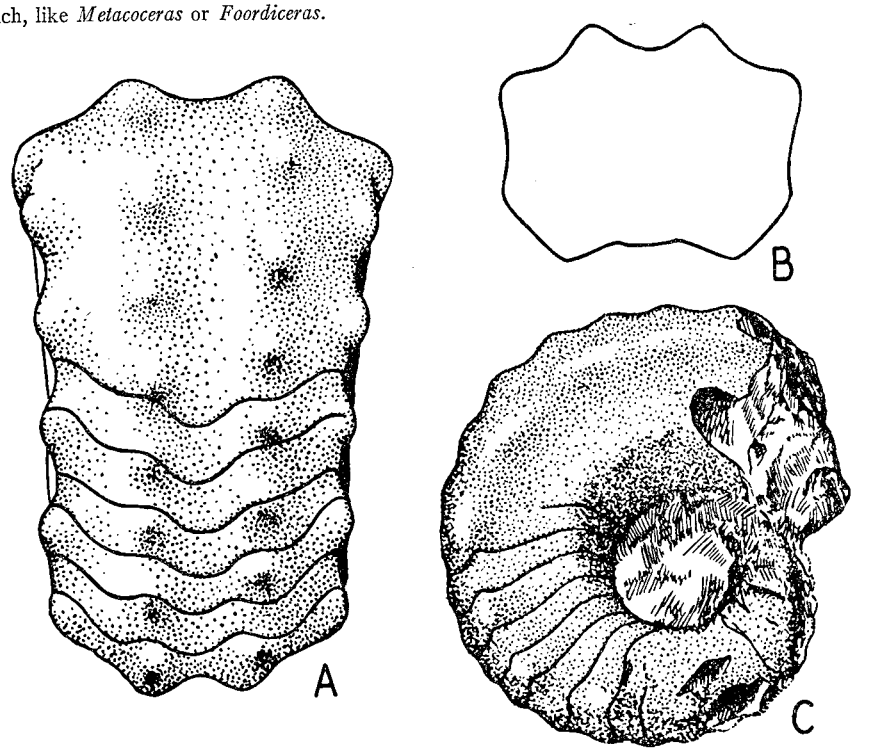

FIGURE 26.—*Tainoceras clydense* Miller and Kemp

Two of the syntypes, from the Clyde formation at the "Old Military Crossing" of the Big Wichita River, in Baylor County, Texas, × 1. After Hyatt.

OCCURRENCE.—All the specimens we are referring to this species came from the Clyde and overlying Lueders formations of Baylor County, Texas. Those illustrated and described by White and Hyatt are from the Grape Creek limestone member of the Clyde at the "Old Military Crossing" of the Big Wichita River. Three of the specimens we are regarding as conspecific with these syntypes (including both of those figured on Plate 29) are from the basal portion of the Lueders formation east of Throckmorton highway along Self School Creek and adjacent parts of Brazos bluff about 8 miles south of Seymour—stratigraphically the basal Lueders is about 100 feet above the Grape Creek.

REPOSITORIES.—Presumably the specimens (syntypes) studied by White are in the U. S. National Museum, and those studied by Hyatt are at The University of Texas. The other syntypes (which are rather poorly preserved and fragmentary) and three conspecific specimens from the Lueders formation (including both of those illustrated on Plate 29) are in the private collection of Augusta Hasslock Kemp of Seymour, Texas.

Tainoceras duttoni Hyatt

1893. *Tainoceras duttoni* HYATT, 1893, Texas Geol. Surv., Ann. Rept. 4, p. 401–402, text figs. 3, 4.
1933. *Tainoceras duttoni* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 146.
1942. *Tainoceras duttoni* [part] MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720, 728–729 [not pl. 115, figs. 1, 2].

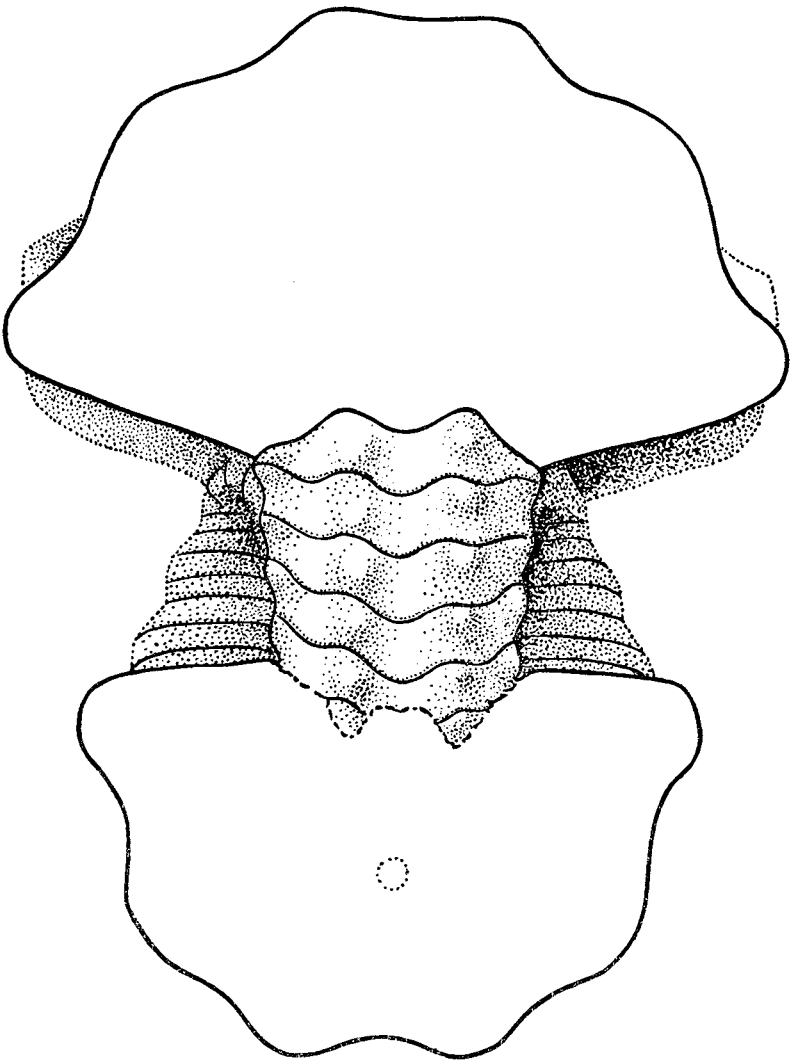

FIGURE 27.—*Tainoceras duttoni* Hyatt

The holotype, from the Chupadera? formation, some 12 to 15 miles southwest of Grants, New Mexico, × 1. After Hyatt. Same specimen as Figure 28, in text.

The original description of this species reads as follows:

"This interesting form is easily distinguished from all others of its genus, so far described, by reason of the great transverse breadth of the whorls through the umbilical shoulders, the consequent breadth of the smooth umbilical zones of the whorls and the unusual prominence and size of projecting ridges which form the shoulders. In the paraneanic and ephebic stages these ridges are tuberculated and much more prominent than the ventral angles and their rows of tubercles. In consequence of this the lateral zones converge and are concave, as are all the other external parts of the whorl. The form in section is consequently pyramidal, although it has eight faces and zones, as in other species of this genus.

"During the ananeanic sub-stage the tubercles and ridges of the umbilical shoulders are less prominent and the form of the whorl is then similar to what it is in the adult of *T. quadrangulum*. The sutures are more widely separated at all stages than in that species and the coiling appears to have

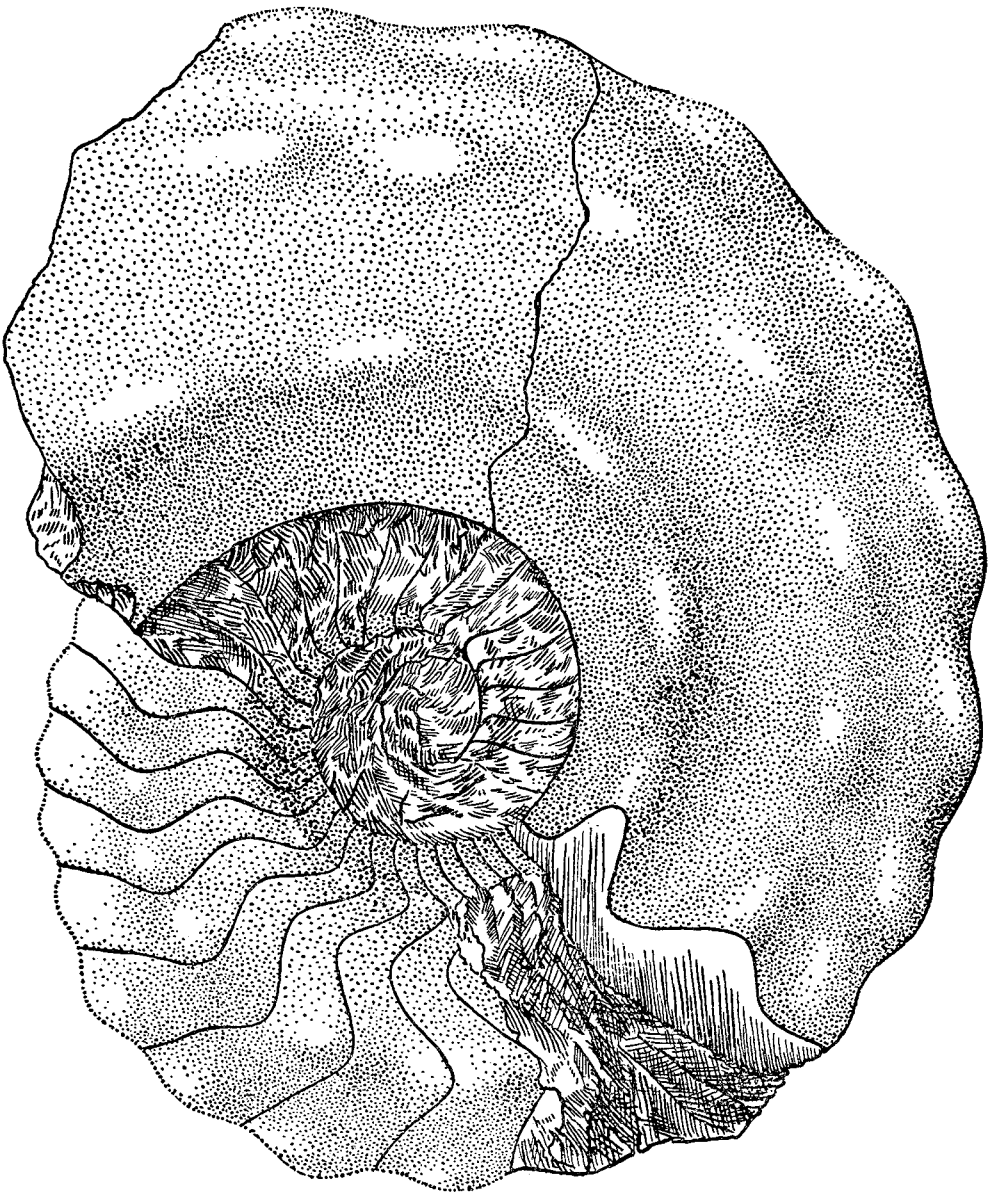

FIGURE 28.—*Tainoceras duttoni* Hyatt

The holotype, from the Chupadera? formation, some 12 to 15 miles southwest of Grants, New Mexico, × 1. After Hyatt. Same specimen as Figure 27, in text.

been closer. The siphuncle was apparently central in the full-grown shell, but this was not positively determined.

"The cast of the dorsum in the last whorl is deeply impressed by the tubercles of the abdomen of the next inner whorl and a central dorsal face and lateral dorsal faces are formed. These characteristics indicate that the shell was proportionately much thinner on the zone of involution than in *T. quadrangulum*, and more closely molded upon the inner whorl.

"In the anagerontic sub-stage the tubercles on the umbilical shoulders disappear, but the shoulders do not lose their prominence. The other rows of tubercles disappear later, the abdominal rows before those on the abdominal angles. So far as seen, the whorl does not begin to decrease in bulk during the anagerontic sub-stage, but the specimen examined was not of maximum size. The last sutures indicate this fact, being the normal distance apart instead of closely approximate, as is usual in very old parageronic specimens of chambered shells.

"The sutures are similar to those of *T. quadrangulum*, but the lateral lobes and saddles are as a rule more pronounced in correlation with the heavier umbilical shoulders. The dorsal sutures do not appear to have been materially affected by the presence of the central dorsal face in the zone of impression, and the single suture seen across the dorsum showed no signs of having an annular lobe. The air chambers are deeper and less numerous at the same stages than in *T. quadrangulum*. The incomplete living chamber in the type specimen was one-half of the volution in length."

REMARKS.—We have not seen the holotype of this species, and therefore are reproducing Hyatt's illustrations and description of it. While reading this description, one should keep in mind that Hyatt had a very broad concept of *Tainoceras quadrangulum* (McChesney), to which he referred several times. As a matter of fact, in the same report in which this description was originally published, Hyatt illustrated and described as *T. quadrangulum* some specimens for which Miller and Kemp (1947, p. 352) have recently established the name *T. clydense*.

The most distinctive specific character of *T. duttoni* seems to be the fact that its conch bears longitudinally elongate dorsolateral and ventrolateral nodes but rounded ventral nodes. The ventral nodes on the specimen from the Toroweap formation of Arizona that Miller and Unklesbay referred to this species are large and are obliquely elongate, and therefore we believe that form is specifically distinct and we are proposing the name *T. unklesbayi* for it. Both of these species have whorls that are more nearly subcircular in cross section than are those of the other American Permian representatives of this genus, and both have longitudinally elongate nodes on their umbilical shoulders.

Kruglov (1930, p. 114–115, 117) has described a specimen from the Late Paleozoic of the Ussuri region that is said to be very much like *T. duttoni*. However, little information is available in regard to this Asiatic form.

OCCURRENCE.—The only known representative of this species was found by "Capt. Dutton, U. S. A.", in some unrecorded horizon (probably the Chupadera formation) in the "upper valley of Zuni Plateau, 12 to 15 miles" southwest of Grants, Valencia County, New Mexico.

HOLOTYPE.—Hyatt states that the specimen on which he based this species was in his personal collection, so presumably it is at the Harvard Museum of Comparative Zoology.

Tainoceras nebrascense Miller, Dunbar, and Condra

(Plate 30, figures 3, 4; Plate 31, figures 1–5; Plate 32, figures 1–4)

1933. *Tainoceras nebrascense* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 151–154, 155, 156, pl. 11, figs. 1–6.

Conch rapidly expanded and at full maturity consists of some two and a half volutions and attains a diameter of some 90 mm. The largest of the syntypes represents the living chamber and the adoral two camerae of the phragmacone. Its dorsal margin is incomplete but there is probably not much loss, if we may judge by comparison of the length of the living chambers in younger specimens. The conch of this specimen attains a width of at least 50 mm. and a corresponding height of about 32 mm.

In the adult stages the cross section of the volution is irregularly pentagonal, the ventral side being slightly convex, the lateral zones essentially flat, the umbilical shoulders bluntly rounded, the umbilical walls moderately steep but gently convex and about equal in width to the dorsal impressed zone. The maximum width of conch is attained at the umbilical shoulders. The height of the conch is equal to about three-fourths the width.

The ventral zone bears four subequal rows of nodes, one on each ventrolateral shoulder and a pair so spaced between these as to divide the ventral side of the conch into three subequal areas. The ventrolateral nodes are elongate and rather narrow, increasing regularly in size and spacing with the enlargement of the shell. Where the whorl has a width of about 20 mm. the distance between adjacent nodes, measured from crest to crest, is about 5 mm.—this distance increases to about 8 mm. where the conch has a width of approximately 28 mm., and it measures about 13 mm. where the width of the conch is some 35 to 40 mm. These nodes are so elongated as to be almost connected.

The ventral nodes are likewise small, elongated, and laterally paired. Seven or eight of them occupy a space corresponding to five of the ventrolateral nodes. They tend to shorten into rounded nodes as the conch attains a diameter of some 60 or 70 mm. and are obsolete on the adoral portion of the largest of the known representatives of the species. A single fragment of an adult individual shows staggered ventral nodes—its specific affinities are, of course, uncertain. The space between the rows of ventral nodes is very gently concave, being equal in width to those between the ventral and ventrolateral rows and but little if any deeper. None of the syntypes shows even a trace of nodes on the umbilical shoulders.

The hyponomic sinus is large and rather deep, occupying the full width of the ventral side of the conch. On the internal mold there is a very small ridge or raised line along the venter. The sutures are like those of other typical representatives of *Tainoceras*. The siphuncle is located about midway between the center and the venter.

REMARKS.—The most distinctive characteristics of this species are probably the subrectangular cross section of its conch, its non-nodose umbilical shoulders, and the small longitudinally elongate nodes on its ventrolateral and ventral zones. It resembles *T. nodocarinatum* (McChesney) of the Pennsylvanian of Illinois in having the space between the ventral nodes about equal in width to that between the ventral and ventrolateral nodes. However, in that species the ventral nodes are rounded instead of elongate and staggered instead of paired, whereas the ventrolateral nodes are relatively larger and fewer.

It is possible that this species is the same as that which Swallow (1858, p. 196–197) described long ago from the Lower Permian? of Kansas. His type specimens were never illustrated, the only available description of them is very generalized, and they are believed to have been lost in the fire at the University of Missouri in 1892. Therefore, it is not possible to make satisfactory comparisons with Swallow's species, and it is doubtful if it can ever be recognized with a reasonable degree of certainty.

OCCURRENCE.—The syntypes are from the Fort Riley limestone (top of Barneston formation) in the quarry near the Beatrice power dam at Barneston, Gage County, Nebraska (in association with *Metacoceras* sp.). Specimens that appear to be conspecific have been found in the Hughes Creek shale on Muddy Creek, about 5 miles south of Douglas, Otoe County, Nebraska.

SYNTYPES.—Yale Peabody Museum.

Tainoceras occidentale (Swallow)

1858. *Nautilus occidentalis* SWALLOW, Acad. Sci. St. Louis, Trans., vol. 1, p. 196–197.
1868. *Nautilus occidentalis* [part] MCCHESNEY, Chicago Acad. Sci., Trans., vol. 1, p. 51.
1872. *Nautilus occidentalis* [part] MEEK, Hayden's Final Rept. U. S. Geol. Surv. Nebraska . . ., p. 234–236.
1891. *Nautilus occidentalis* [part] WHITE, U. S. Geol. Surv., Bull. 77, p. 23.
1895. *Nautilus occidentalis* [part] KEYES, Missouri Geol. Surv., vol. 5, p. 224.
1898. *Tainoceras occidentalis* [part] WELLER, U. S. Geol. Surv., Bull. 153, p. 623.
1933. *Tainoceras occidentale*, MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 152, 153.

Swallow's description of this species reads as follows:

"*Shell* of medium size, discoidal, tapering gradually, ornamented with six longitudinal rows of nodules, rendering the spire heptagonal; the two dorsal rows, separated by a deep concave channel, have each a large nodule on every chamber, one on the anterior and the other on the posterior side; those on the dorso-lateral angles have one nodule on every alternate chamber; the nodules around the umbilicus are smaller and less numerous. *Septa* very concave, periphery curved back on the dorsal and lateral margins, forming a rounded sinus in the dorsal channel, and a more obtuse curve on the flat lateral surfaces; *siphuncle* large, sub-central; *umbilicus* large; *aperture* small, sub-ovate.

"Our specimens are imperfect casts of the last volution, from which we can not determine the surface markings or the number of volutions; but it may be easily identified by the arrangement of the nodules and septa.

"Maj. Hawn's collection from the valley of the Cotton-wood, where it was associated with *Monotis Halli* and *Pecten Cleavelandicus*."

REMARKS.—This description is generalized, and it was not accompanied by an illustration. Furthermore, Swallow's type specimens were never figured or restudied, and they are believed to have been lost in the fire at the University of Missouri in 1892. Therefore, as Miller, Dunbar, and Condra

(1933, p. 153) have concluded, it will probably be impossible to recognize the species with a reasonable degree of assurance. However, it is worth noting that apparently Swallow was studying internal molds that had nodose umbilical shoulders. Moreover, it is evident that the ventral nodes on the type specimens were staggered and were about twice as numerous as the ventrolateral nodes (as in *T. clydense* Miller and Kemp), and the space between the two rows of ventral nodes was a deep sulcus. The siphuncle was said to be large and subcentral, and this unqualified statement probably means that it was approximately midway between the dorsum and the venter. It is difficult to interpret Swallow's statement that the aperture is small and subovate.

Meek (1872, p. 234–236, pl. 11, fig. 17) described and figured a specimen from the Pennsylvanian at Nebraska City in southeastern Nebraska, and he referred it to Swallow's species. He expressed confidence in this identification because he had previously seen Swallow's type specimens. However, the fact that he also accepted McChesney's figured specimens of *Nautilus quadrangulus* as specifically identical destroys the value of his testimony. He had only a single fragment before him when writing and evidently allowed much greater latitude for individual variation than can now be granted. Also, there seems to be no good reason to believe that most of the numerous forms from various horizons and localities that from time to time authors have placed in this species are conspecific with the syntypes.

OCCURRENCE.—The type species came from the "valley of the Cotton-wood" in Kansas, presumably from the Lower Permian.

SYNTYPES.—Believed to have been lost in the fire at the University of Missouri in 1892.

Tainoceras schellbachi Miller and Unklesbay

(Plate 14, figures 1–4; Plate 33, figures 3, 4; Plate 45, figure 4)

1942. *Tainoceras schellbachi* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721, 729–732, pl. 114, fig. 1; pl. 115, figs. 3, 4; pl. 116, figs. 1–4.

(?) 1944. *Tainoceras* cf. *T. schellbachi* CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.

The holotype of this species (Pl. 33, figs. 3, 4) is a moderately well preserved silicified internal mold which is septate throughout and which is about 110 mm. in diameter. The cross section is subrectangular as the whorls are depressed dorsoventrally, are flattened ventrally and laterally and slightly impressed dorsally, and have lateral zones that are almost parallel. At the adoral end of the holotype the height and width of the conch measure some 45 mm. and 60 mm., respectively, and the impressed zone is some 5 mm. deep. The diameter of the umbilicus is equal to almost two-fifths that of the specimen. The umbilical shoulders are abruptly rounded. The umbilical walls are almost parallel to the axis of coiling and are nearly straight but are slightly convex exteriorly.

Traces of the growth lines are essentially straight and directly transverse on the lateral zones of the conch, but they form a deep V-shaped but narrowly rounded ventral sinus. There is a row of prominent rounded nodes on each umbilical and each ventrolateral shoulder. Those on the umbilical shoulders are smaller and somewhat less numerous than those on the ventrolateral shoulders. There is a deep rounded groove along the venter and on either side of it a row of nodes that are somewhat obliquely elongate, with their axis of elongation sloping orad from the venter. These nodes are also less prominent than the ventrolateral nodes, but they are much more numerous.

The sutures form ventral, lateral, and presumably dorsal lobes. Their shape is of course affected by the nodes, and each suture forms a lobe as it crosses a longitudinal groove and a saddle as it crosses a row of nodes. The siphuncle of the holotype does not appear to be preserved.

REMARKS.—The single paratype of this species is from the same horizon and locality as the holotype. It is a considerably distorted silicified internal mold which represents only part of one volution of the conch and it is somewhat larger than the adoral portion of the holotype. The specimens represented by Figures 1–4 on Plate 14 and by Figure 4 on Plate 45 seem to resemble this species. Their general physiognomy indicates that they probably belong here, but their relationship is somewhat uncertain inasmuch as they represent only the inner whorls of the conch, which are not preserved in the holotype or the paratype. Also, the individual illustrated by Figures 1 and 2 on Plate 14 appears to be somewhat worn.

T. schellbachi differs from *T. duttoni* Hyatt particularly in that its whorls are more slender. Also, the cross section of the conch in these two species seems to differ markedly, and the ornamentation, though in general similar, is considerably different in detail—in *T. duttoni* the ventrolateral and dorsolateral nodes are longitudinally elongate, whereas in *T. schellbachi* they are rounded. The form from the Lower Permian at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas, which Hyatt (1893, p. 402–404) erroneously referred to *Tainoceras quadrangulum* (McChesney) seems to resemble *T. schellbachi* rather closely, but its umbilical shoulders are non-nodose—Miller and Kemp (1947, p. 352) proposed the specific name *T. clydense* for the Texas species.

OCCURRENCE.—Both the holotype and the paratype came from the Kaibab limestone (β member) at Hilltop, Grand Canyon, Arizona. All three of the specimens we are comparing with this species also came from the Kaibab of Arizona; one of them (Pl. 14, figs. 1, 2) was found near the Iowa State College forestry camp southwest of Flagstaff; the other two came from the α member of the Kaibab in the road-cut at Canyon Padre bridge about 20 miles east of Flagstaff (Pl. 14, figs. 3, 4) and from the Bottomless Pits about 7 miles east of Flagstaff (Pl. 45, fig. 4). In 1944 Clifton listed "*Tainoceras* cf. *T. schellbachi*" from the Blaine and/or Dog Creek formations of north-central Texas—we have not seen his material and hence can not express an opinion in regard to its affinities.

REPOSITORIES.—Grand Canyon National Park Museum, Fk-653 (holotype) and Fk-654 (paratype); Museum of Northern Arizona, 811/G2.1512 (Pl. 45, fig. 4) and 570/3060 (Pl. 14, figs. 3, 4); and State University of Iowa, 2122 (Pl. 14, figs. 1, 2).

Tainoceras unklesbayi, n. sp.

(Plate 33, figures 1, 2)

1942. *Tainoceras duttoni* [part] MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721, 728–729, pl. 115, figs. 1, 2.
1948. *Tainoceras duttoni* [part] BRANSON, Geol. Soc. Am., Mem. 26, p. 835.

The single specimen on which this species is based is an internal mold of the adoral half volution of the phragmacone and the extreme adapical part of the living chamber. The preserved portion of the specimen attains a diameter, measured across the umbilicus, of about 110 mm. In cross section the conch is more or less semicircular, though impressed dorsally, and near the mid-length of the holotype the conch is about 40 mm. high and 70 mm. (estimated) wide. The diameter of the umbilicus is equal to approximately half that of the conch. The umbilical walls are very broadly rounded and very steep, being almost parallel to the axis of coiling. The umbilical shoulders bear longitudinally elongate nodes. Also, on each of the ventrolateral zones of the conch there is a row of large narrowly rounded nodes which are circular or nearly so in cross section; and on each side of the rather deep ventral groove there is a row of large narrowly rounded nodes that are obliquely elongate —the axis of elongation slopes orad from the venter.

The camerae are of only moderate length and those in the adoral portion of the phragmacone are particularly short, indicating that the individual had attained full maturity. The sutures are of course greatly affected by the rows of nodes and the intermediate longitudinal grooves, but aside from them they form broad shallow rounded lobes on the ventral, lateral, and presumably dorsal zones of the conch as well as on the umbilical wall. As a result of the ornamentation, each suture forms a deep narrowly rounded lobe as it crosses a groove and a similar saddle as it crosses a row of nodes. No trace of the siphuncle is visible on the holotype.

REMARKS.—This form resembles *T. duttoni* Hyatt, to which it was referred by Miller and Unklesbay, in that its conch is low and broad and is more or less semicircular in cross section and the dorsoventral and ventrolateral nodes on it are longitudinally elongate. However, in *T. duttoni* the ventral nodes are moderately small and are rounded whereas in *T. unklesbayi* they are large and are obliquely elongate. The specific name is given in honor of Dr. Athel G. Unklesbay of the University of Missouri.

OCCURRENCE.—Toroweap formation (130 feet above the Coconino and the Toroweap contact) about 2 miles south of Coconino Point in Grand Canyon, Coconino County, Arizona.

HOLOTYPE.—Grand Canyon National Park Museum, Fk-764.

Tainoceras wyomingense Miller and Thomas

(Plate 7, figure 7; Plate 25, figures 3, 4; Plate 47, figure 6)

(?) 1908. *Tainoceras occidentale* GIRTY, Geol. Soc. Am., Bull., vol. 19, p. 429.
1936. *Tainoceras wyomingense* MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 732–733, pl. 96, fig. 13; pl. 97, fig. 6; pl. 98, figs. 3, 4.

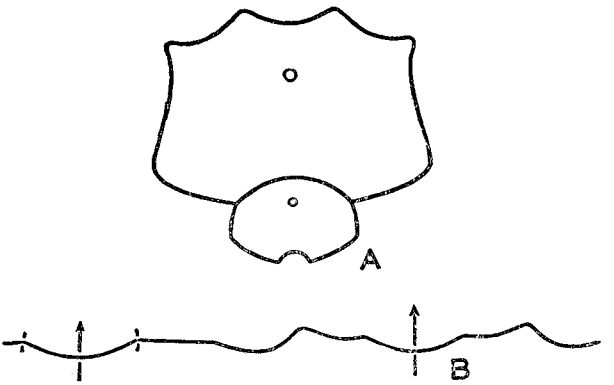

FIGURE 29.—*Tainoceras wyomingense* Miller and Thomas

Diagrammatic cross section of ultimate and penultimate volutions of conch, and diagrammatic representation of a mature suture, both × 1. The latter is based on the specimen represented by Figure 3 on Plate 25, whereas the former is a composite figure and is based on the specimens represented by Figures 3 and 4 of the same plate. Both of these specimens are syntypes.

Conch, which forms at least three volutions, is subdiscoidal, nautiliconic, and rather large at maturity. One of the syntypes attains a maximum diameter, measured across the umbilicus, of about 60 mm. and a maximum height and width of conch of about 25 mm. and 35 mm., respectively; and another crushed fragmentary syntype, which represents only a portion of one volution of the conch is at least 25 or 30 per cent larger. Mature whorls are depressed dorsoventrally and their cross section (Fig. 29A, in the text), though in general subrectangular, is unequally octagonal. Ventral, ventrolateral, and dorsolateral sides of the conch are relatively narrow, compared with dorsal and especially lateral zones. Except near the apex, where conch is circular or nearly so in cross section, adapical portion of conch is subelliptical in cross section, being strongly depressed dorsoventrally, very broadly rounded ventrally and dorsally, and rather narrowly rounded laterally; dorsal side of conch is less strongly convex than ventral (see Pl. 7, fig. 7). Conch is expanded orad very rapidly, and at adoral end of first volution it is about 12½ mm. wide and 8 mm. high. Half a volution orad of this point, it is about 20 mm. wide and 12½ mm. high.

Umbilicus moderately large and perforate. In large mature individuals diameter of umbilicus is equal to nearly half diameter of specimen, and in younger individuals it is relatively larger. Umbilical perforation is oval in shape and it is about 5 mm. long and 3 mm. wide. Umbilical walls steep; umbilical shoulders subangular and at full maturity slightly nodular.

On mature portion of conch each growth line forms a broad moderately deep rounded ventral sinus and on each side of it a broad low rounded lateral salient, but growth lines are essentially straight and directly transverse on umbilical walls. Adapical portion of conch is smooth or nearly so but near adoral end of adapical volution lateral zones of conch become very slightly nodular, and on adapical portion of next volution there is developed rather gradually on each of the ventrolateral shoulders of the conch a row of longitudinally elongate nodes. Near the midlength of the second volution of the conch, two rows of similar nodes are gradually developed on the ventral side of the conch. Apparently the nodes in all four of these rows continue to enlarge throughout ontogenetic development, and they seem to become progressively less elongate longitudinally. Nevertheless, on large specimens the ventral nodes are distinctly elongate longitudinally and the ventral nodes are

elongate obliquely (Pl. 25, fig. 4). During full maturity the ventral nodes become as large and prominent as the ventrolateral nodes and also the umbilical shoulders become slightly nodular.

Camerae moderate in length (see Pl. 25, fig. 3). As shown in Figure 29B, in the text, each mature suture forms broad shallow rounded ventral, lateral, and dorsal lobes, and these are separated by subangular saddles. As a result of the ventral nodes, the flanks of the ventral lobe are sinuous. Also, it should be noted that on the umbilical shoulders there is an abrupt change in the curvature of the sutures, and that on the umbilical walls the sutures are essentially straight. Siphuncle small, circular in cross section, and subventral in position.

REMARKS.—In 1908 Girty studied a specimen (or specimens) from the same general horizon and locality as the types of this species, and he referred it (or them) to *Tainoceras occidentale* (Swallow). We have not seen Girty's material, but it seems likely that it belongs in the species under consideration. The most distinctive features of this species seem to be the shape of the cross section of its conch and the size, form, and position of the nodes, particularly the longitudinally elongate shape of the small ventrolateral nodes and the obliquely elongate shape of the small ventral nodes.

In 1893 Hyatt stated that during ontogenetic development representatives of *Tainoceras* pass through first a *Temnocheilus* and then a *Metacoceras* stage before assuming their own generic characters. *T. wyomingense* passes through a *Metacoceras* stage during late adolescence but its early adolescent stage (with subelliptical conch and low lateral nodes) is not at all like *Temnocheilus* but is reminiscent of *Endolobus*, which Hyatt regarded as a synonym of *Temnocheilus*.

OCCURRENCE.—Abundant in *Stenopoceras* beds of Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Albany County, Wyoming.

SYNTYPES.—State University of Iowa, 1159–1163.

Genus *Aulametacoceras* Miller and Unklesbay, 1942

GENOTYPE: *Aulametacoceras mckeei* MILLER AND UNKLESBAY

This genus was based largely on a single specimen from the Permian of North America, but an European Triassic species appears to be congeneric. From a study of the American specimen and the published illustrations and descriptions of the European form, we can diagnose the genus as follows:

Conch nautiliconic, and volutions, which are about as high as wide, are flattened ventrally and laterally and slightly impressed dorsally. Ventrolateral and umbilical shoulders abrupt and at least ventrolateral ones are nodose. Umbilicus large. Ventral zone of conch bears several longitudinal grooves and ridges, the latter of which are slightly nodose. Sutures form shallow ventral, lateral, and dorsal lobes. Siphuncle of genotype is not known, but that of a congeneric form is small in size and is located considerably nearer the dorsum than the venter.

This genus resembles *Metacoceras* in so far as general physiognomy, sutures, etc., are concerned, but is readily distinguished by means of the longitudinal grooves and ridges on the ventral zone of the conch. The genotype came from the Middle Permian of Arizona, and the only other species that we are referring to the genus, *Nautilus rectangularis* Hauer, is from the Upper Triassic of the Carnic Alps. *N. rectangularis* has been referred to *Trematodiscus*, *Thuringionautilus*, and *Coelonautilus*, but it is not closely similar to the type species of those genera.

Aulametacoceras mckeei Miller and Unklesbay

(Plate 34, figures 1, 2)

1942. *Aulametacoceras mckeei* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721, 726–728, pl. 112, figs. 1, 2.

The only known representative of this species is a moderately well preserved internal mold, almost all of which is septate. This specimen is somewhat distorted, but its maximum diameter (measured across the umbilicus) is about 280 mm., and the diameter normal to this is about 230 mm. The conch is nautiliconic in its mode of growth. The volutions, which are slightly depressed, are subhexagonal in cross section as they are flattened ventrally, laterally, and dorsolaterally and slightly impressed dorsally, and the ventrolateral and umbilical shoulders are almost subangular (Fig. 6A).

Near the midlength of the outer volution of the holotype, the conch is some 77 mm. high and 92 mm. wide.

There is a row of low rounded nodes on each umbilical and each ventrolateral shoulder. Those on the umbilical shoulders are more closely spaced than those on the ventrolateral shoulders. The nearly flat ventral side of the conch bears six prominent ridges and five intermediate grooves. The grooves are more broadly rounded than the ridges, which are slightly but distinctly nodose. The umbilicus is large and its diameter is equal to about half that of the conch.

Each suture forms a broad shallow ventrol lobe (which is distinctly undulate), narrowly rounded ventrolateral saddles, broad rounded lateral lobes, low narrowly rounded saddles on the umbilical shoulders, very shallow lobes on the umbilical walls, and presumably small saddles on the umbilical seams and a shallow dorsal lobe. Siphuncle unknown, but it is not ventral in position.

REMARKS.—The prominent ventral ridges and grooves of this species serve to distinguish it from all other Permian forms known to us. *A. rectangulare* (Hauer) of the Upper Triassic of the Carnic Alps has a somewhat similar ventral zone, but its umbilical shoulders are not nodose, its ventrolateral nodes are relatively prominent, the cross section of its conch is subquadrate rather than subhexagonal, and its umbilicus is relatively small.

OCCURRENCE.—Kaibab limestone (presumably α member) on east side of Lake Mary, about 10 miles southeast of Flagstaff, Arizona.

HOLOTYPE.—Museum of Northern Arizona, 895/G2.1992.

Genus *Temnocheilus* M'Coy, 1844

GENOTYPE: *Nautilus* (*Temnocheilus*) *coronatus* M'Coy

When M'Coy established this genus, he interpreted it rather broadly. However, subsequent authors (particularly Miller, Dunbar, and Condra) have limited its scope so that it now includes only forms that closely resemble the genotype, *Nautilus* (*Temnocheilus*) *coronatus* M'Coy of the Lower Carboniferous of Ireland and possibly England (Pl. 35, figs. 6, 7). That is, at present the genus contains only those species in which the nautiliconic conch has whorls that are subtrapezoidal in cross section, as they are strongly flattened ventrally and laterally and only slightly impressed dorsally, and typically the lateral zones converge dorsad. The umbilicus is large, open, and perforate. Growth lines show that there was a deep hyponomic sinus. Ventrolateral shoulders of conch bear a single row of longitudinally elongate nodes. Sutures form ventral, lateral, and dorsal lobes. Siphuncle small, subcentral, and orthochoanitic.

Hyatt (1900, p. 524) regarded both *Endolobus* Meek and Worthen and *Cryptoceras* d'Orbigny as synonyms of *Temnocheilus*. However, as was concluded by Miller, Dunbar, and Condra, the first of these is a distinct valid genus, and the other is a homonym of *Cryptoceras* Barrande (which has priority) and a synonym of *Solenochilus* Meek and Worthen. In *Endolobus* the conch is subelliptical in cross section and there are lateral (rather than ventrolateral) nodes. *Metacoceras*, which is also related, has whorls that are subrectangular in cross section.

As now understood, the genus *Temnocheilus* ranges from the Lower Carboniferous to the Permian, inclusive, and it is well represented in both North America and Eurasia. In The United States it is not particularly rare in the Pennsylvanian, being known from Illinois, Kentucky, Missouri, Kansas, Texas, and Colorado. However, we are referring to it only two American Permian specimens, and both of these may well be adolescent representatives of some other genus.

Temnocheilus inaequilaterale, n. sp.

(Plate 36, figures 1-4)

This species is being based on a single specimen which is a well preserved silicified replacement of the adapical one and a half volutions of the conch. The maximum diameter of the preserved portion of this specimen measures about 82 mm., and near its adoral end the height and width of its conch are about 40 mm. and 50 mm., respectively.

The extreme adapical portion of the conch, which is expanded orad very rapidly, is essentially circular in cross section. However, by the time the conch had completed one full volution, it had

become rather strongly elliptical in cross section and it is about 27 mm. wide and 20 mm. high. Orad of the adapical volution there are developed a shallow dorsal impressed zone, very slight umbilical shoulders (which remain indefinite throughout the holotype), and rounded nodose ventrolateral shoulders. The ventrolateral nodes are very prominent on the left side of the holotype but are hardly discernible on the right side of the same specimen. The growth lines, which are fine but very distinct, are essentially straight and directly transverse on the umbilical walls, but on the lateral zones of the conch they swing apicad and then form broad shallow rounded ventral sinuses.

The umbilicus is large, open, and perforate. The umbilical perforation is subovate in shape, and its two diameters measure about 6 mm. and 9½ mm.

At least the adapical volution of the holotype is septate and therefore represents phragmacone. The shape of the sutures and the nature of the siphuncle are not elucidated by the holotype.

REMARKS.—This form is not very similar to any previously described species with which we are familiar. The holotype changes rapidly throughout its entire length, and may therefore represent only the adolescent portion of the conch. Presumably its lack of bilateral symmetry should be taken to mean that it is an abnormal individual. All in all, it appears to be closer to the type species of *Temnocheilus* than to any other genotype, and we are therefore referring it to that genus.

OCCURRENCE.—Lower part of the upper Leonard formation on the south side of the road between the road fork and the Sheep Tank at the old Word Ranch house in the Glass Mountain region of Brewster County, Texas.

HOLOTYPE.—U. S. National Museum.

Temnocheilus? sp. [of New Mexico]

(Plate 39, figures 3–5)

From a block of Hueco limestone collected by Carl Branson, J. B. Knight etched a small silicified specimen that seems to be unique. Unfortunately, it appears to represent only the immature portion of the conch, and therefore its affinities can not be determined with a reasonable degree of certainty.

The maximum diameter of the preserved portion of this specimen measures about 31 mm., and near its adoral end its conch is about 19 mm. wide and 14 mm. high. The umbilical perforation is large, and its two diameters measure about 4 mm. and 6 mm. The extreme adapical portion of the conch is circular, or nearly so, in cross section and is rapidly expanded orad. In the first volution, both umbilical and ventrolateral shoulders are developed, and immediately orad of this volution the ventrolateral shoulders become nodose—the nodes are longitudinally elongate and are more or less confluent. The siphuncle is small, and it is located considerably closer to the venter than the dorsum.

REMARKS.—Superficially this specimen resembles the holotype of *Temnocheilus inaequilaterale*, and therefore we are referring it with question to the same genus. However, it develops ventrolateral nodes at a much smaller size, and also in its adoral portion there is a rather prominent umbilical shoulder. Perhaps the last feature, that is, the umbilical shoulder, should be taken to indicate a relationship to *Metacoceras* rather than to *Temnocheilus*.

OCCURRENCE.—Hueco limestone (bed just below top of an isolated hill) just south of a small hill of trachyte porphyry near the center of sec. 25, T. 22 S., R. 8 E., 0.7 mile south of railroad station at Orogrande, Otero County, New Mexico.

REPOSITORY.—U. S. National Museum.

Temnocheilus spp. [of Texas]

(Plate 55, figures 2–5)

1891. *Nautilus (Temnocheilus) winslowi* [part] WHITE, U. S. Geol. Surv., Bull. 77, p. 16, 23, pl. 3, figs. 1–4 [not 5].
(?) 1944. *Temnocheilus?* sp. CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.
1947. *Temnocheilus* spp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.

In 1891 White stated:

"A considerable number of imperfect specimens and fragments of a species of *Nautilus* occur among the fossils obtained at the Military Crossing of the Big Wichita, which are referred to the *N. winslowi*

of Meek and Worthen. Although these specimens vary in certain respects from the type specimens as figured and described by the authors, they vary quite as greatly among themselves. These as well as other specimens indicate that the species is a very variable one, and its variability is believed to be so great as to include the *N. latus* of the same authors. The variability is observable in the different degree of acuteness of the lateral revolving angles, the prominence and shape of the nodes upon them, the difference of the convexity of the peripheral side, etc. The Texas specimens are also all smaller than the type specimens of *N. latus* and of *N. winslowi* respectively. Both the latter are from the Coal Measures of Illinois."

White also illustrated four of the specimens he was referring to Meek and Worthen's species, and we are reproducing his illustrations as Figures 1–5 on Plate 55. The individual represented by Figure 1 on that plate is being made a paratype of *Knightoceras kempae*. However, the other three are tentatively being left in *Temnocheilus*, though it is recognized that they are all small and may therefore be immature representatives of some form or forms which may be quite different at maturity.

In 1947 Miller and Kemp indicated that in Baylor County, Texas, the genus *Temnocheilus* is represented in three Lower Permian horizons: (1) the Elm Creek limestone of the Admiral formation, near the middle of the Lower Permian; (2) some 500 feet higher in the section, the Grape Creek limestone of the Clyde formation (the horizon of the well-known "Old Military Crossing" of the Big Wichita River, which yielded the specimens illustrated and described by White); and (3) the Lueders formation (and probably just below its base), about 100 feet stratigraphically above the Grape Creek. All of the material on which these statements are based is rather incomplete and/or poorly preserved, but it appears to be closer to the type species of *Temnocheilus* than to any other genotype.

Occurrence.—Grape Creek limestone of the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas (the figured specimens); and the Elm Creek limestone of the Admiral formation and the Lueders formation (and probably just below its base) in the same county. For the sake of completeness, it should be added that in 1944 Clifton listed "*Temnocheilus*? sp." from the Blaine and/or Dog Creek formations of north-central Texas—we have not seen his material.

Repositories.—U. S. National Museum (specimens studied by White, including Pl. 55, figs. 2–5) and private collection of Augusta Hasslock Kemp of Seymour, Texas (specimens listed by Miller and Kemp).

Genus ***Foordiceras*** Hyatt, 1893

Genotype: *Nautilus goliathus* Waagen

Although this genus was proposed by an American author in an American publication and has been included in both editions of the Zittel-Eastman "Text-book of paleontology," it has been neglected by most American paleontologists. As a result, in Branson's recently issued "Bibliographic index of Permian invertebrates" not a single American species is referred to *Foordiceras*; and in their study of "The nautiloid cephalopods of the Pennsylvanian system in the Mid-Continent region", Miller, Dunbar, and Condra mention the genus only incidentally. This general apathy of most American paleontologists toward *Foordiceras* is probably a result of the fact that Hyatt's original diagnosis of the genus is not very easy to understand, and he included in it only Eurasiatic species.

By original designation, the genotype is *Nautilus goliathus* Waagen of the Upper Productus limestone of the Salt Range in India (Pl. 37, figs. 1, 2, of the present publication). This species has a thickly discoidal conch in which the volutions are wider than high and are subrectangular in cross section. The umbilicus is moderately wide and is open. The lateral zones of the conch bear prominent slightly curved transverse ribs which can be thought of as lateral extensions of ventrolateral nodes. That is, the ribs end abruptly on the ventrolateral zones of the conch more or less as rather prominent nodes, but dorsally they diminish gradually, disappearing entirely, however, somewhat ventrad of the umbilical shoulders. The sutures form broad rounded ventral, lateral, and dorsal lobes. Although the nature of the siphuncle in the genotype is not known, that of similar species is subcentral in position and orthochoanitic in structure.

Typical representatives of *Tainonautilus* Mojsisovics (for example, *Nautilus transitorius* Waagen of the Upper Productus limestone of India) and particularly *Parametacoceras* Miller and Owen (for example, *P. bellatulum* M. and O. of the Cherokee formation of Missouri) hardly seem to us to differ

sufficiently from the genotype of *Foordiceras* to be regarded as generically distinct. With some hesitation, we are therefore suppressing both of these names in favor of *Foordiceras*, which has priority. The genotype of *Metacoceras* Hyatt, *Nautilus* (*Discus*) *sangamonensis* Meek and Worthen of the McLeansboro formation of Illinois (Pl. 11, figs. 9, 10) is also close to that of *Foordiceras*, but the ventrolateral nodes on its conch do not have long prominent lateral extensions. Many of the species which have been referred to *Metacoceras* should, in our opinion, be placed in *Foordiceras*, but these two genera are somewhat gradational.

The only known representative of the genotype of *Shansinautilus* Yabe and Mabuti, *S. ozakii* Y. and M. of the Taiyuan formation of Shansi, northeastern China, is crushed and rather poorly preserved, and it does not reveal the nature of its septa, sutures, or siphuncle. In so far as we can determine from the published data in regard to this species, it probably falls within the limits of *Foordiceras*, as we are interpreting that genus. Therefore, we are tentatively suppressing *Shansinautilus* as a synonym of *Foordiceras*, which has priority.

Forms that seem to us to be close enough to *Foordiceras goliathum* to be regarded as congeneric with it are widespread and abundant in the Pennsylvanian or Upper Carboniferous and the Permian of both North America and Eurasia. Stratigraphically the genus ranges throughout essentially all these two Late Paleozoic systems. Hyatt included in this genus two species from the Triassic of central Europe, *Nautilus nodosus* Bronn and *N. bidorsatus* Schlotheim; we are uncertain in regard to the generic affinities of the first of these, but the second is now the genotype of *Germanonautilus* Mojsisovics.

Foordiceras cooperi (Miller)

(Plate 38, figures 11, 12)

1945. *Metacoceras cooperi* MILLER, Jour. Paleont., vol. 19, p. 283, 285–286, 287, 288, 290, pl. 45, figs. 11, 12.

The holotype of this species is an exceptionally fine specimen that represents about two volutions of the conch. It is almost but not quite complete adapically and adorally. The maximum diameter attained by the preserved part of this specimen measures about 65 mm., and near its adoral end the conch is about 27 mm. high and about 29 mm. wide. The umbilicus attains a diameter of about 26 mm., and the umbilical perforation is about 5 mm. long and about 3 mm. wide. The umbilical walls are steep and are almost perpendicular to the flattened lateral zones of the conch.

The adapical half of the first volution of the conch is subcircular in cross section, but the rest of it is almost square, though at full maturity it is slightly concave both dorsally and ventrally. The change in the shape of the cross section is abrupt. On the subcircular adapical part of the conch, the growth lines are fairly prominent. Elsewhere they are not conspicuous, but at maturity they are nearly straight on the lateral zones of the conch and form a deep rounded ventral salient. At the adoral end of the first half volution of the conch, a rounded and conspicuous dorsolateral keel is developed. It is never very prominent and on the adoral half volution of the holotype is essentially obsolete. At the same time that the conch became more or less square in cross section and developed a dorsolateral keel, it developed lateral ribs which are much more prominent on the ventral half of the lateral zones than on the dorsal half. These ribs gradually diminish dorsally, and they do not extend quite to the dorsolateral keel. Ventrolaterally they end abruptly and form very narrowly rounded nodes. On the extreme adoral part of the holotype, these lateral ribs seem to become obsolete.

No trace of the siphuncle is visible on the holotype. However, the collections under consideration contain three fragmentary specimens (paratypes) that belong in this species, and one of them shows that the siphuncle is small and is located somewhat nearer the venter than the dorsum.

REMARKS.—This species resembles *Foordiceras magnicostatum* (Miller), with which it occurs in direct association. However, the nodes on its conch are smaller, the dorsolateral keel is less prominent, and the umbilical perforation is considerably smaller.

OCCURRENCE.—Upper part of Leonard formation south of the road 0.2–0.5 mile east of Split Tank, 1.5 miles northeast of the bowed fork near the old Word Ranch house, about 19 miles north-northeast of Marathon, Brewster County, Texas.

TYPES.—U. S. National Museum, 111612 (holotype) and 111613 (three paratypes).

Foordiceras gregarium (Miller)

(Plate 36, figure 5; Plate 38, figures 5–8; Plate 39, figures 1, 2, 6–9; Plate 40, figures 1–4; Plate 41, figures 5–9)

1945. *Metacoceras gregarium* MILLER, Jour. Paleont., vol. 19, p. 283, 285, 286–287, pl. 45, figs. 5–8.

This species was originally based on six specimens from a single horizon and locality in the Leonard formation of west Texas. The largest of the figured syntypes (Pl. 38, fig. 8) consists of slightly more than two volutions, and it attains a maximum diameter of about 63 mm. Near the adoral end of this specimen, the conch is about 26 mm. high, and near the midlength of the outer volution it is about 17 mm. high and about 20 mm. wide. The conch of one of the unfigured syntypes attains a height of as much as 28 mm., and that of one of the largest of the figured hypotypes (Pl. 39, fig. 6) is about 30 mm. high near its adoral end—the corresponding width of conch of this last specimen is estimated to be some 35 mm., and the preserved portion of this specimen attains a maximum diameter of about 72 mm.

The umbilicus is large and open, and that of the largest of the figured syntypes measures about 26 mm. in diameter. The umbilical perforation of this specimen is about $5\frac{1}{2}$ mm. long and $3\frac{1}{2}$ mm. wide; that of the syntype represented by Figures 5 and 6 on Plate 38 is slightly larger and measures about 6 mm. in length and 4 mm. in width, and the corresponding measurements of the umbilical perforation of the specimen illustrated by Figure 4 on Plate 40 are about $6\frac{1}{4}$ mm. and 4 mm., respectively. The umbilical walls are steep, being almost perpendicular to the lateral zones of the conch.

The adapical half of the first volution of the conch is rapidly expanded orad and is circular or nearly so in cross section. Then the conch becomes abruptly flattened laterally, dorsally, and ventrally. After it has completed one full volution, it becomes slightly concave dorsally as it develops a shallow impressed zone, and in the outer volution of large individuals it becomes slightly concave ventrally. The dorsolateral (umbilical) shoulders are subangular, but in this species they do not develop an appreciable keel.

On the adapical half of the first volution of the conch, the growth lines are very prominent and also there appears to be a ventrolateral ridge. On the remainder of the conch, the growth lines are almost straight and directly transverse on the umbilical wall, but they curve somewhat apicad as they approach the umbilical shoulders. On the lateral zones of the conch their shape is influenced somewhat by the ribs, but they are either straight or slightly sigmoidal. Ventrally they form rather deep rounded sinuses.

As soon as the conch becomes more or less square in cross section, it develops transverse lateral ribs. During early maturity these ribs are much less prominent on the dorsal than on the ventral parts of the lateral zones, and they form rather prominent ventrolateral nodes. However, after full maturity is attained, the ribs extend clear across the lateral zones with almost equal prominence, though invariably they end ventrolaterally more abruptly than dorsolaterally.

The septa are rather closely spaced and are moderately convex apicad. Where the conch is about 19 mm. high, the siphuncle is a little more than 1 mm. in diameter and is located about 8 mm. from the venter. It appears to be composed of cylindrical segments and presumably, therefore, is orthochoanitic in structure.

REMARKS.—This species can be differentiated from similar congeneric forms by the fact that at full maturity, the lateral ribs extend clear across the lateral zones of the conch. Also, these ribs are not as high as are those of *Foordiceras magnicostatum*, and the umbilical perforation of this form is larger than that of *F. cooperi* and smaller than that of *F. megaporum*—all of these species occur in close association in the Leonard formation of west Texas.

OCCURRENCE.—All of the syntypes and most of the hypotypes of this species are from the middle part of the upper Leonard formation on slopes south of the road 0.2–0.5 mile east of Split Tank, 1.5 miles northeast of the bowed fork near the old Word Ranch house, about 19 miles north-northeast of Marathon, Brewster County, Texas. The specimen represented by Figure 4 on Plate 40 is from the lower part of the upper Leonard formation "on the south side of the road between the road fork and the Sheep Tank at the Old Word Ranch". The specimen illustrated by Figures 8 and 9 on Plate 41 came from the "fossil bed of the Hess member—eastern facies of the Leonard formation"—on "the crest of the hill 3.8 miles airline N. 78° E. of Hess Ranch house and .4 mile southwest of the head

of the south branch of Hess Canyon," also in the Glass Mountain region of Brewster County, Texas. The specimen illustrated by Figures 5–7 on Plate 41 is from the middle portion of the upper Leonard formation on the south side of the road about half a mile west of Split Tank near the old Word Ranch house of the Glass Mountain region. In addition, we are referring with question to this species two rather poorly preserved unfigured specimens from the third limestone of the Word formation on the north slope of the hill on the south side of Hess Canyon, about 4 miles N. 35° E. of the Hess Ranch house, and about 14 miles north-northeast of Marathon.

TYPES.—U. S. National Museum, 111614 (figured syntypes), 111615 (unfigured syntypes), 111616 (Word specimens questionably referred to this species). The figured hypotypes are all at the same institution.

Foordiceras magnicostatum (Miller)

(Plate 38, figures 9, 10; Plate 15, figures 9, 10)

1945. *Metacoceras magnicostatum* MILLER, Jour. Paleont., vol. 19, p. 283, 286, 287–288, pl. 45, figs. 9, 10.

The holotype of this species is well preserved and fairly complete. The portion of the conch that it represents consists of about two and a quarter volutions. It attained a maximum diameter of about 57 mm. and a maximum height and width of conch of about 22 mm. and 25 mm., respectively. The umbilicus is large and open, and that of the holotype measures about 22 mm. in diameter at the adoral end of the specimen. The umbilical perforation, which is subovate in shape, is about $6\frac{1}{2}$ mm. long and about 4 mm. wide. The umbilical walls are steep and are almost perpendicular to the flattened lateral zones of the conch.

The adapical half of the first volution of the conch is circular, or nearly so, in cross section, but the rest of it is almost square in cross section as it is flattened laterally, is very slightly concave dorsally and ventrally, is subangular dorsolaterally, and is narrowly rounded ventrolaterally. Apparently only the adoral half of the outer volution is concave ventrally, but the dorsal zone becomes concave during the second half of the first volution and remains so throughout ontogenetic development. Along the center of the ventral concave zone, there is a faint ridge. The growth lines are rather prominent on the adapical half of the first volution of the conch. Elsewhere they are very faint, but they seem to be almost straight and directly transverse on the umbilical walls and the lateral zones of the conch but to form deep rounded ventral sinuses.

Except on the adapical half of the first volution, there is a low rounded carina on the dorsolateral (umbilical) shoulder, and the lateral zones of the conch bear prominent short transverse ribs. Dorsally these ribs die out gradually, and they do not extend quite to the carina on the umbilical shoulder. However, ventrolaterally they end abruptly, and they can be said to form prominent rounded ventrolateral nodes.

The septa are moderately convex apicad. A structure that appears to represent the siphuncle is small, circular in cross section, and is located somewhat closer to the venter than the dorsum.

REMARKS.—The most distinctive feature of this species is the prominence of the lateral nodes on the conch. It is perhaps closest to *Foordiceras cooperi* (Miller), which, in addition to having smaller nodes, has a less prominent carina on its umbilical shoulder, and a smaller umbilical perforation.

This species was originally based on a single individual, but a fragmentary incomplete specimen from the same horizon and locality was referred to it with question. The specimen represented by Figures 9 and 10 on Plate 15 also comes from the same horizon and locality, and it seems to have the same large lateral ribs and prominent dorsolateral keel as the holotype and the fragmentary specimen. Accordingly, we are referring it to this species, though its umbilical perforation appears to be relatively small.

OCCURRENCE.—Middle part of upper Leonard formation on slopes south of road 0.2–0.5 mile east of Split Tank, 1.5 miles northeast of the bowed fork near the old Word Ranch house, about 19 miles north-northeast of Marathon, Brewster County, Texas.

REPOSITORY.—U. S. National Museum, 111617 (holotype), 111618 (fragmentary specimen referred to this species with question), and the specimen illustrated on Plate 15 is at the same institution.

Foordiceras mammiferum (Miller)

(Plate 15, figure 8; Plate 38, figure 2)

1945. *Metacoceras mammiferum* MILLER, Jour. Paleont., vol. 19, p. 282, 288–289, 291, pl. 45, fig. 2.

The holotype of this species (Pl. 38, fig. 2) is a silicified replacement of part of two volutions of the conch. The preserved part of this specimen is estimated to have attained a diameter of about 35 mm. Near the midlength of the remaining portion of the outer volution of this specimen the conch is about 14 mm. high, and its corresponding width is estimated to have been about 18 mm. Two of the fragmentary paratypes represent considerably larger individuals which appear to have attained dimensions something like 50 per cent larger than those of the holotype. Also, the specimen illustrated on Plate 15 is considerably larger than the holotype—it is somewhat crushed and therefore measurements more nearly accurate than those which can be secured from the illustration would have little significance.

The umbilicus is large and open, and the umbilical walls are moderately steep. Where the diameter of the conch measures about 26 mm., that of the umbilicus measures about 11 mm. The umbilical perforation is subovate, about 6 mm. long, and about 3½ mm. wide. The umbilical shoulders are fairly distinct but are not keeled during any stage of ontogenetic development.

The adapical half of the first volution of the conch is subcircular in cross section, but at the adoral end of that half volution, the conch is abruptly flattened dorsally, ventrally, and laterally. Eventually the dorsal side of the conch becomes concave as it is impressed by the ventral side of the preceding volution, but the ventral side remains slightly convex throughout ontogenetic development.

On the mature portion of the conch the growth lines, which are very fine, are almost straight and directly transverse on the umbilical walls, though they curve rather strongly apicad in the immediate vicinity of the umbilical shoulders. On the lateral zones of the conch, the growth lines are slightly sigmoidal, and on the ventral zone they form a deep rather narrowly rounded sinus. Except on its adapical half volution, the conch bears prominent ventrolateral nodes. When these were first developed, they had the appearance of short lateral ribs that were particularly prominent ventrolaterally. However, they soon evolved into prominent rounded ventrolateral spinose processes that had slight prolongations on the lateral zones of the conch, and they retained this form throughout the life of the individual—in the specimen illustrated on Plate 15, the lateral prolongations of the spines are more prominent than in the holotype. There are about 15 of these spines to the volution.

REMARKS.—The ventrolateral spines of this species, which are its most distinctive characteristic, are similar to those on the specimen from the Wewoka formation (mid-Pennsylvanian) of Oklahoma that Girty described as *Metacoceras cornutum* var. *sinuosum*. That form is known from only a single specimen that represents part of one volution of the conch, and therefore detailed comparisons are not possible. However, its ventral zone bears two longitudinal grooves, and in view of the fact that it is much older than the species under consideration, it is not probable that the two are closely related.

OCCURRENCE.—About 100 feet above the base of the Bone Spring limestone near the mouth of Apache Canyon about 0.2 mile north of the Van Horn quadrangle on the second promontory north of the lower bench on the outside rim of the northern part of Apache Canyon in the Sierra Diablo of Hudspeth County, Texas.

TYPES.—Princeton University (holotype and paratypes) and U. S. National Museum (Pl. 15, fig. 8).

Foordiceras megaporum (Miller)

(Plate 38, figures 3, 4)

1945. *Metacoceras megaporum* MILLER, Jour. Paleont., vol. 19, p. 282, 289–290, pl. 45, figs. 3, 4.

The holotype of this species is an essentially complete well preserved specimen about 50 mm. in diameter. Its conch, which consists of approximately two volutions, attains a maximum height of about 19 mm. and a corresponding width of about 24 mm. The length of the living chamber can not be determined, but it is at least a third of a volution. The umbilicus of this specimen is about 22 mm. in diameter; and the subovate umbilical perforation is about 8.5 mm. long and about 6 mm. wide.

The umbilical walls are very steep and are essentially perpendicular to the flattened lateral zones of the conch.

The adapical half of the first volution of the conch is rapidly expanded orad and is circular or nearly so in cross section. After the conch had completed half of a volution, it became abruptly flattened laterally, ventrally, and dorsally, and throughout ontogenetic development it remained almost square in cross section. However, before the conch had completed one full volution it became slightly concave dorsally and ventrally. The dorsal concave zone developed into an impressed zone in the adapical part of the second volution, but it is perhaps worth noting that the extreme adapical part (about 4 mm.) of the conch is not quite in contact with the following volution.

The adapical half volution of the conch bears prominent transverse growth lines and a slight ventrolateral ridge or raised line. At maturity, the growth lines are nearly straight on the umbilical walls, but they curve rather strongly apicad as they approach and cross the umbilical shoulders. On the dorsal part of the lateral zones their curvature is abruptly reversed, and they form a broad shallow rounded salient on the remainder of the lateral zones. On the ventral side of the conch they form a broad, deep, rather narrowly rounded sinus, a hyponomic sinus. At the adoral end of the first half volution, when the conch became more or less square in cross section, it developed a low rounded dorsolateral keel, which became relatively larger throughout ontogenetic development but at no time was very prominent. At about the same time that it developed a dorsolateral keel, the conch developed abruptly a row of rounded ventrolateral nodes, prolongations of which extend out onto the lateral zones of the conch as short ribs. These nodes increased in prominence until the conch attained full maturity, but on the extreme adapical part of the holotype they seem to diminish. On the outer volution of the holotype there are 12 of these nodes or ribs.

REMARKS.—In general physiognomy, this species resembles rather closely *Foordiceras cooperi* (Miller) of the Leonard formation in the Glass Mountains of west Texas. However, that form has a small umbilical perforation, whereas this one has a particularly large perforation. The size of the umbilical perforation seems to be one of the most distinctive characters of the species and suggested its name.

OCCURRENCE.—About 100 feet above the base of the Bone Spring limestone near the mouth of Apache Canyon about 0.2 mile north of the Van Horn quadrangle on the second promontory north of the lower bench and on the outside rim of the northern part of Apache Canyon in the Sierra Diablo of Hudspeth County, Texas.

HOLOTYPE.—Princeton University.

Foordiceras mutatum (Miller)

(Plate 38, figure 1)

1945. *Metacoceras mutatum* MILLER, Jour. Paleont., vol. 19, p. 283, 290–291, pl. 45, fig. 1.

This species is based on a single specimen that is exceptionally well preserved and almost complete—the adoral two-fifths of its outer volution represent living chamber. The conch consists of very slightly more than two full volutions, and its maximum diameter measures about 52 mm. Near the mid-length of the outer volution, the conch is about 19 mm. wide and about 17 mm. high.

The umbilicus is large and open, and its maximum diameter measures about 23 mm. The umbilical perforation is subovate, about 6 mm. long and 3.5 mm. wide. The umbilical walls are steep but not quite perpendicular to the flattened lateral zones of the conch. As in other representatives of this genus, the extreme adapical part of the conch is rapidly expanded and is almost circular in cross section. However, after the conch had completed approximately half a volution, its shape changed abruptly. That is, it was somewhat expanded in a lateral direction, its lateral and dorsal zones became flattened, and its ventrolateral and dorsolateral zones became subangular and developed slight carinae. The ventrolateral carina was developed somewhat more abruptly than the inconspicuous dorsolateral one, and it becomes obsolete on the adoral quarter volution of the holotype.

In the adoral part of the second half volution of the conch, the dorsal zone becomes slightly but distinctly concave, simulating an impressed zone, which of course does not start until the conch has completed a full volution. The ventral zone of the conch is slightly convex except in the adoral

half volution of the holotype, where it develops a rather prominent median groove some 6 or 7 mm. wide and at least 1 mm. deep. Also, in the adoral three-fifths of the outer volution of the holotype, there is a shallow groove about 1 mm. wide near the mid-height of the lateral zones.

For the most part, the growth lines are nearly straight and directly transverse on the umbilical walls, but as they approach the umbilical shoulders, they curve apicad. On the lateral zones of the conch these growth lines are sigmoidal, and on the ventral zone they form a moderately deep, rather broadly rounded sinus. On the adapical half volution of the conch, the growth lines seem to be particularly prominent. The adapical one and a third volutions of the conch do not bear more than a suggestion of lateral ribs. However, on the remainder of the holotype, that is, on the adoral two-thirds of its outer volution, low rounded lateral plications are gradually developed, and these become very large and prominent in the adoral part of the holotype. They are much more prominent on the ventral half of the lateral zones than on the dorsal half. They end abruptly on the ventrolateral zones and can almost be said to form nodes there.

The siphuncle is small and is composed of cylindrical segments. Where the conch is about 16 mm. high, the siphuncle is about 1 mm. in diameter and is located about 5 mm. from the venter.

REMARKS.—The most distinctive character of this species is the development of the prominent lateral ribs and ventral and lateral grooves on the adoral portion of an otherwise almost smooth conch. The adapical and the adoral half volutions of the holotype contrast strongly with the rest of it.

OCCURRENCE.—Upper part of Leonard formation south of the road 0.2–0.5 mile east of Split Tank, 1.5 miles northeast of the bowed fork near the old Word Ranch house, about 19 miles north-northeast of Marathon, Brewster County, Texas.

HOLOTYPE.—U. S. National Museum, 111619.

Foordiceras ornatissimum, n. sp.

(Plate 46, figures 3-5)

1947. *Metacoceras* aff. *M. cheneyi* MILLER AND YOUNGQUIST, Kansas Univ. Paleont. Contr., Mollusca, art. 1, p. 6.

The holotype of this species is a small rather well preserved specimen that consists of much of two volutions. Its maximum overall length, in its present incomplete condition, measures about 38 mm. The conch is expanded orad rather gradually and at maturity is subrectangular in cross section, being strongly flattened laterally and ventrally and in general slightly convex dorsally (but with a slight dorsal impressed zone). The lateral zones of the conch are essentially parallel. At the adoral end of the holotype the conch is about 16 mm. high and 21 mm. wide. The umbilicus is large and is perforate, and the umbilical walls are steep, being inclined to the flat lateral walls of the conch at an angle of some 75 degrees.

On the ventral side of the mature portion of the conch, there is a broad median zone that is essentially flat or even very slightly concave. Faint traces of the growth-lines suggest that there was a broad deep rounded hyponomic sinus on this flat ventral area. The lateral zones of the conch are almost flat, but superficially they appear to be concave as there is a row of very prominent nodes on each of the ventrolateral shoulders of the conch and a distinct carina on the dorsolateral (umbilical) shoulders. The ventrolateral nodes are in general rounded, but they extend dorsally on the lateral zones of the conch as low short oblique ridges. The dorsolateral carina is narrowly rounded and is not particularly prominent; it is present on at least all of the preserved part of the outer volution of the holotype. As shown by Figure 5 of Plate 46, on the adapical portion of the conch there are very prominent raised lines. These form a deep narrowly rounded V-shaped ventral sinus but are essentially straight and directly transverse on the lateral zones of the conch.

The sutures form broad shallow rounded ventral and lateral lobes and somewhat deeper dorsal lobes (on the impressed zone). The siphuncle is small and is subcentral in position but is distinctly nearer the venter than the dorsum; its segments are not expanded transversely within the camerae.

REMARKS.—Miller and Youngquist (1947, p. 6 in discussing their then new species, *Foordiceras* ["*Metacoceras*"] *cheneyi*, mention that they had one fragmentary specimen which "has very prominent rounded ventrolateral nodes that are reminiscent of those that occur on *M.* [*F.*] *mammiferum*".

Miller. It came from the same horizon and locality as the holotype of *F. ornatissimum*, and a direct comparison leaves no doubt in our minds that the two are conspecific. These specimens seem to differ particularly from the holotype of *F. mammiferum* in that their dorsolateral shoulders bear distinct carinae.

OCCURRENCE.—Wildcat Creek shale member of Admiral formation about 4½ miles south-southwest of Coleman, Coleman County, Texas.

TYPES.—Renfro Collection, Fort Worth, Texas (holotype); and U. S. National Museum (fragmentary paratype).

Foordiceras praecursor Girty

(Plate 42, figures 8–10)

1908. *Foordoceras shumardianum praecursor* GIRTY, U. S. Geol. Surv., Prof. Pap. 58, p. 22, 55, 498, pl. 25, figs. 15–15b.
1942. *Parametacoceras praecursor* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720.
1948. *Parametacococeras praecursor* BRANSON, Geol. Soc. Am., Mem. 26, p. 807.

The only published description of this species reads as follows:

"This species is related to the preceding [*Foordiceras shumardianum* Girty] and has, in fact, about the same general aspect. A careful inspection, however, reveals differences which render it impossible to consider them the same. The septa are somewhat more closely arranged. There is no sharply defined umbilical shoulder, and the growth lines, which are clear and very elegant over the small area of surface preserved in my specimen, show a considerably deeper hyponomic sinus. Like the foregoing, this species is marked on the umbilical and lateral zones with transverse and revolving lines, which produce a reticulated surface ornamentation."

REMARKS.—We have not seen the type specimens of this form, and therefore are reproducing the available illustrations and description of the species. That description is, unfortunately, very brief.

In view of the fact that the syntypes of this species came from a much lower horizon than did the type specimens of *Foordiceras shumardianum*, it is not likely that these two forms are as closely related as Girty apparently believed, and they do not seem to us to be very similar. Miller and Unklesbay placed them in two different genera, *Parametacoceras* and *Metacoceras*. However, *Parametacoceras* is now known to be a synonym of *Foordiceras*, and Girty's illustrations of the form Miller and Unklesbay referred to *Metacoceras* do not show very well the lateral ribs that are so characteristic of *Foordiceras*—in his text Girty makes it clear that these ribs are present.

OCCURRENCE.—Black limestone member of Bone Spring formation at two localities in the Guadalupe Mountains of Culbertson County, Texas: (1) "Small canyon among foothills about 2 miles south of Guadalupe Peak and (2) "low hills, about 2 miles south of El Capitan."

SYNTYPES.—U. S. National Museum.

Foordiceras shumardianum Girty

(Plate 42, figures 4–7)

1908. *Foordoceras shumardianum* GIRTY, U. S. Geol. Surv., Prof. Pap. 58, p. 16, 55, 490, 496, 497–498, pl. 9, figs. 26–27a.
1942. *Metacoceras shumardianum* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720.
1948. *Metacoceras shumardianum* BRANSON, Geol. Soc. Am., Mem. 26, p. 792.

When Girty established this species, he described it as follows:

"Shell rather small, somewhat rapidly enlarging. The transverse section is more or less that of a rectangle, with the width slightly greater than the height. The sides are flattened and nearly parallel. They are marked by well-defined pilae, which appear to be slightly curved, with the concave side directed toward the aperture. The pilae terminate above in nodes and the distance between them is about the same as their own length. The ventral arch is broad, the chief curvature occurring at the abdominal angle. There is also a distinct umbilical shoulder which, where the shell is not exfoliated, is marked by an abrupt change in direction. The angle thus produced is emphasized by slight depressions above and below. The depressed zone is narrow, not so broad as either the umbilical or lateral zones, which are about equal in width.

"The venter is marked by fine but distinct transverse lines, the direction of which indicates the presence of a rather deep, broad hyponomic sinus. On the lateral and umbilical zones these appear

to become slightly stronger, more regularly arranged and sublamellose. On these areas also they are crossed by revolving lines, which are both fainter and finer than the transverse ones.

"The flexures of the sutures are all gentle. The entire ventral area is occupied by a broad, shallow lobe; a low saddle falls upon the abdominal shoulder; a second shallow lobe occurs on the lateral zone, while from the umbilical shoulder to the edge of the depressed zone the suture is practically straight.

"The siphuncle is nearly central in the mature portion of the shell, but becomes more ventral in the earlier stages.

"This species seems to belong to the group for which Hyatt proposed the term *Foordoceras*, and which is found chiefly in the Salt Range of India. It probably is a member of the *Goliathus* section, as recognized by Hyatt, but differs in having a proportionately narrower venter and a more distinct umbilical shoulder. The shape is in fact more like the *transitorius* section, but it does not have the depressed median belt along the venter which characterizes that division. The Indian shells are not described as having the surface ornamentation possessed by the present species, but the revolving lines which are its most peculiar feature are confined to the sides, where they might easily be concealed."

REMARKS.—We have not seen the syntypes of this species, and therefore are reproducing the published illustrations and description of them. Both of the figured specimens are small, and they may well not be conspecific. The lateral ribs on their conchs (described by Girty but not shown very plainly by his illustrations) indicate a relationship to *Foordiceras*, rather than to *Metacoceras*.

OCCURRENCE.—Middle of Capitan formation ("about 1,000 feet below summit of El Capitan and the top of the Capitan limestone") "just below knob on crest of spur running northward from El Capitan," Guadalupe Mountains, Culbertson County, Texas.

Foordiceras sp.

1891. *Temnocheilus Conchiferous* [part?] HYATT, Texas Geol. Surv., An. Rept. 2, p. 329–330, text figs. 23, 24.
1891. *Temnocheilus conchiferus* [part?] HYATT, Texas Geol. Surv., An. Rept. 2, p. 332.
1893. *Temnocheilus conchiferus* [part?] HYATT, Texas Geol. Surv., An. Rept. 4, p. 391.
1933. *Endolobus conchiferus* [part?] MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 194.
1942. *Endolobus conchiferous* [part?] MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720.
1948. *Endolobus conchiferous* [part?] BRANSON, Geol. Soc. Am., Mem. 26, p. 775.

When Hyatt established "*Temnocheilus Conchiferous*" he apparently based it on a variety of specimens, but he illustrated only one. It is a subglobose non-nodose individual which we are designating the holotype, and on the basis of it the species is being referred to *Stearoceras*. However, Hyatt stated that some of the original type specimens have convex sides that are "ornamented with short, thick, heavy-looking fold-like pilae, which are prolongations of the thick, heavy, but not very prominent nodes on the edges of the abdomen." Presumably these are referable to *Foordiceras*, but it should be emphasized that we have not seen any of the material studied by Hyatt.

OCCURRENCE.—The specimens described by Hyatt in 1891 came from some unrecorded horizon and locality (or horizons and localities) in the Late Paleozoic of Texas. In 1893 Hyatt stated that he had some conspecific material from the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas, and the strata exposed there belong in the Grape Creek limestone of the Clyde formation.

REPOSITORY.—University of Texas.

Genus *Metacoceras* Hyatt, 1883

GENOTYPE: *Nautilus* (*Discus*) *Sangamonensis* Meek and Worthern.

When Hyatt established this genus, he designated as its type *Nautilus* (*Discus*) *Sangamonensis* Meek and Worthen of the Upper Pennsylvanian McLeansboro formation of Sangamon County, Illinois (Pl. 11, figs. 9, 10). At that time, only one other specific representative of the genus was cited, "Meta. (Lit.) occidentale, sp. Hall from Trenton of Ill. Am. Mus. N. Y." Considerable doubt exists as to whether Hyatt thought that the Illinois specimen in the American Museum of Natural History, to which he referred, belongs in the species which in 1861 Hall described from the Black River of "Beloit and elsewhere, in Wisconsin" as *Lituites undatus* var. *occidentalis*, or in the species that in 1860 Hall described from the Niagaran of Illinois as *Nautilus* (*Lituites*) *occidentalis*. However, in either

case, it is very improbable that an Early Paleozoic form belongs in this genus, which has a Late Paleozoic genotype.

As we look over the numerous forms that have been referred to this genus, it is clear that they show a great deal of variation particularly in so far as cross section of conch, ornamentation, and general physiognomy are concerned. Several attempts have been made to subdivide these species into natural groups, without very satisfactory results. We are removing to *Foordiceras* those that possess prominent lateral ribs. Nevertheless, it now seems to us that the genus *Metacoceras* will have to be allowed a considerable amount of latitude and that for the present, at least, it will retain the majority of the numerous forms which have been referred to it. These are widespread and abundant in both the Pennsylvanian and the Permian of this country, and they have been recorded from the Late Paleozoic strata of Great Britain (Bisat, 1930), Belgium (Demanet, 1943), Spain (Delépine, 1943), Italy (Merla, 1931), Soviet Russia (Tzwetaev, 1888; Jakowlew, 1899; Kruglov, 1928), China (Grabau, 1924), Sumatra (Roemer, 1880, 1881; and Fliegel, 1901), etc.

From a study of the published illustrations and descriptions of the genotype and many similar forms, and the numerous specimens available to us, we have drawn up the following generic diagnosis of *Metacoceras:*

Conch rather thickly subdiscoidal in shape and nautiliconic in its mode of growth but only slightly involute. Whorls rather gradually expanded orad and subquadrate or subrectangular in cross section being only slightly depressed dorsoventrally or compressed laterally and in typical forms slightly concave laterally. Umbilicus large, open, and perforate. Umbilical shoulders abrupt and umbilical walls steep. Surface of test bears fine growth lines which form a deep rounded ventral sinus. Ventrolateral zones of conch nodose, and in some forms nodes occur also on the umbilical shoulders. Sutures form broad shallow rounded ventral, lateral, and dorsal lobes. Siphuncle small, subcentral, and orthochoanitic.

Clearly *Metacoceras* is closely related to such genera as *Domatoceras, Foordiceras, Stearoceras, Temnocheilus,* and *Titanoceras.* In *Domatoceras* the whorls are compressed and are not concave laterally, and the ventrolateral nodes are developed only during late maturity and are largely confined to the test. The lateral zones of *Foordiceras* bear prominent ribs which are extensions of ventrolateral nodes. There are no prominent ventrolateral or dorsolateral nodes in *Stearoceras.* In *Temnocheilus* the conch is strongly depressed dorsoventrally, the nodes are large, and the lateral zones of the conch are converged dorsad. *Titanoceras* characteristically has whorls that are concave ventrally and convex laterally and have broadly rounded umbilical shoulders. Nevertheless, it should be clearly understoond that forms are known that are more or less intermediate between each of these several genera, and particularly between *Foordiceras* and *Metacoceras.*

Representatives of *Metacoceras* are both widespread and abundant in the marine phases of the Pennsylvanian or Upper Carboniferous and the Permian of North America and Eurasia, and stratigraphically the genus is known to range throughout essentially all of those two systems. Altogether, the collections now available to us for study contain several hundred specimens which are referable to this genus. These reveal so much variation in the details of the shape, ornamentation, etc. of the conch, that it is indeed difficult to delimit species. Normally, we would be inclined to regard many of the forms under consideration as varieties of established species, but such a procedure does not seem to be practicable in this case because of the extreme amount of variation in all of the characters involved. Therefore, more or less as a matter of expediency, we are recognizng most of the variants as distinct species.

Metacoceras baylorense, n. sp.

(Plate 43, figures 1, 2; Plate 44, figure 1)

The holotype of this species (Pl. 43, figs. 1, 2) is about 150 mm. in diameter. It is an internal mold that represents much of the phragmacone and the living chamber. With the exception of the adoral quarter volution, the phragmacone of this specimen is very poorly preserved. The part of the living chamber that is retained is almost half a volution in length. The conch appears to be expanded orad rather gradually for this genus. The whorls are subrectangular in cross section, being flattened laterally and ventrally and only slightly impressed dorsally. The ventral zone is divisible into three

subequal parts, the median one of which is slightly concave, whereas the lateral ones are slightly convex. The lateral zones of the conch are essentially flat, or very slightly concave. The whorls are distinctly wider than high, and at the junction of the phragmacone and the living chamber the conch is about 45 mm. high and its corresponding width is estimated to be some 50 to 55 mm.

The umbilicus is large and open, and its diameter is equal to about three-fifths that of the specimen. The umbilicus of the holotype attains a maximum diameter of about 90 mm. The umbilical shoulders are rounded but are fairly definite. The umbilical walls are rather steep and are slightly but distinctly convex.

On each of the ventrolateral zones of the conch, there is a single row of large rounded nodes that are somewhat elongate obliquely. Also there are traces of low rounded nodes just outside the umbilical shoulders. The preservation of these nodes on the holotype is only fair, and the specimen appears to have been slightly distorted during fossilization. Small fragments of the test preserved near the umbilical seam of the figured side of the holotype are reticulate as they bear fine transverse and longitudinal lines—the longitudinal lines are sinuous. This ornamentation may well be on an inner layer of the test rather than on its surface.

The camerae are short. Each suture forms a broad shallow rounded ventral lobe and on either side of it a rather narrowly rounded ventrolateral saddle and a moderately deep (for this genus) asymmetrical lateral lobe. The course of the sutures across the umbilical walls is essentially straight and directly transverse. Presumably there is a broad rounded dorsal lobe. No trace of the siphuncle is visible on either of the type specimens.

The single paratype (Pl. 44, fig. 1) resembles the holotype in general physiognomy. However, only faint traces of nodes are present on it, presumably as a result of weathering which the specimen appears to have undergone. The maximum diameter of this specimen measures about 125 mm.

REMARKS.—The most distinctive characters of this species seem to be its rather large size for this genus, only slightly depressed whorls, shallow concave zone along the venter, oblique ventrolateral and faint dorsolateral nodes, short camerae, and rather strongly sinuous sutures. In general physiognomy it resembles the form from the Lueders limestone of north-central Texas that we are illustrating and describing as *Metacoceras* sp. However, its ventral zone is more strongly flattened, its ventrolateral nodes are more numerous, and its dorsolateral nodes are less prominent.

OCCURRENCE.—Both of the type specimens came from the basal portion of the Lueders formation east of Throckmorton highway along Self School Creek about 8 miles south of Seymour, Baylor County, Texas.

TYPES.—Private collection of Augusta Hasslock Kemp of Seymour, Texas.

Metacoceras bituberculatum, n. sp.

(Plate 49, figures 3, 4)

The only known representative of this species is a silicified replacement of half of two volutions of the conch. The preserved portion of this specimen was about 80 mm. in diameter, and near its adoral end the conch was about 45 mm. wide and 32 mm. high. The whorls are subrectangular in cross section as they are flattened ventrally, laterally, and dorsally, but medianly are slightly concave on all four sides.

The umbilicus, which is perforate, is moderately small for this genus, and that of the preserved part of the holotype attained a maximum diameter of some 27 mm. The umbilical shoulders are abrupt, and the umbilical walls are steep.

Both the dorsolateral and the ventrolateral shoulders of the conch are nodose. In each case the nodes are rounded and are rather far apart. Those on the ventrolateral shoulders are relatively large, and the nodes in the two series are not paired. No traces of growth lines, septa, or siphuncle are discernible on the holotype.

REMARKS.—The nodose dorsolateral shoulders serve to distinguish this species from most congeneric forms. The relatively small umbilicus and the size and spacing of the nodes differentiate it from the others.

OCCURRENCE.—Lower part of upper Leonard formation on the south side of the road between the

road fork and the Sheep Tank at the old Word Ranch in the Glass Mountain region of Brewster County, Texas.

HOLOTYPE.—U. S. National Museum.

Metacoceras cheneyi Miller and Youngquist

(Plate 45, figures 1–3; Plate 46, figures 6–8)

1947. *Metacoceras cheneyi* MILLER AND YOUNGQUIST, Kansas Univ. Paleont. Contr., Mollusca, art. 1, p. 2, 6, pl. 1, figs. 16–18.

This species was based on two specimens, both of which are illustrated. The more nearly complete one (Pl. 45, figs. 2, 3) is the holotype. It represents the adoral camera of the phragmacone and much of the living chamber, whereas the paratype is non-septate throughout. The holotype attains a maximum diameter of about 70 mm., and near its adapical end the conch is about 25 mm. wide and 17 mm. high—the maximum width is attained at the umbilical shoulders. The conch is expanded orad rather gradually and regularly, but because of the incompleteness of the adoral portion of the holotype, significant measurements of it can not be secured.

The whorls are irregularly hexagonal in cross section. The broad ventral zone is in general convex, but it is very slightly concave medianly. The lateral zones are distinctly concave, the dorsolateral convex, and the dorsal concave. The umbilical shoulders are fairly distinct, the umbilical walls are only moderately steep, and the maximum diameter of the umbilicus of the holotype measures about 40 mm. The living chamber is at least three-fifths of a volution in length.

Traces of the growth-lines are preserved on the adoral portion of the holotype. They are more or less straight and directly transverse on the umbilical walls and the lateral zones of the conch, but they form sinuses as they cross the umbilical shoulders. On each ventrolateral and dorsolateral shoulder of the conch there is a single row of prominent nodes. Those on the ventrolateral shoulders are longitudinally elongate, and the distance between them seems to increase adorally. There are eight of these nodes on the adoral half-volution of the holotype. The dorsolateral nodes are less prominent than the ventrolateral ones. They are also elongate but the direction of their elongation is oblique to the long axis of the conch. Although the dorsolateral and the ventrolateral nodes are about equal in number, there seems to be no interrelationship between the nodes in the two rows.

Along the venter, the adoral camera of the phragmacone of the holotype (the only one preserved) is about 6 mm. in length. The sutures are directly transverse to the long axis of the conch, but they are slightly sinuous, forming shallow ventral, lateral, dorsolateral, and almost certainly dorsal saddles. No trace of the siphuncle is visible in either of the type specimens.

The single paratype (Pl. 45, fig. 1) does not seem to differ materially from the holotype. Inasmuch as both are of about the same general size and proportions, it is probable that they represent mature individuals.

The specimen illustrated by Figures 6–8 on Plate 46 is largely if not entirely septate. It is strikingly similar to the adapical portions of the type specimens in so far as size, shape, and ornamentation are concerned. The adapical end of this specimen is formed by a septum which shows that the siphuncle is subcentral in position but is somewhat nearer the venter than the dorsum.

REMARKS.—This species is readily differentiated from most of the known representatives of *Metacoceras* by means of the nodes on its umbilical shoulders. Furthermore, in the few forms in which dorsolateral nodes occur, they are not very prominent or obliquely elongate, for example, in *M. mutabile* Miller and Owen and *M. biseriatum* Miller and Owen of the Cherokee of Missouri and in *M. angulatum* Sayre of the Westerville limestone (Kansas City) of the same state.

For the sake of completeness, it should be mentioned that the collections we are studying contain three small fragments that we are tentatively associating with this species. All of them are from the same horizon and locality as the types. It should also be stated that one of the fragments which Miller and Youngquist (1947, p. 6) mentioned in their discussion of this species is being designated as the paratype of *Foordiceras ornatissimum*, n. sp.—that specimen has very prominent rounded ventrolateral nodes that have rib-like extensions on the lateral zones of the conch.

OCCURRENCE.—Wildcat Creek shale member of Admiral formation about $4\frac{1}{2}$ miles south-southwest of Coleman, Coleman County, Texas.

REPOSITORIES.—U. S. National Museum (holotype, paratype, and 3 specimens tentatively left in this species); and Renfro Collection, Fort Worth, Texas (Pl. 46, figs. 6–8).

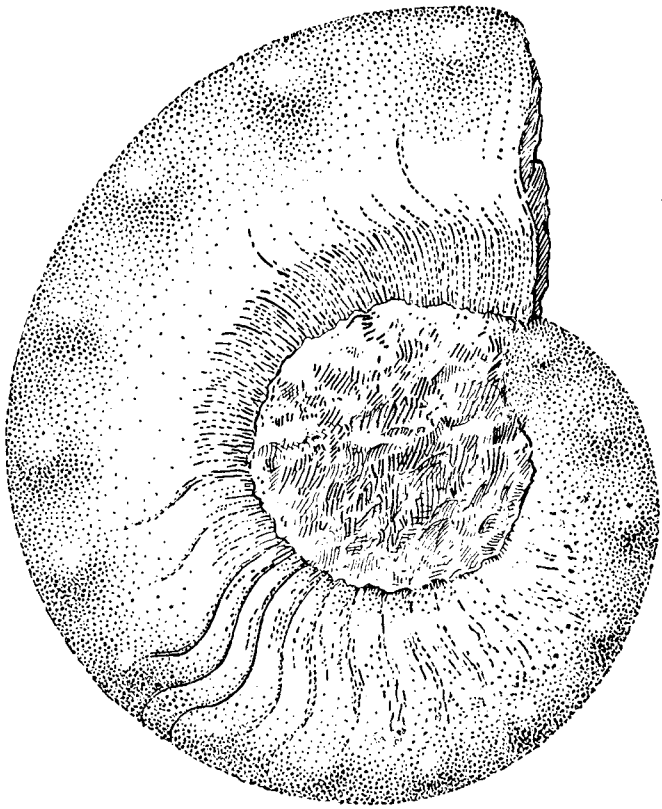

FIGURE 30.—*Metacoceras dubium* Hyatt

The holotype, from the Fort Riley limestone? at Junction City, Kansas, × 1. After Hyatt.

Metacoceras dubium Hyatt

1891. *Metacoceras dubium* HYATT, Texas Geol. Surv., An. Rept. 2, p. 336–337, text figs. 34, 35.
1893. *Metacoceras dubium* HAY, Kansas Acad. Sci., Trans., vol. 13, p. 38, 39–40, text figs. 6, 7.
1915. *Metacoceras dubium* GIRTY, U. S. Geol. Surv., Bull. 544, p. 239.
1933. *Metacoceras dubium* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 168, 176–178, text figs. 26, 27.

Hyatt's description of this species reads as follows:

"There are no lines of abdominal tubercles, only low broad, longitudinal swellings on either side of the depressed central zone of the abdomen, and the nodes on the sides are large and prominent, as in other species of this genus. The sides, however, are narrow and slightly concave, and internally a ridge is formed on account of the suddenness with which they incline to the umbilicus at the dorsal shoulders, and inside of this there are two broad, smooth, only slightly convex zones on either side of the umbilical shoulders. The umbilical shoulders or crests may be slightly nodular in some specimens. There is an impressed zone on the dorsum, the involution embracing the surface of the abdomen but not covering the nodes. The transverse diameter through the umbilical shoulders is greater than that measured through the dorsal part between any two nodes in a full grown shell which has not been distorted by compression. Fig. 35 [31 of the present publication].

"The sutures are nearly straight or slightly concave on the inside of the umbilical shoulders, with

a shallow lobe on the dorsal zone, slight lateral lobes on the sides, and small saddles at the junction (genicular crest) of sides and abdomen. On the abdomen there are only very shallow broad lobes.

"Siphuncle above the centre. Living chamber somewhat over one-half of a volution in length and still imperfect."

REMARKS.—We have not seen any representatives of this species and therefore are reproducing the only available illustrations and description of it. Hyatt was of the opinion that this form may not be referable to *Metacoceras*, but it comes well within the scope of that genus as now understood.

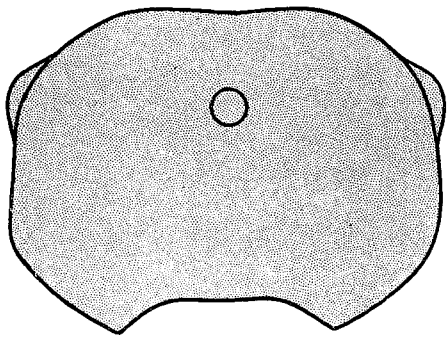

FIGURE 31.—*Metacoceras dubium* Hyatt

Diagrammatic cross section of the holotype, from the Fort Riley limestone? at Junction City, Kansas, × 1. After Hyatt.

Nevertheless, it seems to be quite distinct from all of the species with which we are familiar. Price (Swartz, Price, and Bassler, 1919, p. 578) has referred with question to this species some specimens from the Pennsylvanian Brush Creek and Ames limestones of Maryland, but because of the disparity in age between the beds there and those that yielded the holotype, we are inclined to suspect that the relationship is not close.

OCCURRENCE.—The only information given by Hyatt in regard to the distribution of this species is that the holotype came from the Carboniferous of Kansas. Hay, however, states that it came from Junction City, in Geary County, Kansas, and therefore it seems probable that it is from the Fort Riley limestone.

HOLOTYPE.—Robert Hay Collection.

Metacoceras hayi Hyatt

1891. *Metacoceras Hayi* HYATT, Texas Geol. Surv., An. Rept. 2, p. 339–340, text figs. 38, 39.
1893. *Metacoceras Hayi* HAY, Kansas Acad. Sci., Trans., vol. 13, p. 38, 40–41, text figs. 8, 9.
1901. *Temnocheilus* (*Metacoceras*) *Hayi* [part] FLIEGEL, Palaeontographica, Bd. 48, p. 119–120 [not pl. 8, fig. 13].
1915. *Metacoceras hayi* GIRTY, U. S. Geol. Surv., Bull. 544, p. 239, 240.
1933. *Metacoceras hayi* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 168, 173–175, text fig. 25.

Hyatt described this species as follows:

"This cast [internal mold] has broad flattened sides, having angular umbilical shoulders where the sides descend abruptly to the umbilici. There is an outer row of tubercles on the edge of the abdomen. These are elongated longitudinally and the depressions between them are often very distinct; the surface of the cast is otherwise smooth. The sutures have short and very broad lateral lobes with saddles at the umbilical shoulders and on the abrupt edges of the abdomen. The abdominal lobe is short and broad. It has a slight angle or V-shape in the specimen, but this is proabably due to compression. The sutures just inside of the umbilical shoulders appear to be nearly straight on the nearly vertical narrow zones on either side of the outer whorl, but there is probably a shallow dorsal lobe on the impressed zone. The living chamber is about one-fourth of a volution in length and still incomplete. The specimen is much narrowed by compression, and making due allowance for this the abdomen is slightly broader than the dorsum, measuring through the umbilical shoulders, and it has been

so represented in the drawing. The amount of involution is slight, the whorls being in contact only along the surface of the slightly convex abdomen, and there is consequently only a shallow impressed zone in the dorsal surface of each whorl. Nevertheless the increase by growth in the dorso-abdominal diameter of the whorl is evidently rapid.

"Specimens of this and some other species were received through the courtesy of Captain George E. Pond, of Fort Riley, Kansas.

"The front view [Fig. 32A] is in large part restored from a much compressed specimen.

"Its nearest ally occurs in the Carboniferous in Russia. It differs from *Metacoceras* (*Nautilus*) *Tschernyschewi* Tzwetaev, in having somewhat broader sides and a narrower abdomen at the same age, and fewer tubercles. These also are elongated longitudinally, whereas in *Tschernyschewi* they are elongated transversely forming a series of rib-like folds."

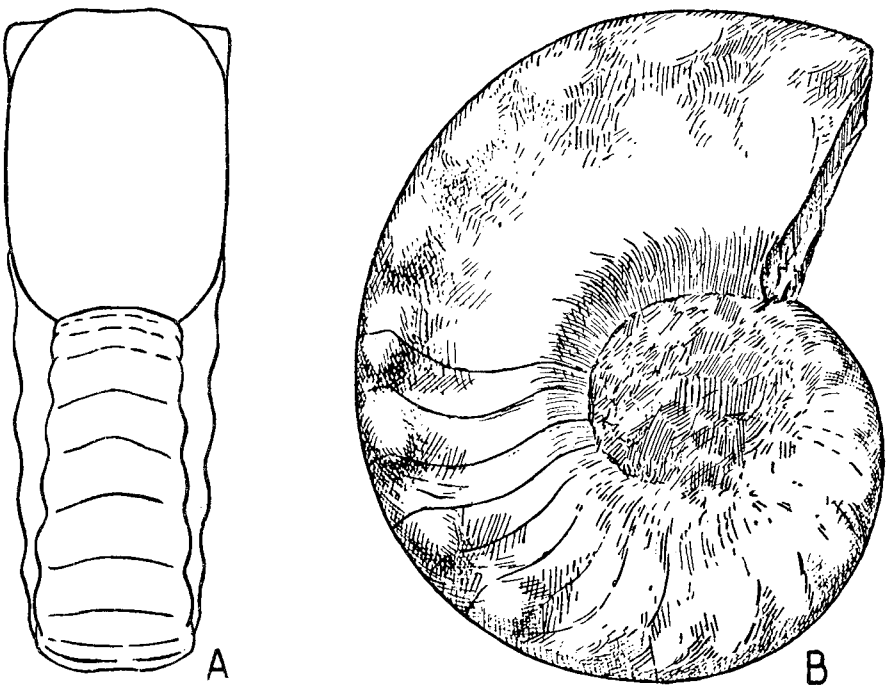

FIGURE 32.—*Metacoceras hayi* Hyatt

The holotype, from the Fort Riley limestone? at Junction City, Kansas, × 1. A is a restoration. After Hyatt.

REMARKS.—We have not seen any representatives of this species, and hence are reproducing the only available description and illustrations of it. One of these pictures (Fig. 32A) indicates that the conch is considerably higher than wide, which, to say the least, is very unusual for this genus. However, that drawing is stated to be "in large part restored from a much compressed specimen," and it may therefore not be very accurate.

A specimen from the Permian of Sumatra has been referred to this species by Fliegel (1901, p. 119–120, pl. 8, fig. 13—see also Roemer, 1880, p. 9, pl. 3, fig. 3; and 1881, p. 300, pl. 3, fig. 3). It appears to bear a striking resemblance to the holotype and is most probably related. However, both specimens are stated to be considerably crushed, they came from widely separated localities, and there is no good reason to believe that the beds which yielded them are of the same age. Therefore, we are inclined to suspect that the similarity is more apparent than real.

OCCURRENCE.—The only information given by Hyatt in regard to the distribution of this species is that the type specimen came from the Carboniferous of Kansas. Hay, however, states that it came from Junction City, in Geary County, Kansas, and therefore it seems probable that it came from the Fort Riley limestone.

HOLOTYPE.—Robert Hay Collection.

Metacoceras inconspicuum Hyatt

1891. *Metacoceras inconspicuum* HYATT, Texas Geol. Surv., Ann. Rep. 2, p. 340–341, text figs. 40, 41.
1893. *Metacoceras inconspicuum* HAY, Kansas Acad. Sci., Trans., vol. 13, p. 38, 41–42, text figs. 10, 11.
1915. *Metacoceras inconspicuum* GIRTY, U. S. Geol. Surv., Bull. 544, p. 239.
1933. *Metacoceras inconspicuum* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 168, 181–184, text figs. 29, 30.
(?) 1942. *Metacoceras inconspicuum* CLIFTON, Jour. Paleont., vol. 16, p. 688, 696.
(?) 1944. *Metacoceras inconspicuum?* CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.

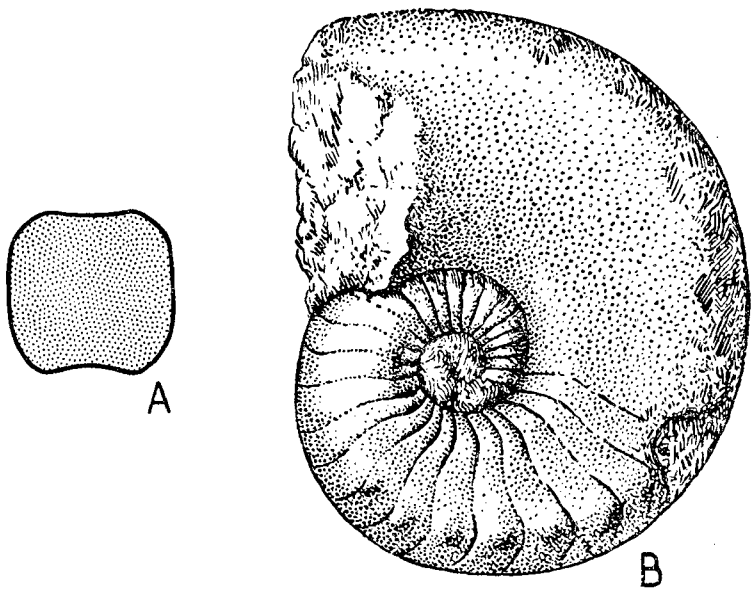

FIGURE 33.—*Metacoceras inconspicuum* Hyatt

The holotype, from the Fort Riley limestone? near Junction City, Kansas, × 1. The cross section represents the "adolescent whorl without tubercles." After Hyatt.

Hyatt described this species as follows:

"This cast [internal mold] has an aspect which at first sight leads one to think it is a species of Tainoceras, but the abdominal sutures are deficient in the pair of saddles distinguishing that genus, and there are no lines of abdominal tubercles. The whorl increases in abdomino-dorsal diameters faster than *Metacoceras cavatiformis*, but not in the transverse diameters; the whorl is consequently more compressed. The umbilical shoulders are not so angular as in that species, and the sides broader and less convergent outward, and the tubercles on the outer border of the sides are less conspicuous upon this cast. The sutures have about the same general contour as in the nearest ally just mentioned, but the lateral lobes are broader and shallower and the saddles at the umbilical shoulders are not so prominent.

"The young do not seem to have the pilae so plainly shown in the umbilicus of *Metac. cavatiformis*, but the cast may deceive the observer in this respect.

"Fig. 41 [33A of the present publication] represents a section of the adolescent whorl without tubercles."

REMARKS.—We have not seen any representatives of this species, and therefore are reproducing the only available description and illustrations of it. They indicate that this form is a typical representative of the genus *Metacoceras* but is not particularly close to any of the other known representatives of that genus. One of its most distinctive characters is perhaps the almost square cross section of its conch. The conch of the type species of *Metacoceras* is also about as wide as high, but it is not

as rapidly expanded adorally as is that of *M. inconspicuum* and it is convex rather than concave ventrally.

In 1942 under the heading *Metacoceras inconspicuum* Hyatt, Clifton stated: "Specimens of the genus *Metacoceras* occur in the Blaine and the Dog Creek formations [of north-central Texas]. Some of the forms attain a relatively large size, being as much as 130 millimeters in diameter. The assignment of these specimens to *M. inconspicuum* is not an entirely satisfactory one. The Blaine and the Dog Creek forms may be a new species." We have not seen these specimens, and this quotation is the only available "description" of them. Hence, we are not able to express an opinion in regard to their affinities.

OCCURRENCE. Hyatt indicates only that the type specimen is from the Carboniferous of Kansas. However, Hay states that it came from Junction City in Geary County, Kansas, and presumably therefore it is from the Fort Riley limestone.

Clifton states that the specimens which he rather doubtfully referred to this species are from the Acme member of the Blaine formation and the Guthrie member of the Dog Creek formation of north-central Texas. Furthermore, he indicates that the Acme specimens are from the following localities: (1) "an extensive area, including sections 148, 168, 169, 173, 198 and adjacent sections, north and northwest of Quanah, in Block H, of the Waco and NW. R. R. Company Survey, Hardeman County, Texas;" and (2) "northeast Nolan County and Southeast Fisher County in Texas. Chiefly, Sec. 289, B. H. Stribling Survey, and Sec. 290, R. Cochran Survey." Clifton's Guthrie specimens are stated to be from "section 139 and areas northeast, in Block F, of the H. & T. C. R. R. Co. Survey, Stonewall County, Texas." It should be added that according to Clifton this form is "common at these localities" and that in all three it occurs in association with the ammonoid genus *Perrinites*.

HOLOTYPE.—Robert Hay Collection.

Metacoceras knighti Miller and Thomas

(Plate 47, figures 2, 3)

1936. *Metacoceras knighti* MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 728–729, pl. 97, figs. 2, 3.

Conch, which at maturity consists of at least three or four volutions, is subdiscoidal, nautiliconic though only slightly involute, and large, attaining a diameter (measured across the umbilicus) of at least 115 mm. and a maximum height and width of conch of at least 45 mm. and 55 mm., respectively. Extreme adapical portion of conch is rapidly expanded and is circular or nearly so in cross section. However, lateral diameter increases more rapidly than dorsoventral diameter, and conch becomes depressed very early in its ontogenetic development. During the first volution the dorsal side of the conch is less strongly arched than the ventral side, and the cross section of the conch is subelliptical. Immediately orad of the first volution of the conch, umbilical shoulders are gradually developed and at about the same time there appears on the ventrolateral zones of the conch a low narrow ridge—the lateral walls of the conch are thus defined and the whorls become subrectangular in cross section, which shape is retained throughout ontogenetic development. At full maturity the ventral part of the conch is gently convex, the lateral walls which converge slightly ventrad are nearly straight, and the dorsal part is composed of three divisions—nearly straight umbilical walls separated by a median shallow rounded impressed zone. Both the ventrolateral and the dorsolateral zones of the conch are subangular.

Umbilicus large and perforate. Its diameter is equal to about half that of the specimen. Umbilical perforation is oval in shape and is about 4 mm. wide and 5 mm. long. Umbilical walls moderately steep.

Apertural margins not retained by any of the numerous specimens available for study, but growth lines are essentially straight and directly transverse on umbilical walls and lateral zones of conch, and form broad deep rounded sinuses on ventral side (Pl. 47, fig. 2). With the exception of the growth lines, the first volution of the conch is smooth or nearly so, though at the adoral end of the first half volution there is a slight but very distinct constriction. On the adapical portion of the second volution of the conch, a low narrow ridge appears on each of the ventrolateral zones. During the

first quarter of the second volution these ridges become nodose and each is transformed into a row of longitudinally elongate nodes. These nodes soon develop lateral extensions and gradually they become obliquely elongate (Pl. 47, fig. 3). Orad of the first volution of the conch, umbilical shoulders are developed, and these also gradually become nodose during ontogenetic development. The nodes on them likewise become obliquely elongate. Throughout ontogenetic development, there is a distinct tendency for the umbilical nodes to be paired with the ventrolateral nodes.

At maturity the sutures are like those of typical representatives of *Metacoceras*; that is, each mature suture forms a broad shallow rounded lobe on the ventral, the lateral, and the dorsal sides of the conch, and these are separated by subacute saddles. The part of the suture forming the dorsal side of the lateral lobe continues to curve orad across the umbilical wall, and the subacute dorsolateral saddle centers on the umbilical seam rather than on the umbilical shoulder; there is, however, a marked decrease in the amount of adoral curvature of the sutures on the umbilical shoulder. The siphuncle is small, circular in cross section, subcentral in position (but distinctly nearer the venter than the dorsum), and apparently orthochoanitic in structure—at any rate, it is composed of cylindrical segments.

REMARKS.—This fine, large species was named for Professor S. H. Knight, in recognition of his work on the Casper formation. Its most distinctive characters are the large size of its conch, the oblique elongation of the ventrolateral nodes, and particularly the obliquely elongate nodes on the umbilical shoulders. Superficially, the ornamentation of this form suggests a relationship to *Foordiceras*. In *Metacoceras sulciferum*, which occurs in direct association with this species, the ventral side of the conch is marked medianly by a shallow rounded longitudinal groove.

OCCURRENCE.—Abundant in *Stenopoceras* beds of Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Albany County, Wyoming.

SYNTYPES.—State University of Iowa, 1155, 1156.

Metacoceras sulciferum Miller and Thomas

(Plate 47, figures 4, 5)

1936. *Metacoceras sulciferum* MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 729–730, pl. 97, figs. 4, 5.

Most of the numerous metacoceratids that occur in the Casper formation of southeastern Wyoming are large and are referable to *M. knighti*. However, associated wih these specimens are a few smaller individuals which differ from equal-sized portions of typical representatives of *M. knighti* in that the ventral side of their conchs is marked medianly by a shallow rounded longitudinal groove. In some specimens this groove is very prominent, whereas in others it is small and shallow and is easily overlooked. Nevertheless, these forms can be readily differentiated from typical *M. knighti*.

Conch forms at least two and a half volutions and is subdiscoidal and nautiliconic though only slightly involute. It attains a maximum diameter, measured across the umbilicus, of at least 37½ mm. and a maximum height and width of conch of at least 13 mm. and 23 mm., respectively. Extreme adapical portion of conch is circular or nearly so in cross section, but throughout most of the first volution the conch is depressed dorsoventrally and is subelliptical in cross section, its ventral side being more strongly convex than its dorsal. By the time the conch has completed one full volution, both umbilical and ventrolateral shoulders have started to develop, and these rapidly become subangular; the conch then becomes subrectangular in cross section. Even after the conch has attained full maturity, however, its lateral walls, which are nearly straight, converge ventrad and its ventral and dorsal sides, though concave medianly, are in general convex.

Diameter of umbilicus is equal to about half that of specimen. Umbilicus is perforate and umbilical perforation is oval in shape and is about 5 mm. long and 4 mm. wide. Umbilical walls are steep.

Growth lines are nearly straight on umbilical walls and lateral parts of conch, but they form very shallow subangular sinuses as they cross the umbilical shoulders and broad deep rounded sinuses as they cross the ventral side of the conch. First volution of conch is essentially smooth, but thereafter a row of longitudinally elongate nodes with low rounded inconspicuous lateral extensions is developed on each of the ventrolateral shoulders of the conch. After the conch has completed almost two volu-

tions, a row of similar but smaller nodes is developed on each of the umbilical shoulders. The nodes on the umbilical shoulders also bear lateral extensions, and they seem to be paired with those on the ventrolateral zones of the conch. There are about 15 or more of these nodes to the volution.

In so far as we have been able to ascertain, the sutures of this species are like those of all typical representatives of *Metacoceras*, and they do not differ materially from those of *M. knighti*. The siphuncle, like that of *M. knighti*, is orthochoanitic in structure, being composed of cylindrical segments. Where the conch is about 15 mm. high, the center of the siphuncle is about 5 mm. from the venter and about 8 mm. from the dorsum, the impressed zone being about 2 mm. deep.

REMARKS.—One of the most distinctive characters of this species, which suggested its name, is the longitudinal furrow along the venter. It may be that the specimens on which this species is based should be regarded as aberrant examples of *M. knighti*, or as representing a variety of that species, but it now seems to us best to regard them as specifically distinct. The general physiognomy of their ornamentation suggests a relationship to *Foordiceras*, but they seem to be closer to the genotype of *Metacoceras* than to that of *Foordiceras*.

OCCURRENCE.—*Stenopoceras* beds of Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Albany County, Wyoming.

SYNTYPES.—State University of Iowa, 1157, 1158.

Metacoceras unklesbayi, n. name

(Plate 19, figure 1)

1942. *Metacoceras biseriatum* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 721, 724–725, pl. 113, fig. 1.

(?) 1944. *Metacoceras* cf. *M. biseriatum* CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.

The holotype of this species is a moderately well preserved internal mold representing much of the left lateral half of the living chamber and the adoral one and three-quarters volutions of the phragmacone. Its maximum diameter, measured across the umbilicus, is about 125 mm. The preserved part of the living chamber is about a quarter of a volution in length. The whorls are depressed dorsoventrally and are considerably wider than high. Near the junction of the phragmacone and the living chamber, where the conch is about 50 mm. high, its width is estimated to be about 65 mm. The ventral and lateral zones of the conch are strongly flattened and are almost normal to each other. The ventrolateral zone is narrowly rounded. The umbilical shoulder is somewhat more broadly rounded, and the umbilical wall is inclined to the nearly flat lateral zone of the conch at an angle of some 35 degrees. The dorsal zone is distinctly concave. The diameter of the umbilicus is equal to almost two-thirds that of the specimen.

Both the umbilical and the ventrolateral shoulders of the holotype bear rather small low rounded nodes, which are somewhat elongate longitudinally. The spacing of the nodes in each of these rows is fairly regular, but they appear to be independent of each other. The distance between successive nodes and the size of the individual nodes increases progressively orad, and both rows continue undiminished to the adoral end of the specimen. The nodes on the ventrolateral shoulders are somewhat more prominent than are those on the umbilical shoulders.

Each suture forms a broad rather shallow rounded ventral lobe, a very narrowly rounded ventrolateral saddle, a shallow rounded lateral lobe, a rounded saddle on the umbilical shoulder, a very shallow lobe on the umbilical wall, and apparently a dorsal lobe on the impressed zone. The size and position of the siphuncle are not known.

REMARKS.—The Chupadera formation of New Mexico has yielded a fragmentary septate specimen that is of about the same size and shape as the phragmacone of the holotype just described and compares favorably with it. Although it seems to resemble this holotype rather closely, we are uncertain in regard to its specific affinities because of its incompleteness.

Perhaps the most distinctive character of this species is the fact that its conch bears small longitudinally elongate nodes on both its ventrolateral and dorsolateral shoulders. Miller and Unklesbay therefore called it *Metacoceras biseriatum*, but that name has already been used by Miller and Owen (1934, p. 229–231) for a Pennsylvanian (Cherokee) species.

OCCURRENCE.—Kaibab limestone (α member), along Lake Mary road about 2 miles southwest of

Flagstaff, Coconino County, Arizona; and possibly the Chupadera formation near Bluewater Dam, about 16 miles northwest of Grants, Valencia County, New Mexico. For the sake of completeness it should be added that in 1944 Clifton listed a questionable representative of this species from the Blaine and/or Dog Creek formation(s) of north-central Texas—we have not seen his material.

REPOSITORIES.—Museum of Northern Arizona, 563/GZ.1506 (holotype); and University of New Mexico (specimen compared with this species).

Metacoceras sp. [of Nebraska]

(Plate 42, figures 11, 12)

1933. *Metacoceras* sp. MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, pl. 11, figs. 7, 8.

The collections of the Yale Peabody Museum contain a single representative of *Metacoceras* from the Fort Riley limestone of southeastern Nebraska. It is an internal mold that is about 41 mm. in diameter. The preserved part of the living chamber is almost half a volution in length, and near its mid-length the conch is about 16 mm. high and 19 mm. wide. The volutions are subrectangular iu cross section. However, the lateral zones are slightly converged ventrad, the ventral zone is in general convex but is very slightly concave medianly, and the dorsal zone appears to be slightly impressed.

The umbilicus is open and is large. Its diameter is slightly greater than half that of the specimen, and the maximum diameter attained by the umbilicus of the specimen under consideration is about 25 mm. The umbilical shoulders are abruptly rounded, and the umbilical walls are steep, though they become less so in the extreme adoral part of the specimen.

Each ventrolateral shoulder bears a row of rounded nodes that are distinctly elongate longitudinally. Also, there is a very faint ridge or raised line along the venter of the internal mold.

Each suture forms a very slight ventral lobe and on either side of it a ventrolateral saddle which is almost subangular, an asymmetrical lateral lobe, and a slight dorsolateral saddle, which extends to a presumed dorsal lobe. The nature of the siphuncle can not be ascertained.

REMARKS.—This specimen seems to be a typical representative of the genus *Metacoceras* as now interpreted. It was found in direct association with the type specimens of *Tainoceras nebrascense* Miller, Dunbar, and Condra.

OCCURRENCE.—Fort Riley limestone (top of Barneston formation) in the quarry near the Beatrice power dam at Barneston, Gage County, Nebraska.

REPOSITORY.—Yale Peabody Museum.

Metacoceras spp. [of Texas]

(Plate 48, figures 3, 4)

1947. *Metacoceras* spp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.

In 1947 Miller and Kemp stated that in the Lower Permian of Baylor County, Texas, the genus *Metacoceras* is represented in the following horizons: (1) the Elm Creek limestone of the Admiral formation, near the middle of the Lower Permian, (2) some 500 feet higher in the section in the Grape Creek limestone of the Clyde formation (the horizon of the well known "Old Military Crossing" of the Big Wichita River), and (3) about 100 feet startigraphically above the Grape Creek in the Lueders formation.

Most of the material on which these statements were based is fragmentary and poorly preserved. However, two of the Lueders specimens are described in the present report as the types of a new species for which the name *Metacoceras baylorense* is propsosed. A third specimen from the Lueders is illustrated by figures 3 and 4 on Plate 48. This individual is about 108 mm. in diameter. In general physiognomy it resembles *M. baylorense*. However, its ventral zone is less strongly flattened and is not concave medianly, its ventrolateral nodes are relatively few in number and far apart and do not seem to be obliquely elongate, and its dorsolateral nodes are more prominent.

OCCURRENCE.—Elm Creek, Grape Creek, and Lueders limestones of Baylor County, Texas. The figured specimen is from the Lueders formation in the "bench" just below top of hill south of

Miller Creek between old and new Throckmorton highways about 10 miles south of Seymour, Baylor County, Texas.

REPOSITORY.—Private collection of Augusta Hasslock Kemp of Seymour, Texas.

Metacoceras sp. [of Wyoming]

(Plate 7, figures 4-6)

1936. *Metatoceras* sp. MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 730-732, pl. 96, figs. 10–12.

The Casper formation of southeastern Wyoming has yielded numerous specimens that apparently are referable to *Metacoceras*, but many of them are poorly preserved and incomplete and others are small and presumably immature. There seems to be a great deal of variation among these specimens, and due to their fragmentary nature we have not been able to determine just which of the small, immature individuals are conspecific with certain of the large ones.

A few of the small specimens are exceptionally well preserved. Some of these represent the extreme adapical portion of the conch and are therefore worthy of consideration even though we can not be certain of their specific affinities. One of these, which does not complete a full volution, is figures (Pl. 7, figures 4–6). Its extreme adapical part, which is expanded orad very rapidly, is circular or nearly so in cross section, but its lateral diameter increases more rapidly than its dorsoventral diameter, and it becomes subelliptical in cross section very early in its ontogenetic development, the ventral side being less strongly convex than the dorsal. At the same time that the conch becomes depressed it develops lateral keels which migrate to a ventrolateral position. After the conch has completed almost half of a volution, these keels are abruptly transformed into rows of very prominent longitudinally elongate nodes, each of which possesses a low rounded lateral extension. Soon umbilical shoulders are developed and the lateral zones of the conch are defined. At first these converge dorsad rather strongly, but they gradually become more nearly parallel. The adapical non-nodose portion of the conch is marked by very prominent transverse lirae which presumably represent increments of growth. Each of these forms a narrowly rounded ventral sinus which becomes progressively deeper and more nearly V-shaped during ontogenetic development, and on each side of it a broad gently rounded salient, a shallow subangular sinus which centers on the lateral or ventrolateral keel, and a broad rounded dorsal salient which extends from one of the keels to the other. At the same time that the conch develops lateral nodes, these transverse lirae become much reduced in size and prominence, and they are thus transformed into typical growth lines. As umbilical shoulders are developed the growth lines become straight on the lateral walls of the conch, and then dorsolateral sinuses are rapidly developed. It should perhaps be mentioned in this connection to avoid possibility of ambiguity that the dorsal side of the conch does not become concave until after a full volution is completed, and a dorsal impressed zone is then gradually developed—that is, an impressed zone is not developed until it is needed.

REMARKS.—The lateral ornamentation of this form might be taken to indicate that it belongs in *Foordiceras*, but no representatives of that genus have so far been found in the Casper. The early growth stages of the abundant Casper metacoceratid, *Metacoceras knighti* Miller and Thomas, differ markedly from those of the form just described. The conch of *M. knighti* is non-nodose until it has completed about one and a fourth volutions. Umbilical shoulders are gradually developed immediately orad of the first volution, and at about the same time a low narrow ridge appears on each of the ventrolateral zones of the conch. During the first quarter of the second volution, this ridge becomes nodose, and it gradaully evolves into the nodose ventrolateral zones of the conch. This species, then, during ontogenetic development does not seem to pass through a *Temnocheilus* stage, as does the form just described, but it may be said to pass directly from an *Endolobus* to a *Metacoceras* stage, suggesting that the genus *Metacoceras* as now understood may possibly not be monophyletic.

The early growth stages of the Casper representative of *Tainoceras*, *T. wyomingense* Miller and Thomas, differ markedly from those of the small *Metacoceras* just described (compare Figs. 6 and 7 of Pl. 7), but in general they are similar to those of *M. knighti*. In *T. wyomingense*, after the conch has completed a little over half of a volution, low broad inconspicuous lateral nodes appear. Soon after the conch completes the first volution, these lateral nodes disappear, umbilical shoulders become distinct, and a row of longitudinally elongate nodes is then developed rather gradually on each of the

ventrolateral shoulders. Near the mid-length of the second volution of the conch, two rows of longitudinally elongate nodes are gradually developed on the ventral side of the conch. In this species, as in the representatives of *Metacoceras* just discussed, a dorsal concave zone is not developed until the conch has completed a full volution and an impressed zone is necessary if the conch is to become involute.

OCCURRENCE.—*Stenopoceras* beds of Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Albany County, Wyoming.

FIGURED SPECIMENS.—State University of Iowa, 1153, 1154.

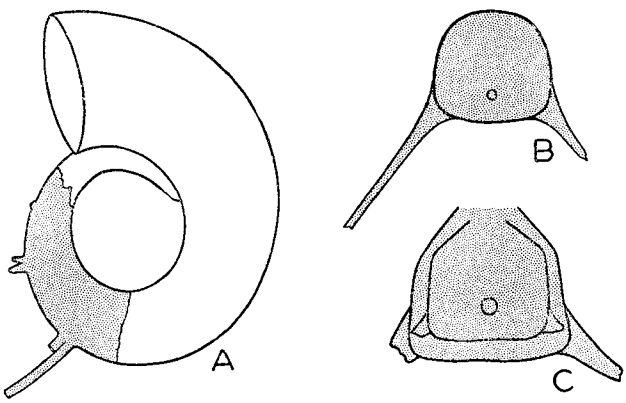

FIGURE 34.—*Cooperoceras*

Original type specimens of *Cooperoceras texanum* Miller [**A, B**] and *C.? spinosum* (Kruglov) [**C**]. **A** indicates the relationship of the preserved part of the holotype of *C. texanum* to the rest of the conch, × 1. **B** represents a cross section through the adoral spines of this holotype, × 1½. **C** is after Kruglov, × 1.

Genus ***Cooperoceras*** Miller, 1945

GENOTYPE: *Cooperoceras texanum* Miller

This genus was originally based on a small fragment of a conch (Pl. 6, figs. 3, 4). Recently, G. A. Cooper and J. B. Knight have etched from limestone matrix and loaned to us for study several fine large silicified individuals which appear to be conspecific with the type specimen. This new material indicates that the holotype represents only an immature portion of the conch. The genus can now be diagnosed as follows:

Conch moderately large and nautiliconic, but not deeply involute. At maturity, whorls are subcuneiform in cross section as they are flattened ventrally and laterally, the lateral zones converge dorsad, and the dorsal zone (which is slightly impressed) is narrow. Along the venter there is a rather narrow shallow median groove. Umbilicus wide, open, and perforate; umbilical shoulders indefinite; and umbilical perforation large and subcircular. At maturity the conch bears sinuous lateral ribs and long slender hollow paired ventrolateral spines that project ventrolaterally and are distinctly recurved. Growth lines form deep ventral and shallower lateral sinuses. Each mature suture consists of a broadly rounded ventral lobe, narrowly rounded ventrolateral saddles, and presumably shallow lateral and dorsal lobes. Siphuncle small, located about midway between the center and the venter, composed of essentially cylindrical segments, and orthochoanitic in structure.

In addition to the type species, which occurs in the Middle Permian Bone Spring and Word formations of west Texas—and possibly the Middle Permian Blaine and/or Dog Creek formation(s) of north-central Texas—this genus may include "*Metacoceras spinosus*" Kruglov (Fig. 34) of the Middle Permian Artinskian beds of the Ural region. However, in that form the umbilical shoulders are fairly definite, the umbilical perforation is somewhat smaller than that of the genotype, and the ventrolateral spines are relatively numerous and close together. *C.? spinosum* (Kruglov) can therefore be said to be more or less intermediate between typical *Metaocceras* and typical *Cooperoceras*.

Cooperoceras texanum Miller

(Plate 1, figure 1; Plate 6, figures 3, 4; Plate 40, figures 6–9; Plate 41, figures 1–4; Plate 49, figures 1, 2; Plate 50, figures 1, 2; Plate 51, figures 1, 2; Plate 52, figures 1, 2)

(?) 1944. Nautiloid sp. (with spine-like appendages) CLIFTON, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.

1945. *Cooperoceras texanum* MILLER, Jour. Paleont., vol. 19, p. 283, 291, 292, pl. 44, figs. 3, 4.

The holotype (Pl. 6, figs. 3, 4) of this species is a silicified replacement of about a third of a volution of a coiled conch. The maximum length of this specimen, measured along the venter, is about 33 mm. The cross section of the conch is shown by Figure 34, in the text, which also elucidates the relationship of the fragmentary holotype to the rest of the conch. The maximum height and width attained by the preserved portion of the holotype measure about 11 mm. and 11.5 mm., respectively. For the most part, the surface of this specimen is smooth, but faint traces of the growth lines indicate that they form broadly rounded dorsal salients and ventral sinuses. Also, on the ventrolateral zones of the preserved part of the holotype, there are the remains of three pairs of long slender hollow spines. These are circular in cross section, they arise abruptly from the surface of the conch, and they extend obliquely outward and downward (ventrad). The most nearly complete of the spines is about 13 mm. long; near its base it is some 2 mm. in diameter but at its broken distal end it is only about 1 mm. in diameter. In the adapical part of the holotype, the camerae average a little less than 2 mm. in length. Apparently the sutures are not strongly sinuous, and the septa are moderately convex apicad. The siphuncle is small, circular in cross section, and is located about midway between the center and the venter.

Large representatives of this species, several of which we are illustrating, show that at full maturity the conch consists of at least one and a half volutions and attains a maximum diameter of at least 120 mm. At full maturity, the conch is subcuneiform in cross section, as it is flattened laterally and ventrally, the lateral zones converge dorsad, the ventrolateral zones are abruptly rounded, and the dorsal zone is narrow and is only slightly impressed. The lateral zones are distinctly convex exteriorly, and the ventral zone is in general broadly rounded but is slightly concave medianly. The dorsal zone of the conch is rounded in the first volution but orad of there is slightly impressed medianly. The maximum width of conch is attained near the ventrolateral shoulders, and that of our largest individual (Pls. 1 [Frontispiece] and 52) measures about 52 mm.—the corresponding height of conch is about 55 mm.

The umbilicus is large and open, and there are no definite umbilical shoulders. The umbilical perforation is wide and is subcircular in outline. In the specimens we are studying, its diameter varies from about 20 mm. (Pl. 41, fig. 4) to about 23 mm. (Pl. 1—Frontispiece).

The test is thin. The ventral side of the conch bears a rather narrow rounded median longitudinal groove. The growth lines on the ventral side of the conch form a broad deep narrowly rounded ventral or hyponomic sinus. They also form similar vntrolateral salients, lateral sinuses, and dorsal salients (which presumably are divided by small median sinuses across the impressed zone). Except in the adapical volution of the conch, on the lateral zones there are sinuous transverse ribs parallel to the growth lines. These ribs are rounded and are rather low. They extend from the umbilical seams, where they are particularly prominent, almost to the ventrolateral shoulders. The most striking feature of the ornamentation is the ventrolateral spines. These are paired and hollow. They project ventrolaterally and are distinctly recurved. There are about ten pairs of them to the volution. They taper very gradually and attain a length of more than 45 mm. As shown by Figure 1 on Plate 52, at full maturity these spines show evidence of wear (beveling) presumably as a result of the animal periodically coming to rest with them against the sea bottom.

All of the representatives of this species available to us for study are silicified replacements of the test, and therefore they do not elucidate the shape of the sutures very well. However, from partial cameral fillings like those shown by Figure 2 on Plate 50, and from such portions of the sutures as are visible, it can be seen that at maturity each suture consists of a broadly rounded ventral lobe, narrowly rounded ventrolateral saddles, and presumably shallow lateral and dorsal lobes.

The siphuncle is small, is located about midway between the center and the venter, is composed of essentially cylindrical segments, and is orthochoanitic in structure. Near the midlength of the adora.

half-volution of the specimen illustrated on Plates 50 and 51, where the conch is about 38 mm. high, the siphuncle is about 3 mm. in diameter and its center is about 9 mm. from the venter.

REMARKS.—There seems to be no good reason to doubt that the large specimens we are referring to this species are conspecific with the holotype although they are stated to be from older beds. One of the individuals illustrated on Plate 40 comes from a considerably different locality than do the others, but like them, it is entirely replaced by silica. It is associated in a small block of limestone with another similar specimen. Although both of these are incomplete, all of their characteristics that can be determined seem to coincide well with the other specimens.

OCCURRENCE.—All the known representatives of this species are from the Middle Permian of west Texas. The holotype is stated to be from the third limestone of the Word formation in the Glass Mountains, on the northern slope of the hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch house, some 14 miles north-northeast of Marathon, Brewster County, Texas. Six of the eight additional conspecific specimens now available for study came from the lower part of the upper Leonard formation at a single locality in the Glass Mountain region of Brewster County, Texas; the other two are in a block of limestone from about 100 feet above the base of the Bone Spring formation in the Sierra Diablo of Hudspeth County, Texas. The precise locality in the Leonard formation of the Glass Mountains is "on the south side of the road between the road fork and the Sheep Tank at the Old Word Ranch". The two specimens from the Bone Spring limestone of the Sierra Diablo are from near the mouth of Apache Canyon about 0.2 mile north of the Van Horn quadrangle "on the second promontory north of the lower bench and on the outside rim on the north part of Apache Canyon". For the sake of completeness, it should be mentioned that in 1944 Clifton listed "Nautiloid sp. (with spine-like appendages)" from the Blaine and/or the Dog Creek formation(s) of north-central Texas—we have not seen his material, but it may well be referable to this species.

TYPES.—U. S. National Museum, where holotype is numbered 111621.

Family LIROCERATIDAE, n. name

In 1893 Hyatt (p. 447–448) proposed the name Coloceratidae for a family in which he included only two genera, *Coloceras* Hyatt [= ? *Liroceras* Teichert] and *Coelogasteroceras* Hyatt. Later he (Hyatt, 1900, p. 523, 524) revised his views and placed these two genera in different families, but we prefer his earlier opinion. However, we would modify it somewhat by including in the same family *Peripetoceras* Hyatt (which in 1900 Hyatt placed in the Koninckioceratidae) and *Condraoceras* Miller and Unklesbay (which was not known when Hyatt did his work).

All four of these genera have nautiliconic conchs in which the volutions are for the most part smooth and rounded but are considerably impressed dorsally, the umbilicus is small, the external sutures are only slightly sinuous and the siphuncle is subcentral in position and orthochoanitic in structure. However, in *Peripetoceras* and *Coelogasteroceras* the conch is slightly flattened ventrally and laterally, giving rise to recognizable ventrolateral shoulders. Also, there is a ventral groove in the conch of *Coelogasteroceras* (which results in slight ventral lobes of the sutures), and there are low ventrolateral nodes or ridges on the test of at least some representatives of this genus (Pl. 56, fig. 9).

Peripetoceras and *Condraoceras* are not treated in detail elsewhere in this report, and therefore they should be briefly discussed here. When Hyatt established *Peripetoceras*, he referred to it only one species, *Nautilus freieslebeni* Geinitz, and it is therefore the genotype. That species was originally described from the Zechstein of Germany, and presumably the German specimens should be regarded as the types of the species and therefore the genus, even though it is clear that when he established this genus Hyatt was studying material from England, which may or may not be identical or closely related. Those German specimens, for example, the one illustrated by Figures 1–3 on Plate 42 of the present publication, indicate that to this genus should be referred smooth subglobular nautilicones with whorls that are slightly flattened laterally and ventrally, small umbilici, a deep rounded hyponomic sinus, slightly sinuous sutures, and a small subcentral siphuncle. The general physiognomy of the genotype of *Peripetoceras* suggests that it is more or less intermediate between typical *Liroceras* and typical *Coelogasteroceras*. No species are known from the Permian of America that are referable to it, but almost certainly it should contain *Solenochilus henryvillense* Miller and Gurley of the Lower Mississippian of Indiana, *Cyclonautilus umbilicatus* Hind of the early Upper Carboniferous of Eng-

land, and possibley *C. dubius* Bisat of the early Upper Carboniferous of Wales. *C. umbilicatus* is the genotype of *Cyclonautilus* Hind, which should be suppressed as a synonym of *Peripetoceras* as it does not have priority.

Condraoceras was established by Miller and Unklesbay (1947, p. 5) and was based on two specimens from the Upper Pennsylvanian (Kansas City) Winterset limestone of west-central Missouri. It is close to *Liroceras* but differs particularly in that its whorls are about as high as wide. Although it also resembles *Peripetoceras*, its ventral side is rounded rather than flattened.

Acanthonautilus Foord, of which *Permonautilus* Kruglov is probably a synonym, may also belong in this family rather than in the *Solenochilidae* where it was placed by Hyatt (1900, p. 525). The genotype of *Acanthonautilus* is *A. bispinosus* Foord of the Lower Carboniferous of Ireland. It seems to differ from typical members of the Liroceratidae chiefly in that at maturity the adoral portions of its umbilical shoulders are greatly extended laterally to form long spine-like processes. Unfortunately the nature of its siphuncle is not known. However, as has been noted by Blake (1897, p. 287), Foord (1900, p. 120–122), and Licharew (1926, p. 61–64), *Nautilus cornutus* Golovkinsky (Pl. 54, figs. 1–3, of the present publication) of the Upper? Permian of the Volga basin is strikingly similar to *A. bispinosus*, and it has a subcentral siphuncle. In 1933 Kruglov (p. 188) proposed the generic name *Permonautilus*, and designated *N. cornutus* as the type species of his genus. It is of course possible that the similarity of this form to the genotype of *Acanthonautilus* is due to homoeomorphy and is a result of convergent evolution. However, in spite of the great difference in their age, we are inclined to doubt that their morphologic dissimilarities are of generic significance. Therefore, we are suppressing *Permonautilus* in favor of *Acanthonautilus*, which has priority. No specimens have been found in America that are similar to either of these genotypes. Most of the forms (other than the genotype) that Kruglov referred to *Permonautilus* seem to us to belong in *Stearoceras*. It should be mentioned that in 1934 Kruglov (p. 737, 742) placed *Permonautilus* in the Tribloceratidae and *Acanthonautilus* in the "Solenocheilidae," and in 1939 Licharew (p. 155–156) apparently followed Kruglov in regard to the taxonomic position of *Permonautilus*.

For reasons explained in the following paragraph, Hyatt's name *Coloceras* has been changed to *Liroceras*, and the name for the family must be altered to correspond. All but one of the genera we are placing in it (*Condraoceras*) are known to occur in both the Carboniferous and the Permian, and geographically the family seems to have been world-wide in its distribution during the Late Paleozoic.

Genus *Liroceras* Teichert, 1940

GENOTYPE: *Coloceras liratum* Girty

Hyatt's well known generic name *Coloceras* was preoccupied in 1882 by Nitzsch (Teichert, 1940, p. 590) or by Taschenberg (Neave, Nomenclator Zoologicus, vol. 1, p. 801, 1939), and Teichert has proposed the term *Liroceras* for the nautiloids generally referred to *Coloceras*. However, inasmuch as the type species of Hyatt's genus, *C. hyatti* Miller, Dunbar, and Condra of the Lower Carboniferous (Viséan) of Belgium, is a very poorly known species of which the affinities are uncertain, Teichert designated *Coloceras liratum* Girty of the Pennsylvanian of Oklahoma, Texas, and Kansas as the genotype of *Liroceras* (Pl. 53, figs. 3–6). This change in genotype does not, however, affect the general concept of the genus for in so far as can be ascertained the type species of *Coloceras* Hyatt is probably congeneric with that of *Liroceras* Teichert.

Liroceras can be said to include subglobose nautiliconic nautiloids in which the conch is rapidly expanded orad and depressed dorsoventrally. All the volutions but the adapical part of the first are reniform in cross section as they are broadly rounded ventrally, somewhat more narrowly rounded laterally, and impressed dorsally. The extreme adapical part of the conch may be longitudinally lirate (Pl. 53, fig. 6), but the rest of it is marked only by the growth lines, which form a deep narrowly rounded ventral sinus (Pl. 53, fig. 5). The umbilicus is rather small and is perforate during early growth stages, but at maturity it may be closed by an umbilical plug. The umbilical shoulders are rounded. The external sutures are essentially straight and directly transverse to the long axis of the conch. The siphuncle is orthochoanitic in structure and is not marginal in position.

As now understood, this genus is widely distributed both stratigraphically and geographically, and it is well represented in the Carboniferous and the Permian of both Eurasia (including Timor)

and North America. In North America it is known to range from the Upper Mississippian (Chester) well up into the Permian.

The genus *Planetoceras* Hyatt may be related to *Liroceras*, but typical representatives of it differ in that their umbilical shoulders are angular and somewhat keeled rather than rounded, at maturity the extreme adoral portion of the conch is not in contact with the preceding volution, and the sutures form shallow lateral and ventral lobes. At least the mature portion of the conch of *Leuroceras* Hyatt is similar to that of *Liroceras*, but the sutures in that genus are sinuous and form lateral and dorsal lobes and ventral and dorsolateral saddles. Superficially Hyatt's genus *Stearoceras* also seems to be fairly close to *Liroceras*, but the sutures of its genotype form slight ventral, lateral, and dorsal lobes and similar ventrolateral and dorsolateral saddles—furthermore its conch is distinctly flattened laterally and ventrally and its umbilicus is relatively large. In such forms as *Koninckioceras* Hyatt, which is probably not closely related, the umbilicus is large and open throughout ontogenetic development.

As now understood, the genus *Liroceras* is widely distributed both stratigraphically and geographically, and it is well represented in the Carboniferous and the Permian of both Eurasia and North America. In North America it is known to range from the Upper Mississippian (Chester) well up into the Permian.

Liroceras globulare Hyatt

(Plate 46, figures 9–11; Plate 55, figures 6–11; Plate 56, figures 1–5)

1891. *Nautilus* ——? White, U. S. Geol. Surv., Bull. 77, p. 16, 23, pl. 3, figs. 6–8.
1891. *Nautilus* ——? White, U. S. Geol. Surv., Bull. 77, p. 16, 24, pl. 2, figs. 7–10.
1893. *Coloceras globulare* Hyatt, Texas Geol. Surv. An. Rep. 4, p. 452–453, text figs. 25–27.
1933. *Coloceras* sp. Miller, Dunbar, and Condra, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 131.
1933. *Coloceras globulare* Miller, Dunbar, and Condra, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 131.
1942. *Liroceras* sp. Miller and Unklesbay, Jour. Paleont., vol. 16, p. 720.
1942. *Liroceras globulare* Miller and Unklesbay, Jour. Paleont., vol. 16, p. 720.
1947. *Liroceras* spp. Miller and Kemp, Jour. Paleont., vol. 21, p. 352.
1947. *Liroceras* cf. *L. globulare* Miller and Youngquist, Kansas Univ. Paleont. Contr., Mollusca, art. 1, p. 4–5, pl. 1, figs. 8–12.

The holotype of this species was described by Hyatt as follows:

"The cast [internal mold] of this shell is smooth. The ventral contour from the umbilical shoulders does not give any sharp distinction between the lateral faces and abdomen, but these are present. The umbilical zones are almost vertical and rounded. The zone of impression broad and deep. The septa are shallow, the sutures nearly straight or with an obscure ventral saddle. The siphuncle is of moderate size and below the center. The young was not seen. So far as this fragment is concerned, I [Hyatt] should have considered it to be identical with Meek's *globatus* but for the position of the siphuncle.

"The form of the zone of impression shows that the young in the neanic stage had a flatter venter than the adult, and that this was more distinct from the lateral zones, which seem to have been gibbous and slightly divergent or parallel, whereas in the adult the corresponding parts were convergent and blended with the venter, as described above.

"This shell evidently approximates in aspect and characteristics to Trautschold's *Naut. excentricum*, which has the siphuncle in the same position, but this organ is phenomenally large in the Russian species.

"The *Naut. excentricus*, sp. Eichwald, Leth. Ross., plate 45, fig. 5, is probably the same as the species cited by Trautschold, although the figures do not enable one to verify the latter's description.

"*Nautilus globatus* of M. et W., Geol. of Illinois, in the position of the siphuncle and globularity of the whorls, approximates to the species described as the type of Coloceras, but there is not information enough to enable me [Hyatt] to refer this to its proper genus.

"*Nautilus missouriensis* of Swallow, as figured by Collett [White, 1884, p. 166, pl. 35, figs. 1, 2], may be a species of this genus. The sutures are similar, and also the form of whorl and involution. The position of siphuncle and development of this shell are unknown."

Remarks.—We have not seen the holotype of this species, which came from the Clyde formation of north-central Texas, nor the similar specimens from the Clyde and Admiral formations of the same general area which White illustrated and briefly described in 1891—therefore we are reproducing the available illustrations of them (Pl. 55, figs. 6–11, and Figs. 35 and 36 in text). However, the

collections available to us contain 21 comparable specimens from the Admiral in this region. All of them are rather fragmentary and only moderately well preserved, but we are illustrating three of the best individuals (Pl. 46, figs. 9–11; Pl. 56, figs. 1–5). As might be expected, there is a considerable amount of variation within this group of specimens and we are of the opinion that they are most probably not all conspecific, and that all of them may be specifically distinct from Hyatt's holotype.

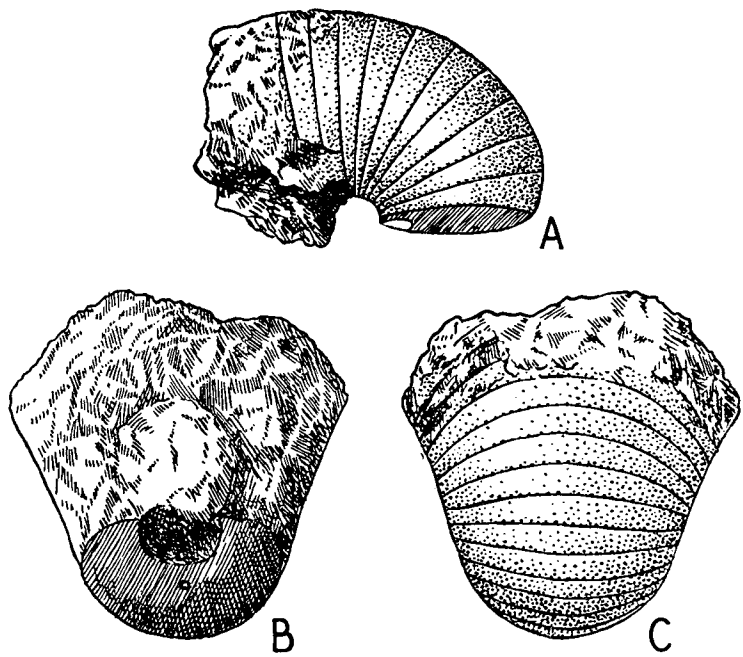

FIGURE 35.—*Liroceras globulare* (Hyatt)

Three views of the holotype, from the Grape Creek limestone of the Clyde formation at the "Old Military Crossing" on the Big Wichita River, Baylor County, Texas, × 1. After Hyatt.

The variation is particularly noticeable in the relative height of the conch (cf. Pl. 56, figs. 2, 4), the size of the umbilicus, the depth of the impressed zone, and particularly the position of the siphuncle—in some of the specimens the siphuncle is located closer to the dorsum than to the venter (as is the case in the holotype of *L. globulare*) whereas in others the reverse is true. We are uncertain in regard to the taxonomic significance of these variations.

The specimen represented by Figures 1 and 2 on Plate 56 is about 42 mm. in diameter, and near its adoral end its conch is about 35 mm. wide and 22 mm. high. The adoral two-fifths of the outer volution of this specimen is non-septate and presumably therefore represents living chamber.

The overall length of the specimen represented by Figures 3–5 on Plate 56 is about 33 mm., and near the mid-length of this individual the conch is about 22 mm. wide and 14 mm. high, and the impressed zone is some 2 mm. deep. The growth-lines form a broad deep rounded ventral sinus, but they are more or less straight and directly transverse on the lateral zones of the conch and on the umbilical walls. In this specimen, and in the one just discussed, structures which appear to represent the siphuncle are distinctly nearer the venter than the dorsum.

The largest specimen that we have is represented by Figures 9–11 on Plate 46. It consists of parts of two volutions of the conch and is noteworthy for its very rapid adoral expansion (see especially Figure 10 on Plate 46). It is septate throughout and at its adoral end attains a maximum height and width of conch of about 38 mm. and 58 mm., respectively. The septum which forms the adapical end of the outer volution of this specimen is only slightly convex apicad, and therefore the sutures are not greatly affected by the impressed zone and form only a slight dorsal lobe.

Some of the unfigured specimens we are studying are less nearly globular than those illustrated. None of them have camerae that are relatively as short as those of the holotype, but that specimen may represent the adoral portion of the phragmacone of a late mature individual, in which the camerae are very short—it is, however, considerably smaller than our largest specimen.

OCCURRENCE.—The holotype and part of the specimens illustrated and described by White in 1891 (Pl. 55, figs. 9–11 of the present publication) came from the Grape Creek limestone of the Clyde formation at the "Old Military Crossing" of the Big Wichita River, Baylor County, Texas. White's

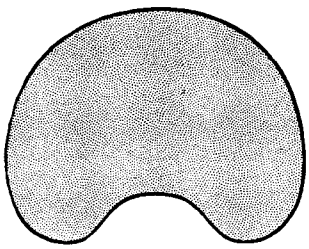

FIGURE 36.—*Liroceras globulare* (Hyatt)

Cross section of a relatively large specimen which according to White (1891, p. 24, pl. 2, figs. 7–10) is probably conspecific with the individual (from the same horizon and locality) which is represented by Figures 6–8 on Plate 55, × 1. After White.

other specimens (Pl. 55, figs. 6–8; and Fig. 36 in the text) were collected from the Elm Creek limestone of the Admiral formation along Godwin Creek near the middle of the eastern boundary of the same county. The material we are studying is from the Wildcat Creek shale member of the Admiral formation about 4½ miles south-southwest of Coleman, Coleman County, Texas.

REPOSITORIES.—The specimens represented by Figures 1–5 on Plate 56 (and 15 unfigured specimens from the same horizon and locality) and presumably the specimens studied by White in 1891 are at the U. S. National Museum. The individual illustrated by Figures 9–11 on Plate 46 (and 3 unfigured specimens from the same horizon and locality) are in the Renfro Collection, Fort Worth, Texas. Also, the private collection of Augusta Hasslock Kemp of Seymour, Texas, contains specimens from both the Elm Creek and the Grape Creek limestones of Baylor County, Texas, that are referable to this species, as we are interpreting it.

Liroceras? sp. [of Mexico]

(Plate 45, figure 7)

1942. *Liroceras?* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 720.
1944. *Liroceras?* sp. MILLER, Geol. Soc. Am., Spec. Pap. 52, p. 72, 77–78, pl. 21, fig. 3.

A single cephalopod was obtained from the limestone which caps Cerro Agujito, in the Valle de Las Delicias, Coahuila. It is a moderately well preserved internal mold of part of the phragmacone of a nautiloid which appears to be referable to *Liroceras* but is so incomplete that its generic affinities are somewhat uncertain. This specimen is subglobular in shape and nautiliconic in its mode of growth. Its maximum diameter, measured across the umbilicus, is about 45 mm. The whorls are depressed dorsoventrally and are reniform in cross section, as they are broadly rounded ventrally, somewhat more narrowly rounded laterally, and impressed dorsally. The conch is expanded orad fairly rapidly; at the adapical end of the outer volution the conch is about 11½ mm. wide and 8½ mm. high, whereas at the adoral end of the same volution corresponding measurements are about 32 mm. and 21 mm. (estimated). The umbilicus is rather large and its diameter is equal to about a third that of the specimen. The umbilical shoulders are rounded. At least the internal mold of the outer volution of the specimen is smooth and entirely devoid of ornamentation.

The camerae are moderate in length and there are about 13 of them in the outer volution of the specimen under consideration. The external sutures of this specimen are essentially straight and directly transverse to the long axis of the conch. However, each suture appears to form a broad

shallow rounded dorsal lobe as it crosses the impressed zone, and in the center of this lobe, on the dorsum, is a small V-shaped annular lobe. Siphuncle small and located close to the ventral wall of the conch but not in contact with it; where the conch is about 8½ mm. high the siphuncle is only a little more than ½ mm. in diameter and its center is only about 2 mm. from the venter.

REMARKS.—The specimen just described seems to resemble the type species of *Liroceras* more closely than any other genotype, but it may not have reached maturity. Furthermore, its umbilicus is larger than that of most of the forms generally referred to as *Liroceras*.

OCCURRENCE.—Upper Permian conglomeratic buff limestone (probably in the zone of *Timorites*) capping Cerro Agujito in the Valle de Las Delicias, Coahuila.

FIGURED SPECIMEN.—Yale Peabody Museum, 16274.

Liroceras sp. [of Wyoming]

(Plate 25, figures 5, 6)

1936. *Coloceras* sp. MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 727–728, pl. 98, figs. 5, 6.

The Casper formation of Wyoming has yielded a single specimen that belongs in the genus *Liroceras*. It is rather small and is septate throughout, and presumably it represents only the adapical portion of the phragmacone.

This specimen is only a little more than one volution in length and is subglobular in shape, attaining a maximum diameter (measured across umbilicus) of about 14 mm. and a maximum width and height of conch of about 11½ mm. and 8½ mm., respectively. The conch is expanded orad rather rapidly, and at the adapical end of the outer volution of the specimen under consideration is only about 5 mm. wide and 3 mm. high. The whorls are broadly rounded ventrally, somewhat more narrowly rounded laterally, impressed dorsally, and reniform in cross section.

The umbilicus, which appears to be perforate, is rather small, and its diameter is equal to only about a fifth that of the specimen. The umbilical shoulders are rounded and not very distinct, though they appear to increase in prominence adorally. The umbilical walls also are rounded.

No trace of the surface markings of the test is discernible on the adoral part of this specimen, which is not very well preserved. However, on portions of the test, or a replacement of it, which adhere to the adapical part of the outer volution, there are rather prominent longitudinal lirae or raised lines. These are about a fifth of a millimeter apart. Traces of the growth-lines on the preserved portions of the test indicate that the conch is marked ventrally by a moderately deep rounded hyponomic sinus and laterally by similar but more broadly rounded salients.

The camerae are moderate in length. The sutures are not very distinct on this species, but they appear to be essentially straight and to be directly transverse to the long axis of the conch. The siphuncle is subcentral in position, but is distinctly nearer the dorsum than the venter.

REMARKS:—The longitudinal lirae on the adapical portion of the outer volution of the specimen being studied are not a specific character, for similar markings have been observed on the adolescent portions of the conch of more than one species of this genus. Since this specimen probably does not represent the mature portion of the conch, its specific affinities are uncertain.

OCCURRENCE.—*Stenopoceras* beds of Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Albany County, Wyoming.

FIGURED SPECIMEN:—State University of Iowa, 1152.

Genus ***Coelogasteroceras*** Hyatt, 1893

GENOTYPE: *Nautilus canaliculatus* Cox

In his *Genera of Fossil Cephalopods* Hyatt (1884, p. 286) proposed the generic name *Solenoceras* for a group of Carboniferous, Permian, and Triassic nautiloids and designated as the genotype the Lower Pennsylvanian species *Nautilus canaliculatus* Cox, which he inadvertently ascribed to Owen. However, 9 years later he (Hyatt, 1893, p. 392, 393, 447) removed all of the forms that he had earlier referred to this genus except the type species and erected a new genus, *Foordiceras*, for them. Also, by that time he had become aware of the fact that his generic name was preoccupied by *Solenoceras* Conrad, 1860, and he therefore proposed "as a substitute the name Coelogasteroceras, the type remaining the same."

The following year, Hyatt (1894, p. 498–499, 519, pl. 10, fig. 33) again discussed this genus and again changed its position in the scheme of classification but referred to it no species other than the type. In his final report on the classification of the nautiloids, Hyatt (1900, p. 524) subdivided the family to which he had referred this genus in 1894 and changed its family name, but he associated it with the same genera as in 1894. More recently the genus has been discussed by Miller, Dunbar, and Condra (1933, p. 211–215), Miller and Cline (1934, p. 286–287), and Miller and Unklesbay (1942, p. 723–724; 1947, p. 320–321).

The collections of the Yale Peabody Museum and those of The American Museum of Natural History contain well preserved representatives of the genotype which were kindly loaned to us for study (Pl. 53, figs. 1, 2). From these it is apparent that forms which are to be referred to this genus should have subglobular nautiliconic conchs with slightly depressed, laterally flattened, and ventrally grooved whorls, moderately small umbilici, sutures which form small ventral and broad lateral lobes, and a subcentral orthochoanitic siphuncle. The flattened lateral zones of the conch converge toward the venter, and the maximum width of the conch is attained just outside the umbilical shoulders.

As thus interpreted, the genus will include, in addition to the genotype, which occurs in the Lower Pennsylvanian of Kentucky, the following forms: *Coloceras mexicanum* Girty of the Yeso formation of New Mexico, the "Minnekahta" and Phosphoria formations of Wyoming, and possibly the Blaine and Dog Creek formations of Texas; *Coelogasteroceras thomasi* Miller and Cline of the Ervay tongue of the Phosphoria formation of Wyoming; *C.* sp. (of Miller and Cline, 1934, p. 287) of the Satanka formation of Wyoming; and probably *C. dubium* Miller and Unklesbay of the Brush Creek limestone (Conemaugh) of Pennsylvania. The species listed last is somewhat intermediate between typical representatives of this genus and *Peripetoceras* Hyatt, in which there is no longitudinal groove along the venter. *Coelogasteroceras* can therefore be said to be rather widespread in the United States and to range stratigraphically from the Lower Pennsylvanian to the Middle Permian, inclusive.

Coelogasteroceras should, of course, not be confused with *Coelonautilus* Foord, which is not closely related and which has for its genotype *Nautilus stygialis* de Koninck of the Lower Carboniferous of Belgium. That species is very similar to another form from the Lower Carboniferous of Belgium, *Nautilus koninckii* d'Orbigny, which is the genotype of *Vestinautilus* Ryckholt. Inasmuch as Ryckholt's name has priority, *Coelonautilus* should be suppressed as a synonym of it.

Coelogasteroceras mexicanum (Girty)

(Plate 11, figures 1–3; Plate 56, figures 6–13)

1909. *Coloceras mexicanum* Girty, U. S. Geol. Surv., Bull. 389, p. 49, 113, pl. 12, fig. 1.
1933. *Coelogasteroceras mexicanum* Miller, Dunbar, and Condra, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 212.
1934. *Coelogasteroceras mexicanum* Miller and Cline, Jour. Paleont., vol. 8, p. 287.
(?) 1942. *Coelogasteroceras mexicanum* Clifton, Jour. Paleont., vol. 16, p. 688, 696.
1942. *Coelogasteroceras mexicanum* Miller and Unklesbay, Jour. Paleont., vol. 16, p. 720, 723–724.
(?) 1944. *Coelogasteroceras mexicanum* Clifton, Am. Assoc. Petrol. Geol., Bull., vol. 28, p. 1026.
1947. *Coelogasteroceras mexicanum* Branson, Geol. Soc. Am., Mem. 26, p. 771.

The original description of this species, which was based on a single specimen from the Yeso formation of New Mexico, reads as follows:

"Shell rather small, subglobose, rapidly expanding. Umbilicus of medium size. Diameter of type specimen [Pl. 11, figs. 1–3] about 55 mm., width at aperture about 35 mm., width of umbilicus 8 mm. Section subcircular or somewhat subquadrate. Umbilical shoulder distinct, the umbilical portions of the volutions being almost parallel to the axis. The sides are slightly flattened, contracting above and rounding gradually into the broad ventral surface, which is gently depressed or concave. Surface smooth. Suture slightly sinuated. Indistinct lobes seem to occur upon the ventral and lateral surfaces, separated by equally obscure saddles, whose position is on the umbilical shoulder and the ventri-lateral shoulder. Height of the chambers 4 mm. Siphuncle situated below the middle, about halfway between the middle and the dorsal surface.

"This form probably belong to the genus *Coloceras* [= ? *Liroceras*], though the faintly impressed ventral surface and the presence of an obscure ventral lobe sustain some doubt on this point. *C. mexicanum* is certainly distinct from the two other American species, not only in possessing the two features just mentioned, but in being narrower as well."

REMARKS:—We have not seen the holotype and therefore are reproducing Girty's illustrations and description of it. However, we have quite a few specimens that appear to be conspecific, and they are discussed in the following paragraphs.

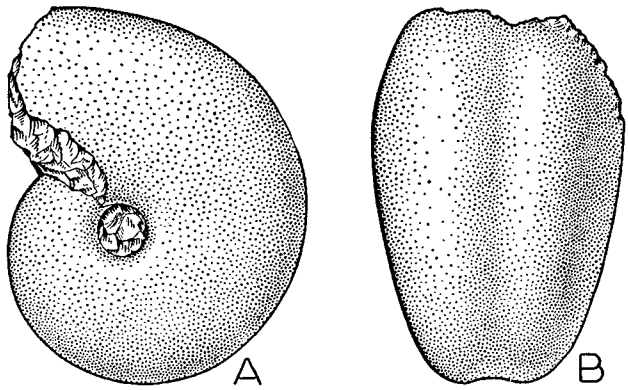

FIGURE 37.—*Coelogasteroceras mexicanum* (Girty)

An essentially complete individual, from the Phosphoria formation west of Lander, Wyoming, × 1. Same specimen as Figures 12, 13 on Plate 56.

H. D. Thomas secured eight nautiloids from the "Minnekahta" limestone of the Shirley Mountains in Wyoming, which are the only cephalopods known from that formation. All of these are closely similar and are probably conspecific. Furthermore, in so far as we can tell from the literature, they can not be differentiated specifically from typical *Coelogasteroceras mexicanum* (Girty) of the Yeso formation of central New Mexico. The largest of these specimens is estimated to have attained a diameter, measured across the umbilicus, of some 50 mm. Near the adoral end of this large specimen, the maximum height and width of conch measure about 25 mm. and 35 mm. respectively. The umbilical shoulders are fairly abrupt, but the ventrolateral zones of the conch are narrowly rounded. The diameter of the umbilicus is equal to about a third that of the specimen. The umbilical walls are almost parallel to the axis of coiling. The lateral zones of the conch are considerably flattened and they converge ventrad. The ventral zone is distinctly concave medianly.

One of the "Minnekahta" specimens (Pl. 56, figs. 8, 9) retains much of the test. The surface of the test bears rather prominent oblique ventrolateral nodes which are considerably elongate and which slope orad from the venter. The long axis of these nodes is parallel to the growth lines, which form a deep rather narrowly rounded ventral sinus and which curve decreasingly orad between the ventrolateral and the dorsolateral shoulders. Three of the specimens bear very distinct longitudinal lirae. In one case these are located in the impressed dorsal zone of the conch, and in the other cases they are on the lateral zones. They seem to be developed on an inner layer of the test, but this conclusion needs verification.

The sutures of these "Minnekahta" specimens are in general directly transverse, but they form slight ventral, lateral, and dorsal lobes. These lobes are separated by somewhat narrower saddles. The siphuncle is small and is located fairly close to the dorsal wall of the conch. Where the phragmacone is about 21.5 mm. wide and 12 mm. high and is impressed to a depth of about 2 mm., the siphuncle is about 1 mm. in diameter and is located about 7.7 mm. from the venter and about 1.5 mm. from the dorsum.

Alfred G. Fischer obtained two specimens from the lower portion of the Phosphoria formation of west-central Wyoming which are probably conspecific with the "Minnekahta" individuals just discussed. One of these represents only part of one whorl, but the other (Pl. 56, figs. 12, 13; and Fig. 37 in the text) is an excellent specimen a little more than 50 mm. in diameter.

In 1942 Clifton indicated that he had found representatives of this species in the Acme member of the Blaine formation and the Guthrie member of the Dog Creek formation in north-central

Texas. We have seen only the specimen he illustrated, and it is rather small, incomplete, and poorly preserved so we are uncertain in regard to its affinities. However, its adoral camera is very short (indicating that in spite of its small size it is probably mature) and there is not more than a suggestion of a groove on its ventral side (making its reference to *Coelogasteroceras* very doubtful).

OCCURRENCE.—The holotype of this species came from the Yeso formation about 2 miles east of the river near Alamillo, Socorro County, New Mexico. Eight of the specimens discussed in the immediately preceding paragraphs were collected by H. D. Thomas from the lower part of a ten-foot limestone member of the "Minnekahta" formation (about 73 feet above the Tensleep sandstone) at the head of Smith Creek, near center of sec. 1, T. 24 N., R. 82 W., on the flank of the Shirley Mountains of Carbon County, Wyoming, about 1 mile west of the Nelson Ranch. The two specimens secured by Alfred G. Fischer came from immediately below the "lower phosphate" member of the Phosphoria formation west of Lander, Fremont County, Wyoming, that is, along Spring Creek (= Trout Creek), near the junction of the $SE\frac{1}{4}SW\frac{1}{4}$ sec. 21 and the $NE\frac{1}{4}NW\frac{1}{4}$ sec. 28, T. 1 S., R. 2 W. (Wind River meridian).

Also Clifton indicates that this species is represented in the Acme member of the Blaine formation at the following two localities in north-central Texas: (1) "an extensive area, including sections 148, 168, 169, 173, 198 and adjacent sections, north and northwest of Quanah, in Block H, of the Waco and NW. R. R. Company Survey, Hardeman County, Texas"; and (2) "northeast Nolan County and Southeast Fisher County in Texas. Chiefly, Sec. 289, B. H. Stribling Survey, and Sec. 290, R. Cochran Survey." In addition, Clifton states that conspecific specimens occur in the Guthrie member of the Dog Creek formation at the following three localities in north-central Texas: (1) "sections 410, 411, 420, and 421, northeast and southeast of Kirkland, in Childress County, Texas;" (2) "section 139 and areas northeast, in Block F, of the H. & T. C. R. R. Co. Survey, Stonewall County, Texas. The very important Croton Falls area is in Section 139;" and (3) "about 2 miles south of Sylvester, Fisher County, Texas." It should be mentioned that the ammonoid genus *Perrinites* is stated to be represented at all five of these localities.

REPOSITORIES.—U. S. National Museum (holotype—Pl. 11, figs. 1–3); State University of Iowa, 2121 (Pl. 56, figs. 6–11; and one unfigured specimen) and 1473 (specimen illustrated by Clifton); and University of Wisconsin (Pl. 56, figs. 12, 13; and one unfigured specimen).

Coelogasteroceras thomasi Miller and Cline

(Plate 57, figures 1, 2)

1934. *Coelogasteroceras thomasi* MILLER AND CLINE, Jour. Paleont., vol. 8, p. 286–287, pl. 39, figs. 26, 27.
1942. *Coelogasteroceras thomasi* MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 724.
1947. *Coelogasteroceras thomasi* BRANSON, Geol. Soc. Am., Mem. 26, p. 771.

This species is based on eleven specimens from one horizon and locality. The individual that is figured is the best of the lot, and it is the holotype.

Form subglobose as conch is rather rapidly expanded orad, is depressed dorsoventrally, and is nautiliconic. Whorls are subquadrate in cross section but are slightly concave ventrally, slightly convex laterally, and more strongly concave dorsally, and the ventrolateral and dorsolateral shoulders are narrowly rounded. The lateral zones of the conch converge ventrally, and the maximum width of conch is attained at the umbilical shoulders. The preserved part of the holotype attains a maximum diameter of about 43 mm. and a maximum width and height of conch of about 34 mm. and 24 mm., respectively; at the adoral end of this specimen the ventral side of the conch is about 23 mm. wide whereas at the adapical end of the outer volution it is only about 8 mm. wide and the conch is only about 9 mm. high and 15 mm. wide. The holotype is not complete adorally and some of the paratypes appear to be as much as 25 per cent larger. The dorsal impressed zone is about a fifth as deep as the whorls are high.

The umbilicus is moderate in size, and its diameter is equal to about two-sevenths that of the specimen; the umbilicus of the holotype attains a maximum diameter of about 12 mm. The umbilical shoulders are rather narrowly rounded. The umbilical walls are slightly convex and are fairly steep.

The surface of the test is marked by very distinct growth lines. On the umbilical walls these are straight and directly transverse, but they curve steadily apicad as they cross the lateral and ventrolateral zones of the conch and show that the aperture was marked ventrally by a broad, deep, rounded hyponomic sinus. On the umbilical shoulders, and for a short distance on both sides of them, the conch is lirate, but even on well preserved specimens the lirae are not prominent and are easily overlooked. The camerae are short and along the venter their length is equal to about a fifth the width of the conch. The sutures are directly transverse but are slightly sinuous. On the mature portion of the conch, each suture forms a very shallow rounded ventral lobe, a similar ventrolateral saddle, and a broader, deeper (but nevertheless very shallow) lateral lobe. The sutures appear to be essentially straight as they cross the umbilical walls and the impressed dorsal zone, but this observation needs verification.

The siphuncle is small and is central (or very nearly so) in position. It is composed of cylindrical segments which are not expanded appreciably within the camerae, and it is therefore orthochoantic in structure. The diameter of the siphuncle is equal to only about a tenth the width of the conch.

REMARKS.—This species resembles *C. mexicanum* (Girty) in which, however, the ventral groove is deeper and the siphuncle is located "about halfway between the middle and the dorsal surface." The specimen from the Satanka formation of southeastern Wyoming that is being described as *C.* sp. also is similar but has a more prominent ventral groove—however, like the form under consideration it has a subcentral siphuncle.

OCCURRENCE.—All of the known representatives of this species came from the Ervay limestone tongue of the Phosphoria formation at the head of Casper Creek, Rattlesnake Hills, Natrona County, Wyoming, that is, about 50 miles west of Casper, Wyoming. *Spiriferina pulchra* (Meek) occurs in direct association with these nautiloids.

TYPES.—State University of Iowa, 701 (holotype), 702 (paratype); and University of Wyoming (paratypes).

Coelogasteroceras sp.

(Plate 57, figures 5, 6)

1934. *Coelogasteroceras* sp. MILLER AND CLINE, Jour. Paleont., vol. 8, p. 287.
1942. *Coelogasteroceras* sp. MILLER AND UNKLESBAY, Jour. Paleont., vol. 16, p. 724.

A single coiled nautiloid was found by H. D. Thomas in the Satanka formation of Wyoming. This specimen is an internal mold representing much of the living chamber of a form that appears to be closely similar to *C. thomasi* Miller and Cline and *C. mexicanum* Girty, and it is of about the same size and shape as the type specimens of those species. Its adapical end is formed by an impression of the adoral septum. On it there is a structure that appears to represent the siphuncle—it is small and is subcentral in position but is slightly nearer the venter than the dorsum. Unfortunately this specimen is too crushed and incomplete to merit detailed description, and adequate comparisons with other forms are not possible. However, it appears to differ materially from *C. thomasi* only in that it is less rapidly expanded orad, the groove on the ventral side of its conch is deeper, and the lateral zones are less strongly converged ventrad. Part, or possibly all, of these differences may be due to the lateral crushing which this specimen has obviously undergone.

OCCURRENCE.—Basal fossiliferous limestone of the Satanka formation at Gypsum Butte, near Red Mountain, southern Albany County, Wyoming. H. D. Thomas has written that "this is the bed which Darton and Lee confused with the Forelle, and which carries the fauna given in paragraphs 4 and 5, page 21, U. S. Geol. Survey, Bull. 364." Thomas added that he had found numerous species not contained in this list and that among them is *Allorisma capax* Newberry, which also occurs in the Yeso formation of New Mexico.

REPOSITORY.—State University of Iowa, 714.

Family EPHIPPIOCERATIDAE, n. fam.

We are establishing this family for two genera of Late Paleozoic nautiolids, *Ephippioceras* and *Megaglossoceras*, in which the sutures form deep ventral and dorsal saddles that are due to a median dorsoventral adoral inflection of the septa. Otherwise these forms do not differ materially from

typical representatives of the Liroceratidae, from which they are believed to have evolved. That is, their conchs are subglobular nautilicones with smooth or slightly costate rounded depressed volutions, small umbilici, and a small subcentral orthochoanitic siphuncle. In *Ephippioceras* the ventral saddle of the sutures is V-shaped, whereas that of *Megaglossoceras* is depressed-U-shaped.

In Europe *Ephippioceras* is widespread and occurs in both the Lower and the Upper Carboniferous. In North America it is not known from the Mississippian, is not rare in many portions of the Pennsylvanian, and ranges up into the Lower Permian. *Megaglossoceras* has so far been reported from only the Pennsylvanian of central United States, but Mr. L. R. Collins has recently donated to the State University of Iowa two specimens from the Conemaugh series of western Pennsylvania.

Genus ***Ephippioceras*** Hyatt, 1884

GENOTYPE: *Nautilus ferratus* Cox

In the original description of this genus, Hyatt designated as the genotype *Nautilus ferratus* Cox (which he inadvertently ascribed to Owen). The syntypes of that species, which came from the Lower Pennsylvanian of west-central Kentucky, seem to have been lost. However, we have available for study a good many specimens from the Pennsylvanian of various parts of the country that are believed to be conspecific (Pl. 53, figs. 7, 8). From these and the published information in regard to the original types, it is clear that this genus should contain subglobose nautilicones in which the conch is smooth or slightly costate and is rapidly expanded orad, and the whorls are few in number and are reniform in cross section, being broadly rounded ventrally and laterally and impressed dorsally. The umbilicus is small, inconspicuous, and closed at maturity, and the umbilical shoulders are rounded and indefinite. Aperture bears a rather shallow rounded hyponomic sinus. Each suture forms a V-shaped but narrowly rounded ventral saddle and on either side of it a broad rounded lateral lobe, a small saddle which centers on or near the umbilical shoulder, a slight lobe on the umbilical wall, a small saddle which centers on the umbilical seam, and a moderately small internal lateral lobe which extends to the broad rounded rather high dorsal saddle. Siphuncle small subcentral and orthochoanitic.

This genus resembles *Megaglossoceras* Miller, Dunbar, and Condra, with which it is somewhat gradational. However, in *Ephippioceras* the ventral lobe of the sutures tends to be V-shaped, in *Megaglossoceras* U-shaped.

Representatives of this genus are known to be widespread in Europe (including the Ural Mountains) and in North America. In Europe they occur in both the Lower and the Upper Carboniferous, but in North America they appear to be limited to the Pennsylvanian and the Lower Permian. All of our Pennsylvanian specimens seem to be referable to one species, *E. ferratum* (Cox), of which *Nautilus divisus* White and St. John (though poorly known) is probably a synonym. *E. ferratum* appears here in the base of the Cherokee (Atoka formation of Arkansas) and continues up to the top of the Lansing (South Bend limestone of Nebraska). The specimens from the Pueblo formation of north-central Texas and the Hueco formation of south-central New Mexico, described in the following paragraphs, show that the genus ranges up into lower portions of the Permian. Geographically, it is known to occur in the United States from Pennsylvania on the east to Texas on the west.

Ephippioceras inexpetcans Miller and Youngquist

(Plate 58, figures 4–7)

1947. *Ephippioceras inexpectans* MILLER AND YOUNGQUIST, Kansas Univ. Paleont. Contr., Mollusca, art. 1, p. 2, 5–6, pl. 2, figs. 1–4.

Two internal molds preserved in limestone constitute the basis for this species. Both of these represent the living chamber, and fortunately the adoral camera of the phragmacone is retained by one of them. Inasmuch as these two specimens are of the same general size, it seems logical to conclude that they are probably mature individuals.

The conch is moderate in size, subglobular in shape, and nautiliconic in its mode of growth. Its diameter, when complete, was somewhat more than 50 mm. The whorls are reniform in cross section as they are broadly rounded ventrally and laterally and are impressed dorsally. At the

junction of the phragmacone and the living chamber of the holotype, which is our most nearly complete specimen (Pl. 58, figs. 6, 7), the width and height of the conch measure about 23 mm. and 16 mm., respectively. This specimen represents about two-fifths of a volution, and near its adoral end it is about 35 mm. wide. The other specimen (Pl. 58, figs. 4, 5) is terminated adapically by an impression of the adoral septum, which is about 23 mm. wide and 17 mm. high. This specimen represents about a third of a volution, and the maximum width and height of its conch, which are attained near its adoral end, measure about 34 mm. and 23 mm., respectively. These measurements show that the conch is expanded orad rather gradually for this genus.

The living chamber is at least a third of a volution in extent. The umbilicus is moderately small but seems to be deep—that of the most nearly complete specimen attained a diameter of at least 16 mm. The umbilical shoulders are rounded and the umbilical walls are steep.

No trace of surface ornamentation is discernible on either of the types, internal molds, and presumably therefore the test was essentially smooth. The length of the single camera that is preserved on one of the type specimens measures about $4\frac{1}{2}$ mm. along the venter. Each suture forms a broad deep V-shaped but narrowly rounded ventral saddle, and on either side of it a broad rounded lateral lobe, and apparently a shallow saddle on or just inside the umbilical shoulder. Neither the shape of the internal sutures nor the nature of the siphuncle is known, but presumably they do not differ materially from those of other representatives of this genus.

REMARKS.—This species resembles *E. ferratum*, the genotype, in most of its characters that can be ascertained. However, its conch is less rapidly expanded orad and presumably is much smaller at maturity.

OCCURRENCE.—Camp Creek shale member of the Pueblo formation (about 24 feet above Saddle Creek limestone), 1.2 miles south and 0.6 mile west of the mouth of Saddle Creek, Mc Culloch County, Texas, in association with *Pseudorthoceras knoxense* (McChesney) and *Artinskia lilinae* Miller and Youngquist.

TYPES.—U. S. National Museum.

Ephippioceras sp.

In the Hueco formation of New Mexico, Carl C. Branson and J. S. Baker found a fragment that belongs in this genus. It is an internal mold of the ventral portion of one volution of a phragmacone that was at least 60 mm. wide. Portions of several of the sutures as well as the general physiognomy of the specimen clearly indicate that its affinities are with *Ephippioceras*, but it is so incomplete that it does not merit illustration or detailed description.

REMARKS.—In so far as we are aware, this specimen is most probably the youngest known representative of the genus. Unfortunately, its specific affinities can not be ascertained, but in all available particulars it does not seem to differ materially from typical *Ephippioceras*.

OCCURRENCE.—Lower part of Hueco formation in SW$\frac{1}{4}$ sec. 20, T. 22 S., R. 10 E., Otero County, New Mexico.

RESPOSITORY.—U. S. National Museum.

Family SOLENOCHILIDAE Hyatt, 1893

When Hyatt established this family, he spelled the name "Solenocheilidae," and he included in it, in addition to *Solenochilus* Meek, the following genera: *Aipoceras* Hyatt, *Oncodoceras* Hyatt, and *Asymptoceras* Ryckholt. In his final work on the classification of the nautiloids, he (Hyatt, 1900, p. 525) retained all of these genera in the family and added *Pteronautilus* Meek and *Acanthonautilus* Foord.

The genotype of *Aipoceras, Gyroceras gibberosum* de Koninck of the Lower Carboniferous of Belgium, has a rapidly expanded laterally compressed conch that is so loosely coiled that the volutions are not in contact. However, the sutures are essentially straight and directly transverse, and the siphuncle is orthochoanitic in structure and is ventral and marginal in position. Therefore, the relationship of this genus to *Solenochilus* is believed to be sufficiently close to justify its inclusion in the same family.

Oncodoceras is based on an unillustrated species, *O. fusiforme* Hyatt of the Lower Carboniferous of Ireland and Belgium. At maturity its conch is compressed dorsoventrally and is composed of

volutions that are presumably in contact but are not impressed dorsally. The aperture is slightly contracted. The sutures form slight ventral, dorsal (annular), and possibly lateral lobes, and the siphuncle is ventral in position. This genus therefore is thought to be fairly close to *Solenochilus*.

According to de Koninck (1878, p. 113), the genotype of *Asymptoceras* is *Nautilus cyclostomus* Phillips, which is stated to be of widespread occurrence in the Lower Carboniferous of Great Britain and Europe. It resembles typical *Solenochilus* rather closely but differs from it in that its conch is almost as high as wide, is impressed very slightly, and becomes somewhat evolute at full maturity. Nevertheless, the two should be left in the same family.

Meek (in Meek and Hayden, 1865, p. 63–64) discussed the family "Nautilidae," as interpreted by him, and in a footnote stated:

"The name *Pteronautilus* is proposed for a remarkable undescribed Permian genus, of which *Nautilus Seebachianus*, Geinitz, is the type (see Dyas, p. 43, tab. 11). It may be characterized as follows:

GENUS **Pteronautilus,** MEEK.

Shell with the involute body portion comparatively very small and globular in form, scarcely umbilicate. Outer chamber very large, and deflected from the involute body, its inner or ventral side being widely open, and the lateral margins greatly dilated, so as to form a very large wing-like expansion on each side.

"Conchologists will readily understand that such a shell as this must have been inhabited by an animal differing widely in its structure from a living typical *Nautili*."

Hyatt (1900, p. 525) recognized this genus and placed it in the Solenochilidae, but otherwise it has been almost entirely overlooked. In so far as we are aware, no specimens have been found that resemble the only known representative of the genotype—it may be a fragmentary incomplete specimen that Geinitz misinterpreted, and it may not even be a nautiloid. Nevertheless, in order to elucidate this matter, we are reproducing as Figures 4 and 5 on Plate 35 Geinitz's figures on which Meek based *Pteronautilus*, but it should be emphasized that we are indeed uncertain in regard to the affinities of this form. No information is available in regard its siphuncle.

In general physiognomy the genotype of *Acanthonautilus, A. bispinosus* Foord of the Lower Carboniferous of Ireland, resembles those of *Solenochilus* and *Liroceras*. It appears to differ chiefly in that at maturity the adoral portions of its umbilical shoulders are greatly extended laterally to form long spine-like processes. However, it should be kept in mind that the siphuncle of this species is entirely unknown; and in *Nautilus cornutus* Golovkinsky of the Permian of the Ural region, which has been generally believed to be congeneric, the siphuncle is subcentral in position. *N. cornutus* (Pl. 54, figs. 1–3) is the genotype of *Permonautilus* Kruglov, which was proposed long after Foord had established *Acanthonautilus*. It now seems to us that, for the present at least, it will be best to suppress *Permonautilus* as a synonym of *Acanthonautilus* and to place that genus in the Liroceratidae.

In summary it can be said that typical members of this family have rapidly expanded rather loosely coiled conchs in which the test is smooth, the sutures are only slightly sinuous, and the siphuncle is orthochoanitic in structure and ventral and marginal in position. Geographically the family is known to be of widespread occurrence, and stratigraphically it ranges from the Lower Carboniferous to the Permian, inclusive.

Genus ***Solenochilus*** Meek and Worthen, 1870

GENOTYPE: *Nautilus (Cryptoceras) Springeri* White and St. John

When Meek and Worthen established this genus, they designated as its genotype a poorly known species, *Nautilus (Cryptoceras) Springeri* White and St. John of the Upper Pennsylvanian of southwestern Iowa. From a study of the published information in regard to this and other similar species and the numerous congeneric Mississippian, Pennsylvanian, and Permian specimens available to us, we have drawn up the following generic diagnosis of *Solenochilus* [commonly mispelled *Solenocheilus*]:

Conch nautiliconic and subglobular, and it consists of only a few whorls. These are very rapidly expanded orad, wider than high, very broadly rounded ventrally, somewhat more narrowly rounded ventrolaterally and laterally, and slightly impressed dorsally—the impressed zone is very small, due to the rapid adoral expansion of the conch. The dorsolateral zones of the whorls are variable, being keeled in some forms (*e.g.*, the genotype), slightly concave in others, and convex in a third group.

The umbilicus is small but deep and is almost certainly perforate. The test is thick. It does not bear ribs or nodes, but fine growth lines on its surface form broad shallow rounded ventral and lateral sinsuses, and ventrolateral and dorsolateral salients. The camerae are moderate in length. The sutures are directly transverse and are straight or only slightly sinuous. The siphuncle is ventral and marginal in position and is rather small in size. The septal necks appear to have the form of

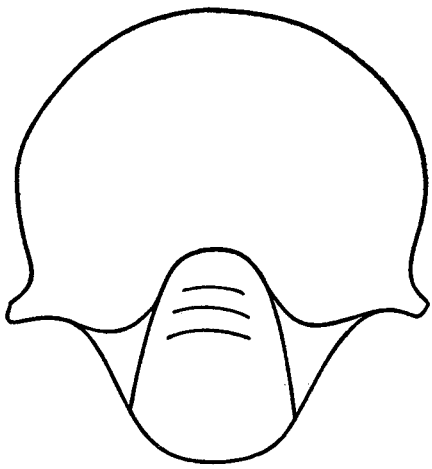

FIGURE 38.—*Solenochilus springeri* (White and St. John)

The single available illustration of the only known (now lost) representative of the genotype of *Solenochilus*, from the Upper Pennsylvanian of Adair County, Iowa, × ½. After White and St. John.

a funnel which is modified on its ventral side where it comes in contact with the test. The connecting rings form a bulb-like expansion immediately apicad of the septal necks but are essentially cylindrical throughout the rest of their length. Adapically the connecting rings invaginate into the septal necks and extend throughout their length. Presumably the siphuncle should be regarded as having a modified orthochoanitic structure.

The genus *Solenochilus* is now known to be widespread in both Europe and North America and it may occur also in South America and in Asia. Stratigraphically it ranges at least from the Lower Mississippian to the Lower Permian, inclusive. The wide globular dorsally impressed nautiliconic conch, the absence of nodes or spines, and particularly the ventral position of the siphuncle are sufficient to distinguish representatives of it from related genera.

Solenochilus? dorsatum (Swallow)

1858. *Cyrtoceras dorsatum* SWALLOW, Acad. Sci. St. Louis, Trans., vol. 1, p. 178, 197.
1948. *Cyrtoceras? dorsatum* BRANSON, Geol. Soc. Am., Mem. 26, p. 773.

All of the available information in regard to this species is contained in the original description, which reads as follows:

"*Shell* short, ventricose, conical, tapering rapidly toward the posterior extremity, strongly curved, depressed on the dorsal and ventral surfaces; last chamber large; *aperture* elliptical, dilated, somewhat irregular and corrugated on the inner margin; *siphuncle* cylindrical, touching the dorsal [ventral] margin; *septa* convex, elliptical, oblique, distant on the dorsal margin less than one-third of the least diameter, approximate on the inner margin, periphery slightly sinuous, curved forward from the back to the sides and back on the sides. Surface markings not seen.

"Major axis of the last septum, 1.26 [inches]; minor axis, 1.01 [inches]; distance between the last and penultimate septum on the outer margin, 0.31 [inches].

"From the Permian Rocks of Kansas, near Smoky-Hill Fork, associated with *Nautilus Permianus* and *Spirorbis orbiculostoma*."

REMARKS.—The type specimen of this species was never illustrated, and if it is extant its location is not known. The shape of the conch and particularly the position of the siphuncle suggest a relationship to *Solenochilus*, to which genus the species is accordingly referred. It is, however, so poorly known that even its generic affinities are uncertain, and it is not possible to place specimens in it with a reasonable degree of assurance.

OCCURRENCE.—Some unknown horizon in the Permian near the Smoky Hill River in central Kansas.

HOLOTYPE.—Probably lost in the fire at the University of Missouri in 1892.

Solenochilus kempae, n. sp.

(Plate 28, figure 3)

1947. *Solenochilus* sp. MILLER AND KEMP, Jour. Paleont., vol. 21, p. 352.

The single specimen on which this species is based is a moderately well preserved incomplete internal mold of the ventral portion of the adoral third of the outer volution of the phragmacone and the adjacent part of the living chamber. The overall length of this specimen measures about 110 mm. and the maximum width about 112 mm. The conch is rapidly expanded orad, and the whorls are depressed and are very broadly rounded ventrally and ventrolaterally.

The camerae are short, particularly in the adoral portion of the phragmacone of the holotype, which suggests that this specimen represents a fully mature individual. The sutures are essentially straight and directly transverse, but along the venter they curve apicad in the immediate vicinity of the siphuncle for that structure was ventral and marginal in position and presumably was in contact with the ventral wall of the conch. Apparently the septal necks were in general infundibuliform, and the connecting rings were more or less cylindircal, but the details of the structure of the siphuncle can not be discerned.

On the adapical portion of the living chamber there are traces of a sinuous ribbon-like structure some 4 mm. wide that probably represents an aponeurotic band. From the region of the anterior end of the siphuncle, this structure extends anterolaterally to the ventrolateral zone of the conch, where it is gradually recurved.

REMARKS.—Foord and Crick (1890, p. 221) have illustrated and described a representative of *Solenochilus latiseptatum* (de Koninck) from the Carboniferous of Scotland that retains the anterior margin of the impression of the aponeurotic band. It is very much like that on the specimen we are studying but is located farther orad of the junction of the phragmacone and the living chamber. The short camerae of this species are believed to be one of its most distinctive features. The few congeneric specimens known from the Permian all have relatively long camerae. The specific name is given in honor of Mrs. Augusta Hasslock Kemp who found the holotype and presented it to the University of Colorado.

OCCURRENCE.—Lower portion of Lueders formation about 10 miles southeast of Seymour, Baylor County, Texas.

HOLOTYPE.—University of Colorado, 18061.

Solenochilus cf. *S. brammeri* Miller, Dunbar, and Condra

(Plate 25, figures 1, 2)

1936. *Solenochilus* cf. *S. brammeri* MILLER AND THOMAS, Jour. Paleont., vol. 10, p. 736–737, pl. 98, figs. 1, 2.

The Casper sandstone of Wyoming has yielded five specimens that are referable to *Solenochilus*. All of these are rather fragmentary and incomplete, but they appear to be conspecific. In so far as we have been able to ascertain, they do not differ materially from *S. brammeri* Miller, Dunbar, and Condra, but the largest of them, which, however, does not represent the adoral portion of the conch, is considerably smaller than the holotype of that species. Furthermore, the fragmentary nature of our specimens prevents us from referring them definitely to any species. The most nearly complete of the five, which is also the smallest, is figured.

Conch, which apparently consists of only a very few volutions, is subglobular, nautiliconic, and large. Phragmacone attains a maximum diameter, measured across the umbilicus, of more than 100 mm. Whorls rapidly expanded orad, depressed dorsoventrally, about half as high as wide, and subrectangular in cross section though somewhat impressed dorsally. Ventral side of conch is very broadly rounded, ventrolateral zones are rounded, and lateral zones are nearly straight and almost parallel. On adapical portion of figured specimen dorsolateral zones of conch are rounded but near mid-length of this specimen a subangular dorsolateral keel is developed on the umbilical shoulder, and in the larger specimens this keel becomes very prominent and the umbilical shoulders are flared; the zones immediately ventrad of the umbilical shoulders are then concave. The umbilicus appears to be relatively small, but its diameter can not be ascertained from our specimens.

Test rather thin, and that of specimens somewhat larger than the one figured is slightly less than 1 mm. thick. Surface of internal mold smooth, and test appears to be marked by only growth lines. Traces of growth lines preserved on our specimens indicate that flared umbilical shoulders project slightly forward at apertural margins as low subangular or very narrowly rounded salients, and that there are broad very shallow broadly rounded sinuses along concave zones just ventrad of umbilical shoulders and similar but broader salients along ventrolateral zones of conch; the course of the growth lines across ventral side of conch can not be ascertained from our specimens.

Camerae are moderate in length, and along venter distance between successive sutures is equal to about a fourth width of conch. Each suture forms a broad very low broadly rounded ventral lobe and on each side of it there is a similar but somewhat deeper and less broadly rounded ventrolateral saddle; sutures are nearly straight or only slightly convex apicad on lateral zones of conch.

Siphuncle small, circular in cross section, ventral and marginal in position, and orthochoanitic in structure. Its diameter is equal to about a twentieth width of conch. Septal necks are about two-fifths as long as camerae, and connecting rings are cylindrical in shape.

REMARKS.—The similarity of the specimens under consideration to the types (particularly the juvenile paratype) of *S. brammeri*, which came from the Upper Pennsylvanian (Kansas City) Argentine limestone of Nebraska, may not be very significant, for none of the known representatives of this genus differ greatly from *S. brammeri*. *S. kentuckiense* Hyatt of the Lower? Pennsylvanian of Edmonson County, Kentucky, also seems to resemble it very closely. Many of the described species of *Solenochilus* are based on such fragmentary specimens that adequate comparisons are not possible.

OCCURRENCE.—*Stenopoceras* beds of Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Albany County, Wyoming.

FIGURED SPECIMEN.—State University of Iowa, 1171.

Solenochilus syracusense Miller, Dunbar, and Condra

(Plate 32, figures 5, 6)

1933. *Solenochilus syracusensis* MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 233–234, pl. 22, figs. 4, 5.
1948. *Solenochilus syracusensis* BRANSON, Geol. Soc. Am., Mem. 26, p. 827.

This species was based on a single internal mold that is not very well preserved but represents the adoral seven camerae of the phragmacone and a considerable portion of the living chamber. The conch was subglobose, being rapidly expanded and strongly depressed. The whorls are subelliptical in cross section as they are very broadly rounded ventrally and dorsally and more narrowly rounded laterally; it is probable that they are slightly impressed along the median zone of the dorsal side, but that portion of the holotype is very poorly preserved. The cross section of the whorl is only a little more than half as high as wide. The umbilicus is small, the umbilical shoulders are abrupt, and the umbilical walls are steep.

The internal mold, at least, is smooth and is free from ornamentation. The distance between successive sutures, measured along the venter, is equal to about a sixth the width of the conch. The sutures are transverse to the long axis of the conch and are nearly straight, but they form broad, very shallow lobes as they cross the broadly rounded venter, and although their course across the dorsal side of the conch can not be determined from the type specimen, it is probable that they form shallow rounded dorsal lobes.

The siphuncle is small, ventral, marginal, and orthochoanitic. The diameter of the siphuncle measures a little less than 3 mm. where the width of the conch is 35 mm.

REMARKS.—This species is similar to *Solenochilus kerefordense* Miller, Dunbar, and Condra of the Upper Pennsylvanian Kereford limestone of northeastern Kansas. However, that form has somewhat longer camerae.

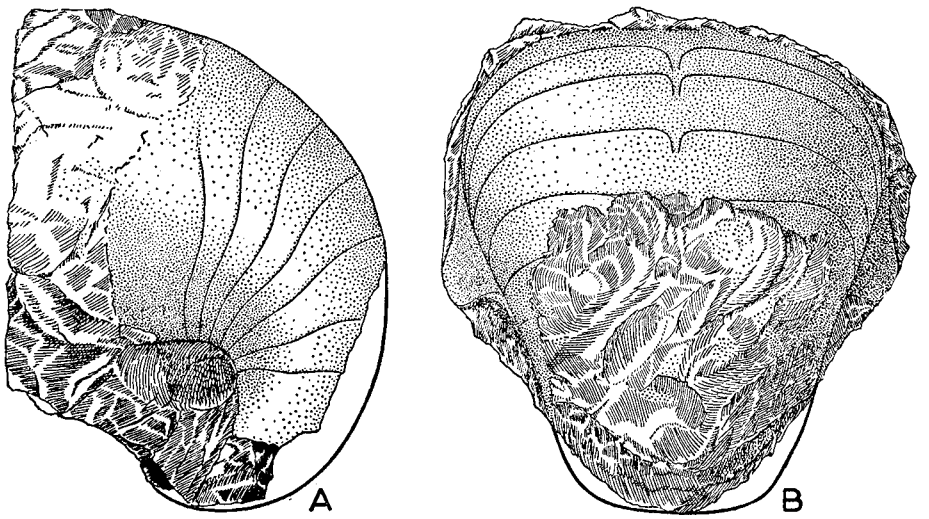

FIGURE 39.—*Solenochilus* sp.
Two views of a specimen from the Lower Permian at Ballinger, Texas, × ½. After Hyatt.

OCCURRENCE.—Hughes Creek shale about 1 mile southwest of Syracuse, Otoe County, Nebraska.
HOLOTYPE.—Yale Peabody Museum, 14004.

Solenochilus spp.

1893. *Solenocheilus collectus* HYATT [not Meek and Worthen], Texas Geol. Surv., An. Rep. 4, p. 463–465, text figs. 31, 32.
(?) 1928. *Solenocheilus* aff. *collectus* KRUGLOV, Mus. Geol., Acad. Sci. URSS, Trav., t. 3, p. 172–174, 181, 196, pl. 15, figs. 6–8.
1933. *Solenochilus collectus* [of Hyatt, not Meek and Worthen] MILLER, DUNBAR, AND CONDRA, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 230.

In 1893 Hyatt illustrated as "*Solenocheilus collectus* Meek and Worthen" (see Fig. 39) a valid representative of *Solenochilus* from Ballinger, Texas—presumably it came from either the Clear Fork or the Wichita group. His brief description reads as follows:

"This name is applied to a large fragment, having siphuncle visible on the venter, but otherwise very distinct from others of its own group. The sides of the whorl are flattened, the venter depressed, but the ventrodorsal diameter is longer than usual. The transverse diameter through centre of the sides was not less than 130 mm., the breadth of the side 63 mm. at this diameter, the breadth of the venter 112 mm. The length of the fragment measured along the arch of the abdomen was 95 mm. The dimensions of this last section were as follows: transverse diameter through center of the sides was 92 mm., breadth of the flattened side 51 mm., breadth of venter 82 mm. I [Hyatt] do not feel entirely sure that this is the adult or old whorl of *S. collectus*, since the young whorls are not visible, but if not identical it is certainly a very close affine of that species. The keels at the umbilical shoulders are well developed and prominent [though they are not elucidated by the illustrations]".

REMARKS.—As was indicated in 1928 by Kruglov and in 1933 by Miller, Dunbar, and Condra, Hyatt's specimen is almost certainly distinct from typical *Solenochilus collectum* Meek and Worthen of

the Mississippian of Indiana and Illinois. Nevertheless, we are reluctant to propose a specific name for this Permian form without an opportunity to study the specimen (the whereabouts of which we are uncertain), and particularly because its precise stratigraphic derivation is indeterminable.

In 1928 Kruglov illustrated and described a specimen from the Middle Permian Artinskian of the Ural region, which he thought was related to Hyatt's "*Solenocheilus collectus*". That Russian specimen is poorly preserved, incomplete, and crushed. It appears to be referable to *Solenochilus*, but its relationship to the Texas form is uncertain.

OCCURRENCE.—At or near Ballinger, Runnels County, Texas, presumably in either the Clear Fork or Wichita group. The specimen which in 1928 Kruglov compared to the individual illustrated by Hyatt came from the Artinskian of the Ural region.

FIGURED SPECIMEN.— University of Texas.

ADDENDUM

A few Permian nautiloids were sent to us so late that a study of them could not be incorporated into this report. That is, Mrs. Augusta Hasslock Kemp of Seymour, Texas, loaned us a collection which she assembled about 5 miles southeast of her home town from an outcrop of the Talpa limestone which forms the cap of a low bench 5–6 feet high "$\frac{1}{4}$ mile north of the southeast corner of section 176, extending about $\frac{1}{8}$ mile west of the north-south section road and a little to the east in section 189." This collection consists primarily of three only moderately well preserved specimens which belong in *Ephippioceras* and which are probably the youngest known representatives of that genus. The conch of this form is subglobular in shape and attains a maximum diameter of more than 85 mm. One of the specimens is imbedded in a block of rock which retains an impression of a representative of *Tainoceras*, and another is in a block which contains a natural transverse section of an ammonoid which appears to be referable to *Properrinites*.

The specimen represented by Figures 1 and 2 on Plate 59 was loaned to us by Mr. L. F. Brady of the Museum of Northern Arizona, who states that he has seen "a number of fragments of this form" in the α member of the Kaibab limestone, but that this is the only one known that is satisfactory for illustration and description. It is an internal mold of essentially all of the living chamber and the adoral three camerae of the phragmacone, and its maximum overall length measures about 75 mm. Its conch is reniform in cross section as it is depressed dorsoventrally, impressed dorsally, rounded laterally, and broadly rounded ventrally, though there is a very slight median concave zone along the venter. Near the mid-length of the speicmen the internal mold of the conch is about 31 mm. wide and 20 mm. high. The matrix which adheres to one side of this specimen shows that it bore a row of rather prominent widely spaced ventrolateral spines, which are represented on the internal mold by only low rounded blunt nodes. However, one of the adoral spines of the phragmacone is preserved, presumably as a replacement, and part of the adoral spine on the same side of the living chamber is similarly preserved. The sutures of this specimen form shallow ventral lobes, and on the dorsolateral zones of the conch they seem to curve orad. No trace of the siphuncle is visible. This specimen is stated to be from the "very top of the α member of the Kaibab limestone" on East Pocket Knob (NE$\frac{1}{4}$ sec. 6, T. 18 N., R. 6 E.), about 18 miles southwest of Flagstaff, Arizona. Clearly its affinities are with the genus *Temnocheilus*, but it is not very close to any described species.

A moderately small well preserved representative of the genus *Stearoceras* was recently found in the San Andres limestone of southeastern New Mexico by H. M. Goodman and was sent to us by R. C. Spivey. It is illustrated by Figures 3–5 on Plate 59. This specimen is an internal mold with a maximum diameter of about 50 mm. Near the adapical end of its outer volution, the conch is subelliptical in cross section, being considerably wider than high. However, at the adoral end of the specimen the cross section is subrectangular as the conch is flattened laterally and ventrally, very narrowly rounded ventrolaterally and dorsolaterally, and only slightly impressed dorsally. The lateral zones are distinctly converged ventrad. The maximum width and height of conch attained by the preserved part of this individual measure about 27 mm. and 22 mm., respectively. The diameter of the umbilicus is equal to about three-sevenths that of the specimen. The umbilical walls are steep and are almost perpendicular to the flattened lateral zones of the conch. The camerae are short, and there are about 30 of them in the outer volution of the specimen under consideration. In the adapical half of this volution, the internal mold bears low narrowly rounded lateral nodes, but no trace of such structures is discernible orad of there. Each of the adoral sutures forms slight ventral, lateral, and presumably dorsal lobes, but is essentially straight and directly transverse as it crosses the umbilical walls. The siphuncle does not appear to be retained. Because of the change in ornamentation and particularly because the shape of the conch of this specimen varies materially throughout the length of the adoral volution that is preserved, it seems likely that we are dealing with the adapical immature portion of a conch that was much larger at full maturity. This specimen may therefore well be referable to *Steraoceras rotundatum* (Miller and Unklesbay), which was originally described from the upper part of the San Andres limestone in the same general region. It came from "approximately 250–300 feet below the top of the San Andres formation" in the northwest wall of Last Chance Canyon in the NE$\frac{1}{4}$SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 32, T. 23 S., R. 22 E., about 1$\frac{1}{2}$ miles along the trail west from the Webster (Lowe) Ranch house, Eddy County, New Mexico.

James P. Conlin of Fort Worth, Texas, kindly loaned us for study an internal mold of a small orthoceraconic nautiloid that most probably belongs in *Thoracoceras* Fischer de Waldheim. It is not complete adorally or adapically, is about 20 mm. long, and varies in diameter from about 5 mm. to about 6 mm. The adapical 7 mm. of this specimen represent the adoral three camerae of the phragmacone. There are 16 small sharp longitudinal ridges within the complete circumference of the conch, and these are separated by broad shallow rounded grooves. A structure that appears to represent the siphuncle is small at its passage through the septa and is located about midway between the center and the venter of the conch. This specimen came from the "Dothan beds" of the Horse Creek formation in a road-side ditch about 2.7 miles west of Dothan, Callahan County, Texas.

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EXPLANATION OF PLATES 2–59

PLATE 2.—*PSEUDORTHOCERAS* AND *MICHELINOCERAS*

Figures — Page

1–7. *Pseudorthoceras knoxense* (McChesney) 18
Figures 1–5 represent three specimens that R. L. Clifton collected from the Guthrie member of the Dog Creek formation in the Croton Falls area of Stonewall County, Texas—Figures 1 and 4 are × 2, 3 is × 1, and 2 and 5 are × 5; 2 is an enlargement of the adoral portion of 1, and 5 is an enlargement of the adoral part of the sectioned portion of 4. Figures 6 and 7 illustrate two specimens collected by H. D. Thomas from the Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming, × 8 and 2, respectively. Figures 1, 2, 5, and 6 are unretouched photographs—2 and 5 illustrate polished sections, 6 a thin section. S. U. I. 1468, 1469, 1467, 1148, and 1147, respectively. (*See also* Plates 3, 55.)

8–10. *Michelinoceras? guadalupense* (Girty) 29
Three views of the holotype, from the Delaware Mountain formation (probably from a limestone just below the Getaway member) on the "west side of road at entrance to Guadalupe Canyon," about 2 miles southeast of El Capitan in the Guadalupe Mountains of Culberson County, Texas, × 3—adapted from Girty. Collected by G. H. Girty. U. S. N. M.


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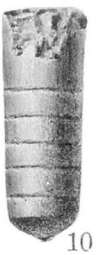
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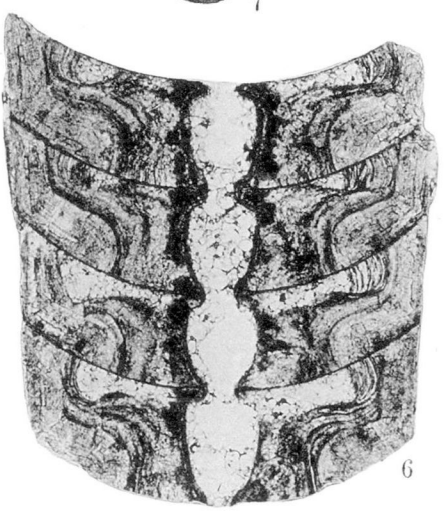
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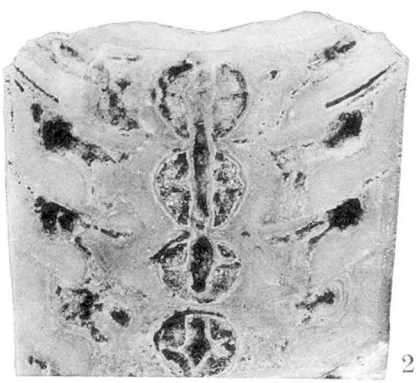
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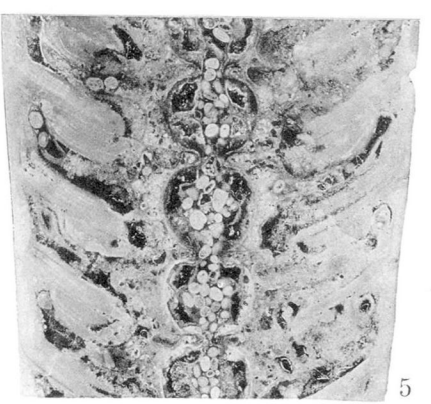
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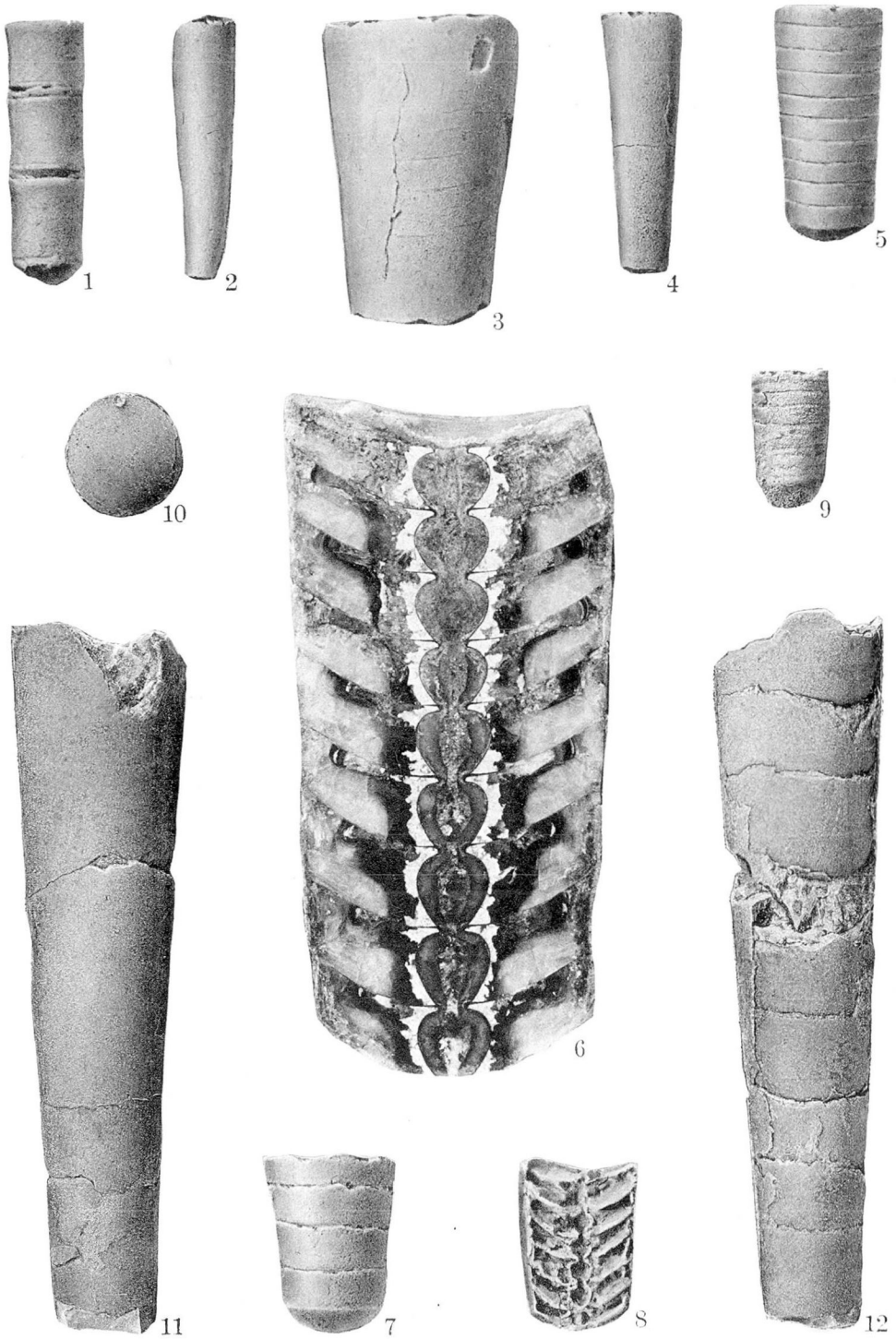
PSEUDORTHOCERAS AND *MICHELINOCERAS*



BITAUNIOCERAS, PSEUDORTHOCERAS, MOOREOCERAS, AND *BACTRITES*

PLATE 3.—*BITAUNIOCERAS, PSEUDORTHOCERAS, MOOREOCERAS,* AND *BACTRITES*

Figures — Page

1. *Bitaunioceras texanum* Miller and Youngquist 31
The holotype, from the Wildcat Creek shale member of the Admiral formation about 4½ miles south-southwest of Coleman, Texas, × 2. Collected by R. C. Moore. U. S. N. M.

2–8. *Pseudorthoceras knoxense* (McChesney) 18
Seven specimens from the same horizon and locality as Figure 1. Figure 2 shows part of the curved adapical portion of the conch, × 2½; 3 portrays a large testiferous individual, × 1; 4 illustrates a typical testiferous specimen, × 1; 5 represents an internal mold showing sutures, × 1; 6 is an unretouched photograph of a longitudinal section through the siphuncle, × 5; 7 portrays an internal mold showing sutures, × 1; and 8 illustrates a natural longitudinal section through the siphuncle, × 1. Collected by R. C. Moore. U. S. N. M. (*See also* Plates 2, 55.)

9. *Mooreoceras giganteum* Clifton? 23
A portion of a phragmacone from the Hueco limestone in sec. 9, T. 22 S., R. 10 E., Otero County, New Mexico, × 1. Collected by C. C. Branson. U. S. N. M. (*See also* Plates 4, 5.)

10–12. *Bactrites? mexicanus* Miller 33
Three views of the most nearly complete syntype, from an Upper Permian concretionary shale in the zone of *Timorites* along the strike between Cerro Wencelao on the south to 300 meters west of El Indio on the north, in the Valle de Las Delicias, Coahuila, × 1. Collected by R. E. King. Y. P. M., 16278. (*See also* Plate 8.)

PLATE 4.—*MOOREOCERAS*

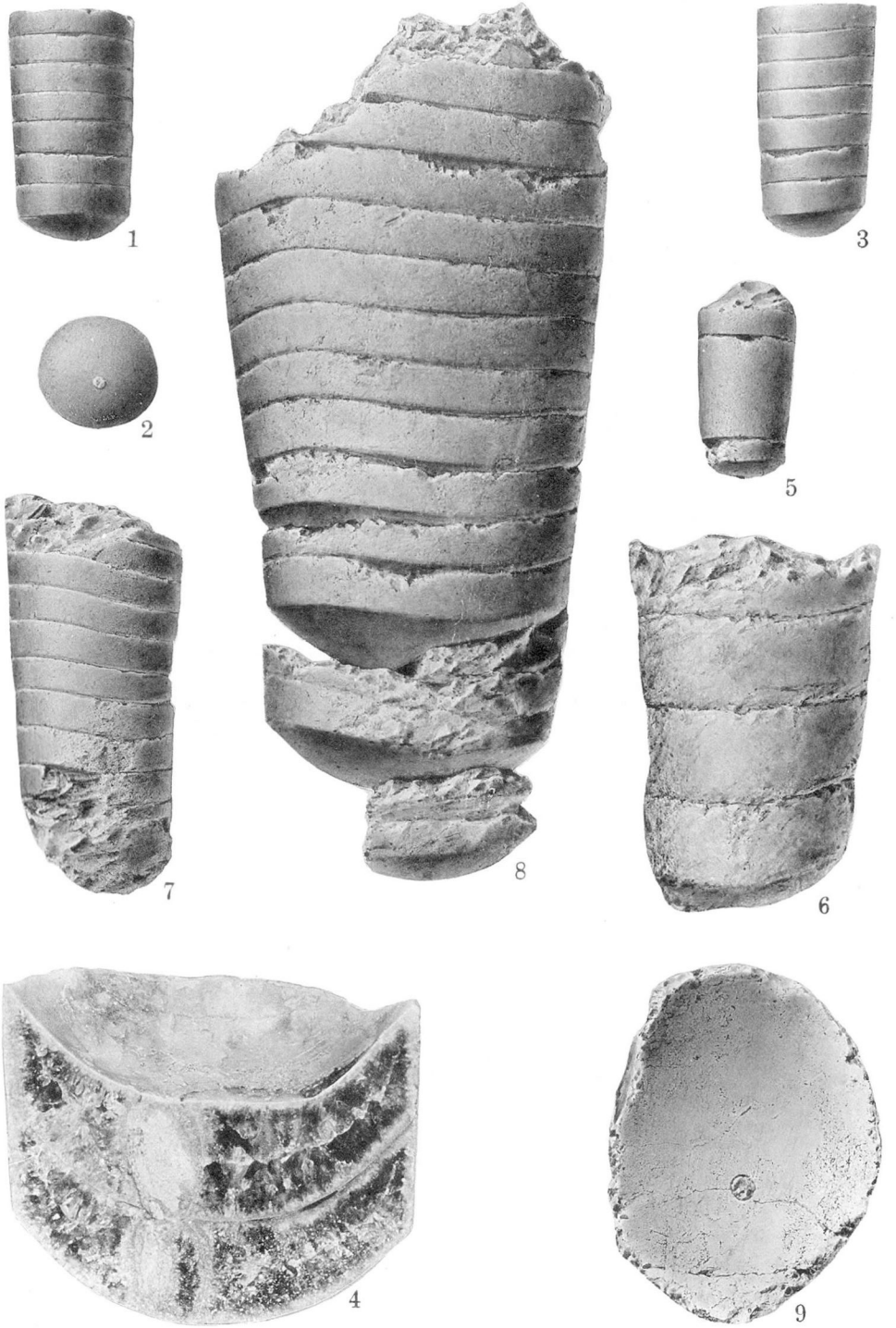
Figures — Page

1–4. *Mooreoceras normale* Miller, Dunbar, and Condra 23
Ventral, lateral, and septal views of the holotype of the type species of *Mooreoceras* (× 1) and an unretouched photograph of a median dorsoventral longitudinal section of the adapical two camerae of the same specimen (× 4), from the Kansas City group (probably the Winterset limestone) near Kansas City, Missouri. Collected by C. E. Beecher. Y. P. M., 13956.

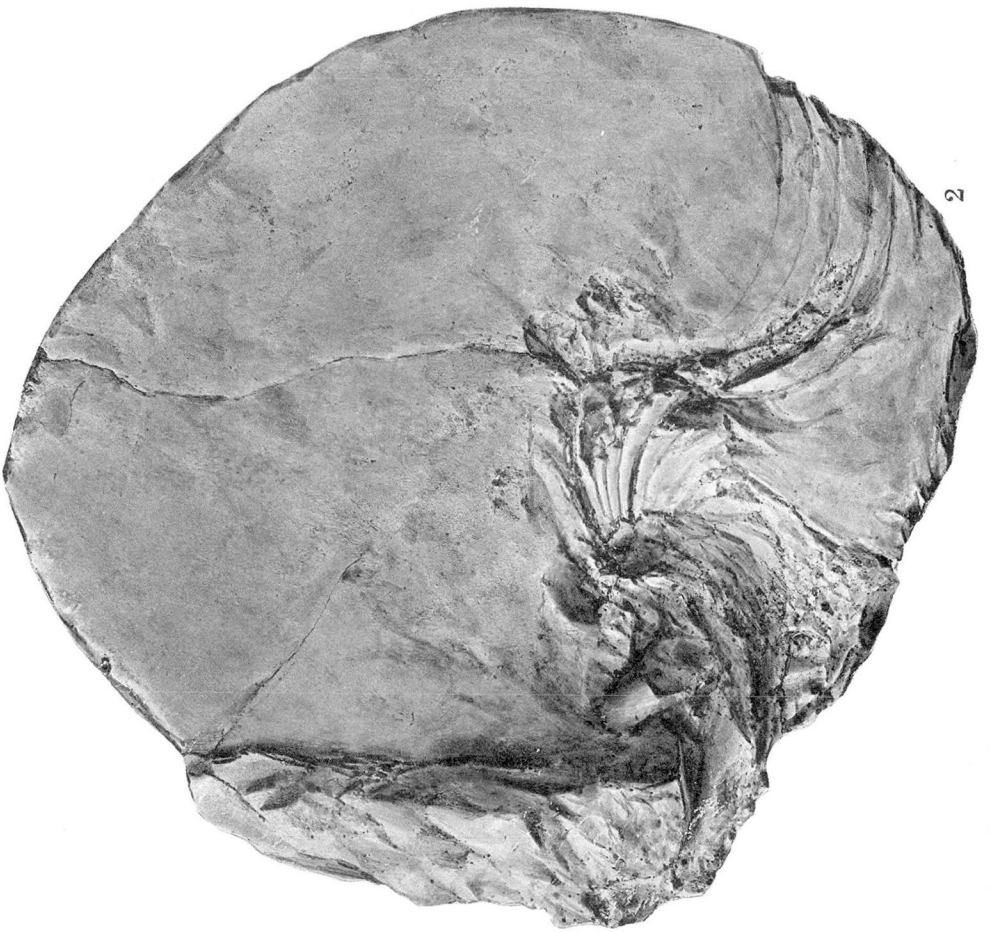
5. *Mooreoceras* sp. 25
Ventral view of part of a phragmacone from the Guthrie member of the Dog Creek formation in the Croton Falls area of Stonewall County, Texas, × 1. Collected by R. L. Clifton. S. U. I., 1470. (*See also* Plates 6, 35, 47, 55.)

6. *Mooreoceras?* sp. 25
A septate specimen from the Cache Creek series near Kamloops, British Columbia, × 3. Collected by M. B. Crockford. U. A. (*See also* Plates 6, 35, 47, 55.)

7–9. *Mooreoceras giganteum* Clifton 23
Lateral view of the specimen Clifton designated as a figured paratype (Fig. 7), from the same horizon and locality as Figure 5; and lateral and septal views of the holotype (Figs. 8, 9), from the Acme member of the Blaine formation near Quanah, Texas; all × 1. Collected by R. L. Clifton. S. U. I., 1472 and 1471, respectively. (*See also* Plates 3, 5.)



MOOREOCERAS



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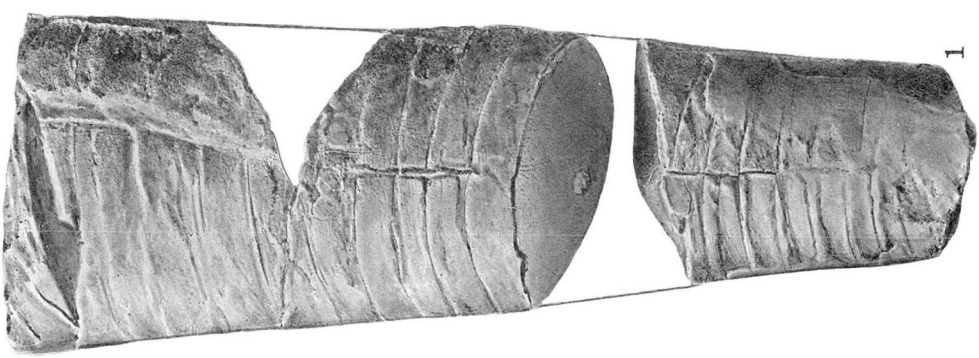

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MOOREOCERAS AND *STENOPOCERAS*

PLATE 5.—*MOOREOCERAS* AND *STENOPOCERAS*

Figures

1. *Mooreoceras giganteum* Clifton 23
   Ventral view of a large fragmentary specimen, which is considerably distorted, from the Hueco limestone in the NE¼ sec. 15, T. 22 S., R. 10 E., Otero County, New Mexico, X $\frac{9}{10}$. Collected by J. S. Baker. U. S. N. M. (*See also* Plates 3, 4.)
2. *Stenopoceras whitei*, n. sp. 76
   Lateral view of a large poorly preserved but almost complete specimen (a paratype) from near the base of the Lueders formation in Rock Creek about 1 mile southeast of Seymour, Baylor County, Texas, × ⅔. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plates 27, 28.)

PLATE 6.—*STEAROCERAS, COOPEROCERAS, STENOPOCERAS MICHELINOCERAS, AND MOOREOCERAS*

Figures — Page

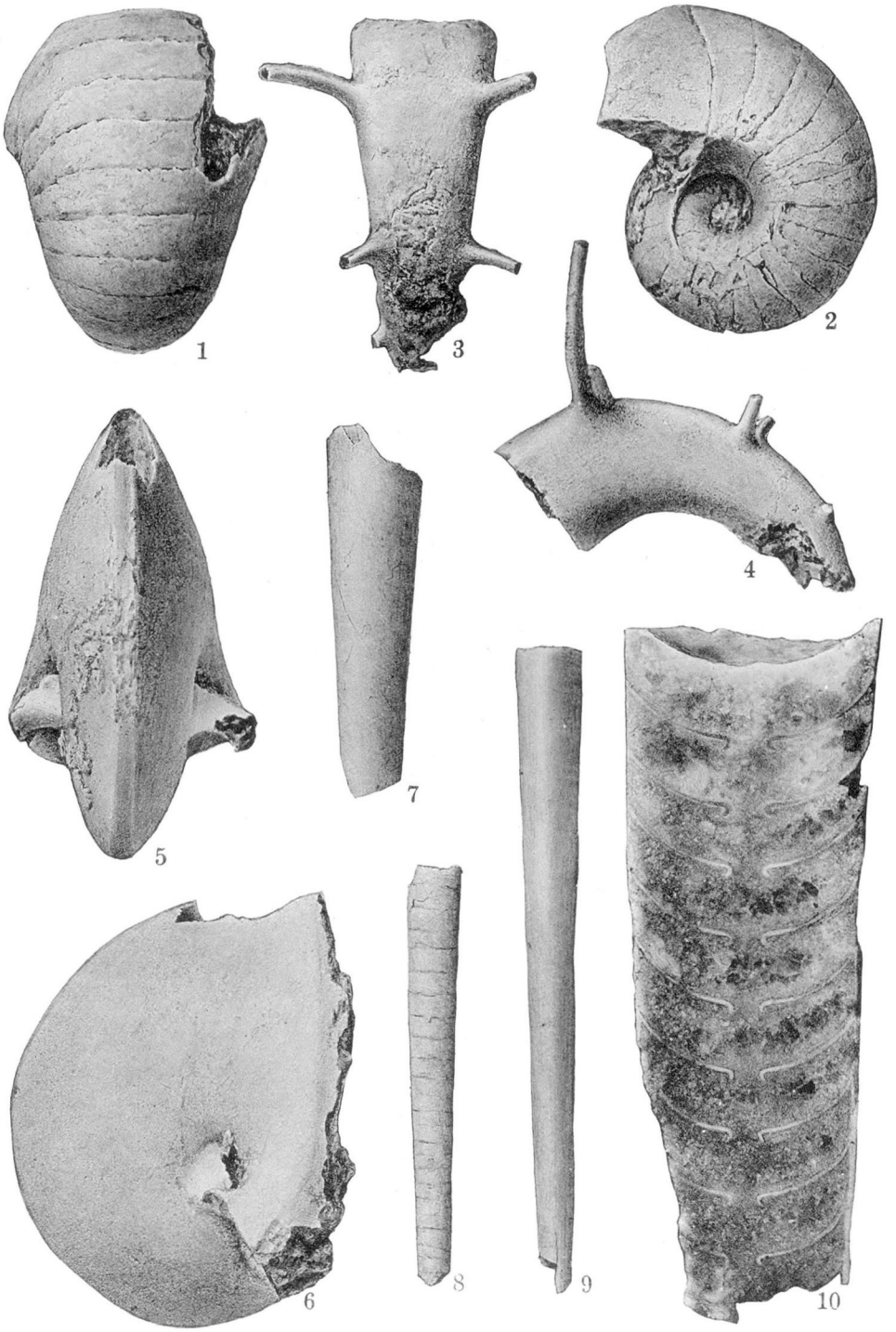
1, 2. *Stearoceras?* sp. — 68
A specimen from the upper part of the Leonard formation southwest of the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 2. Collected by G. A. Cooper. U. S. N. M., 111611.

3, 4. *Cooperoceras texanum* Miller — 118
The holotype, from the Word formation in Hess Canyon northeast of the Hess Ranch house in the Glass Mountain region of Brewster County, Texas, × 2. Collected by G. A. Cooper. U. S. N. M., 111621. (*See also* Plates 1, 40, 41, 49–52.)

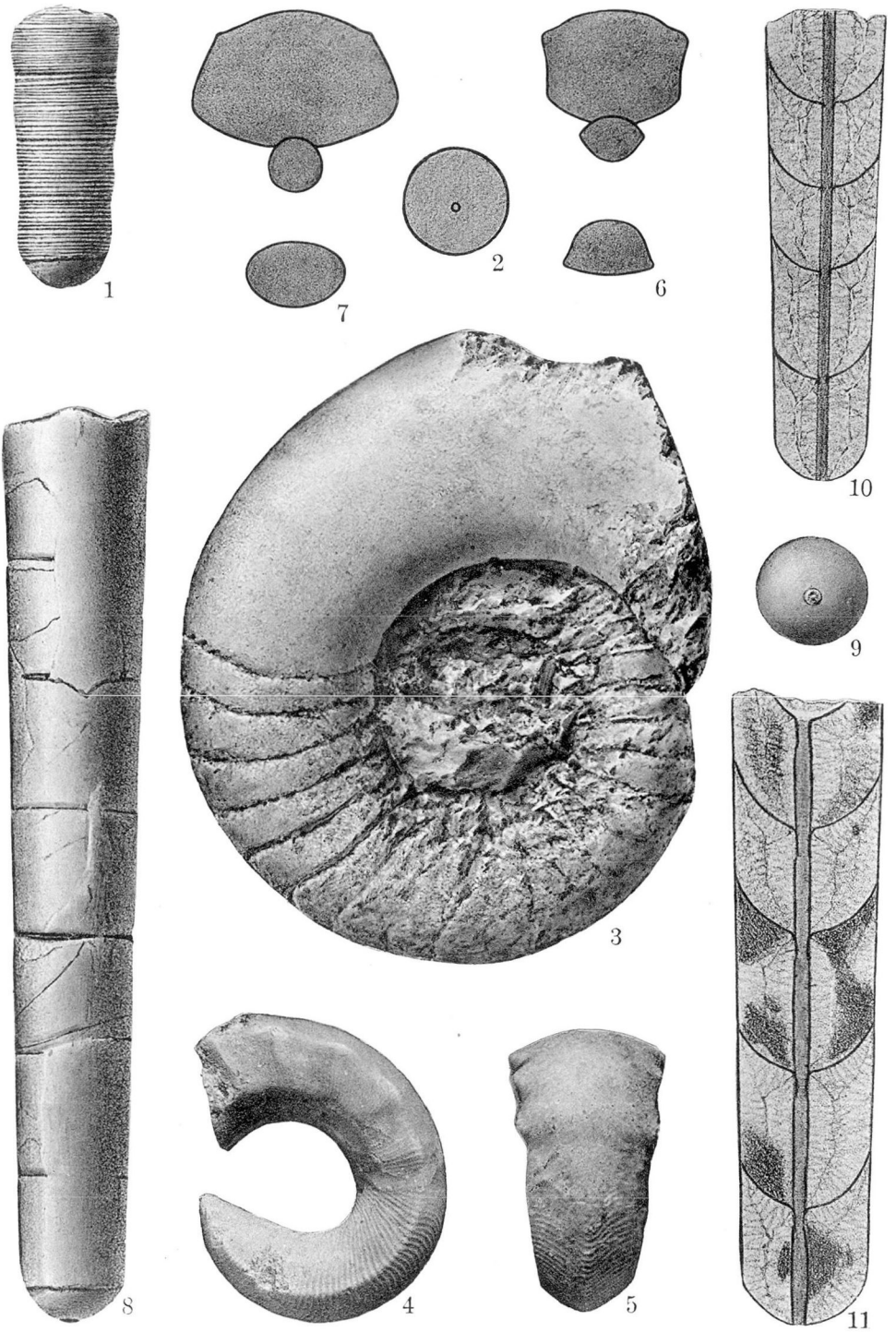
5, 6. *Stenopoceras inexpectans* Miller — 75
The holotype, from the middle part of the upper Leonard formation east of Split Tank in the Glass Mountain region of Brewster County, Texas, × 2. Collected by G. A. Cooper. U. S. N. M., 111622. (*See also* Plates 26, 40.)

7. *Michelinoceras* sp — 30
A specimen from the Bone Spring limestone near the mouth of Apache Canyon in the Sierro Diablo of Hudspeth County, Texas, × 1. Collected by Stanislaus Kříž. P. U.

8–10. *Mooreoceras* sp. — 25
Three specimens. Figure 8, which is × 2, is from the same horizon and locality as 3 and 4; 9, which is × 1, is from the same horizon and locality as 1 and 2; and 10, which is × 6, is from the Word formation in Gilliland Canyon of the Glass Mountain region in Brewster County, Texas. Collected by G. A. Cooper (Figs. 8, 9) and H. E. Vokes (Fig. 10). U. S. N. M., 111609 (Fig. 8) and 111610 (Fig. 9); A. M. N. H. (Fig. 10). (*See also* Plates 4, 35, 47, 55.)



STEAROCERAS, COOPEROCERAS, STENOPOCERAS, MICHELINOCERAS, AND *MOOREOCERAS*



BITAUNIOCERAS, *STEAROCERAS*, *METACOCERAS*, *TAINOCERAS*, AND *MICHELINOCERAS*

PLATE 7.—*BITAUNIOCERAS, STEAROCERAS, METACOCERAS, TAINOCERAS, AND MICHELINOCERAS*

Figures — Page

1, 2. *Bitaunioceras bitauniense* (Haniel) 30
The holotype, from the Bitauni beds at Bitauni, Timor, × 1. After Haniel. Delft.

3. *Stearoceras rotundatum* (Miller and Unklesbay)? 57
A specimen from the Kaibab formation at some unrecorded locality in norther Arizona or southern Utah, presumably × 1. Adapted from McKee.

4–6. *Metacoceras* sp. 116
Lateral and ventral views, × 4, of an immature specimen (S. U. I., 1153); and diagrammatic cross section, × 2, showing shape of conch during early growth stages (composite figure based on S. U. I., 1153 and 1154); from the Casper formation in Gilmore Canyon about 8 miles southeast of Laramie, Wyoming. Collected by H. D. Thomas.

7. *Tainoceras wyomingense* Miller and Thomas 92
Diagrammatic cross section showing shape of conch during early growth stages, from the Casper formation in Gilmore Canyon about 8 miles southeast of Laramie, Wyoming, × 2. Collected by H. D. Thomas. S. U. I., 1159. (*See also* Plates 25, 47.)

8–11. *Michelinoceras michelini* (Barrande) 28
Three of the syntypes, from the Middle Silurian at Kozořz, Bohemia, × 1. After Barrande.

PLATE 8.—*BITAUNIOCERAS* AND *BACTRITES*

Figures — Page

1–7. *Bitaunioceras coahuilense* Miller 30
Four of the syntypes, all but one (Figs. 1, 2) of which are from Upper Permian (zone of *Timorites*) concretionary shales along the strike from Cerro Wencelao on the south to 300 meters west of El Indio on the north, in the Valle de Las Delicias, Coahuila. Figures 1, 2 represent a specimen from Middle Permian (zone of *Waagenoceras*) alternating shale and graywacke about 60 meters N. 35° E. of La Difunta, also in the Valle de Las Delicias, × 3—in this specimen, an internal mold of part of a phragmacone, there is a constriction in each camera represented. Figures 3, 4 illustrate a median longitudinal section of part of a phragmacone, showing the septal necks and the connecting rings of the siphuncle—Figure 4 represents a polished section, × 4; Figure 3 a thin section of part of the same specimen with its orientation reversed, × 10. Figures 5–7 portray a testiferous specimen and an internal mold of three camerae of the phragmacone in which there is only one transverse constriction, all × 3. Collected by R. E. King. Y. P. M., 16264–16267.

8, 9. *Bactrites? mexicanus* Miller 33
Septal (apical) and dorsal views of the largest of the syntypes, which represents only one camera of a phragmacone from the Middle Permian *Perrinites* shale 2600–2800 meters S. 42° E. of Noria de Malascachas, Valle de Las Delicias, Coahuila, × 1. Collected by R. E. King. Y. P. M., 16277. (*See also* Plate 3.)

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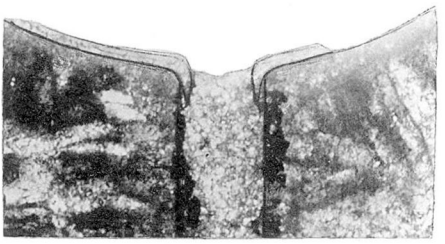

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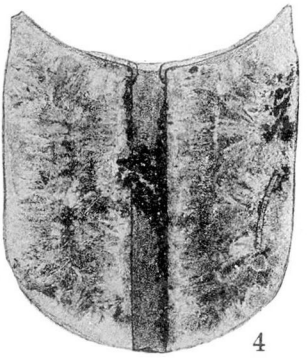

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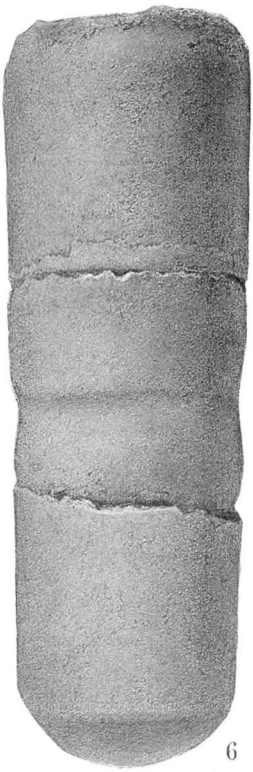

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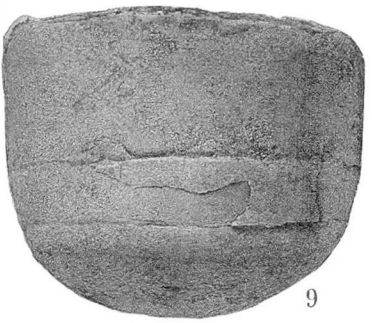

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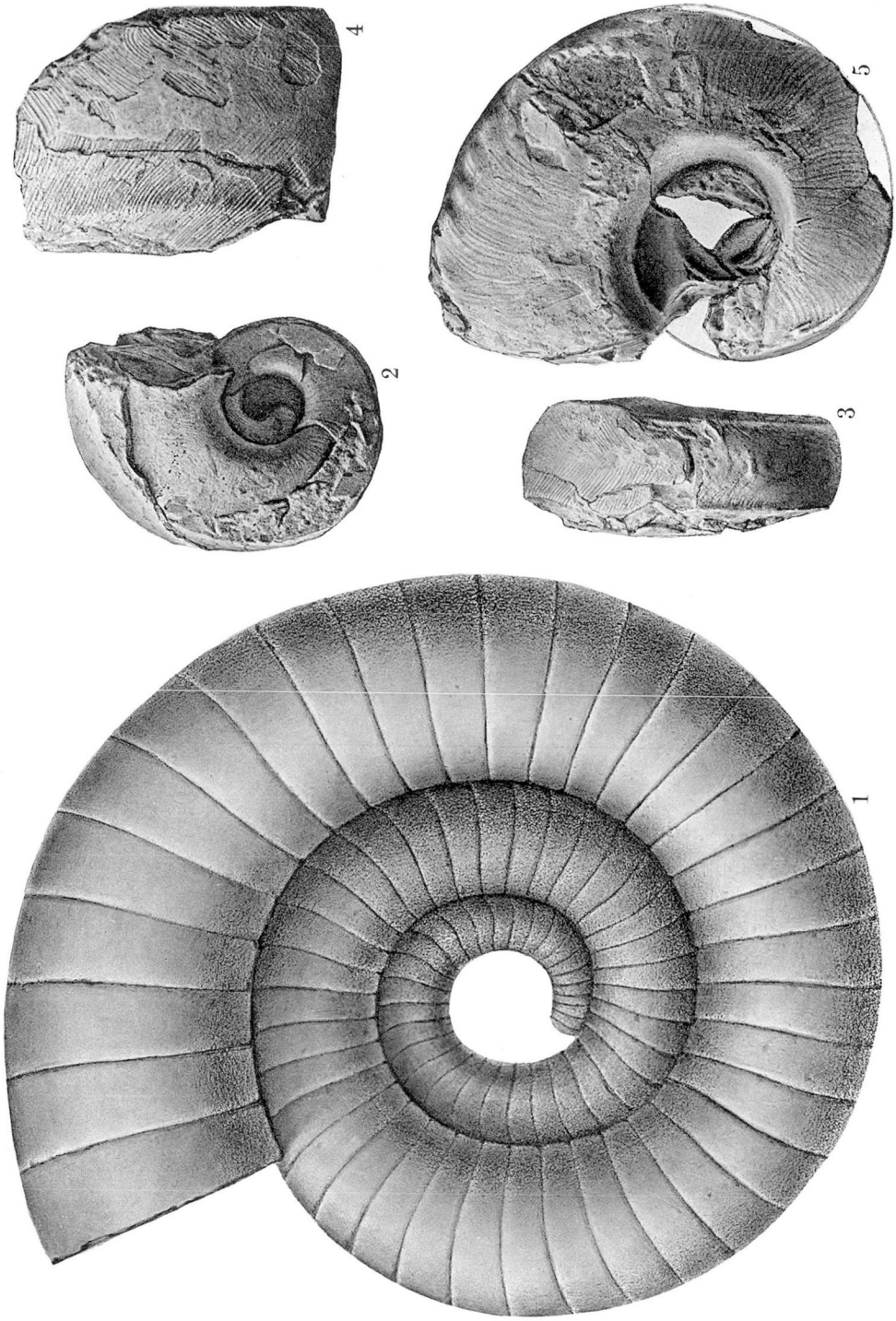
BITAUNIOCERAS AND *BACTRITES*



KONINCKIOCERAS AND *DOMATOCERAS*

PLATE 9.—*KONINCKIOCERAS* AND *DOMATOCERAS*

Figures

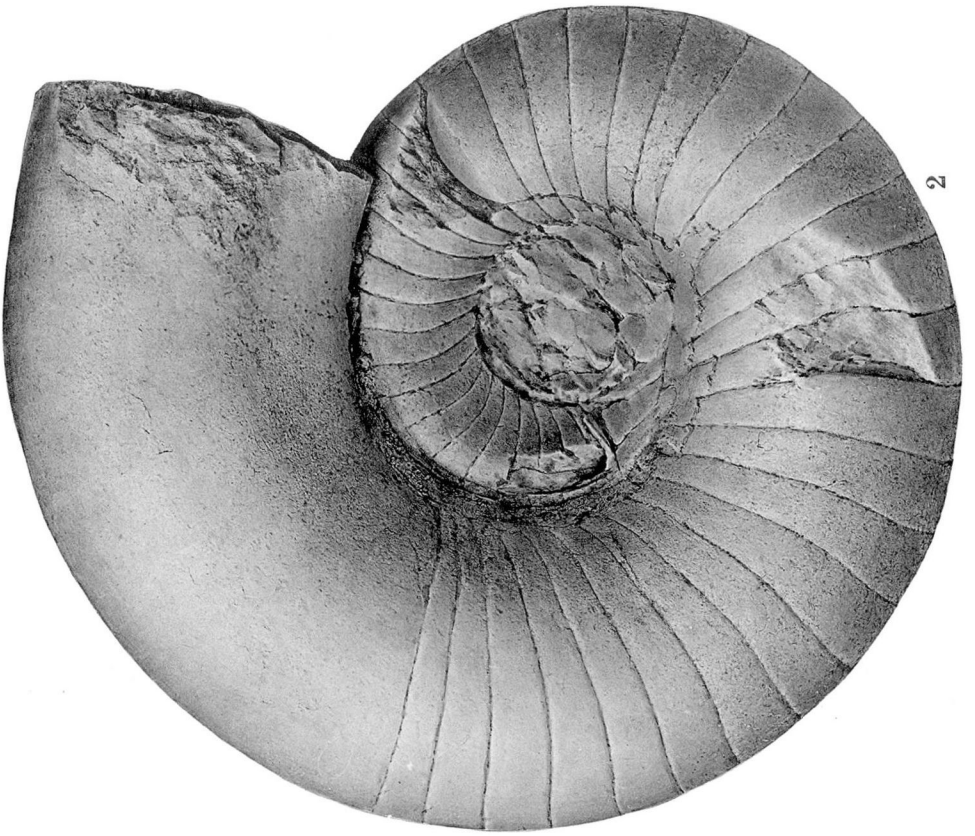
1. *Koninckioceras koninckí* Miller and Kemp ..... Page 34
Lateral view of the holotype, from Lower Carboniferous dense black limestone at Halloy, Belgium, × 1. Collected by d'Omalius d'Halloy. Adapted from de Koninck. M. C. Z.

2–5. *Domatoceras sculptile* (Girty) 41
Two of the syntypes, from the Wewoka formation in sec. 2, T. 6 N., R. 9 E., Hughes County, Oklahoma, × 1 (Figs. 2, 3, 5) and × 2 (Fig. 4, which represents the adapertural portion of the specimen illustrated by Figures 2, 3). After Girty. U. S. N. M.

PLATE 10.—*KONINCKIOCERAS BIBBI*

Figures | Page

1, 2. *Koninckioceras bibbi* Miller and Kemp 36
Ventral and lateral views of the holotype, from near the base of the Lueders formation about 12 miles southwest of Seymour, Texas, × ½. Collected by Flynt Bibb. A. H. K. Collection.



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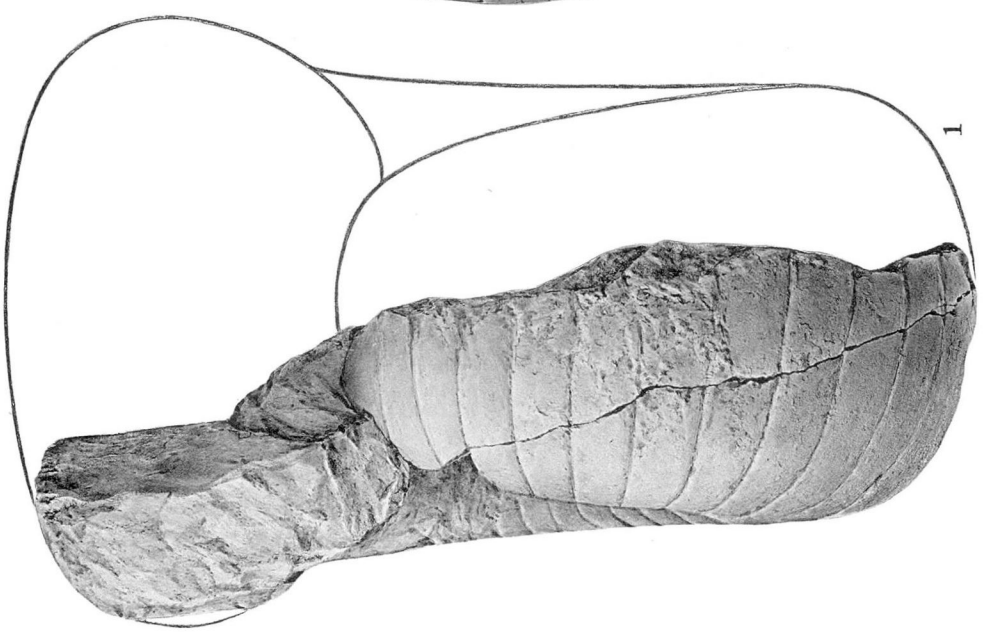

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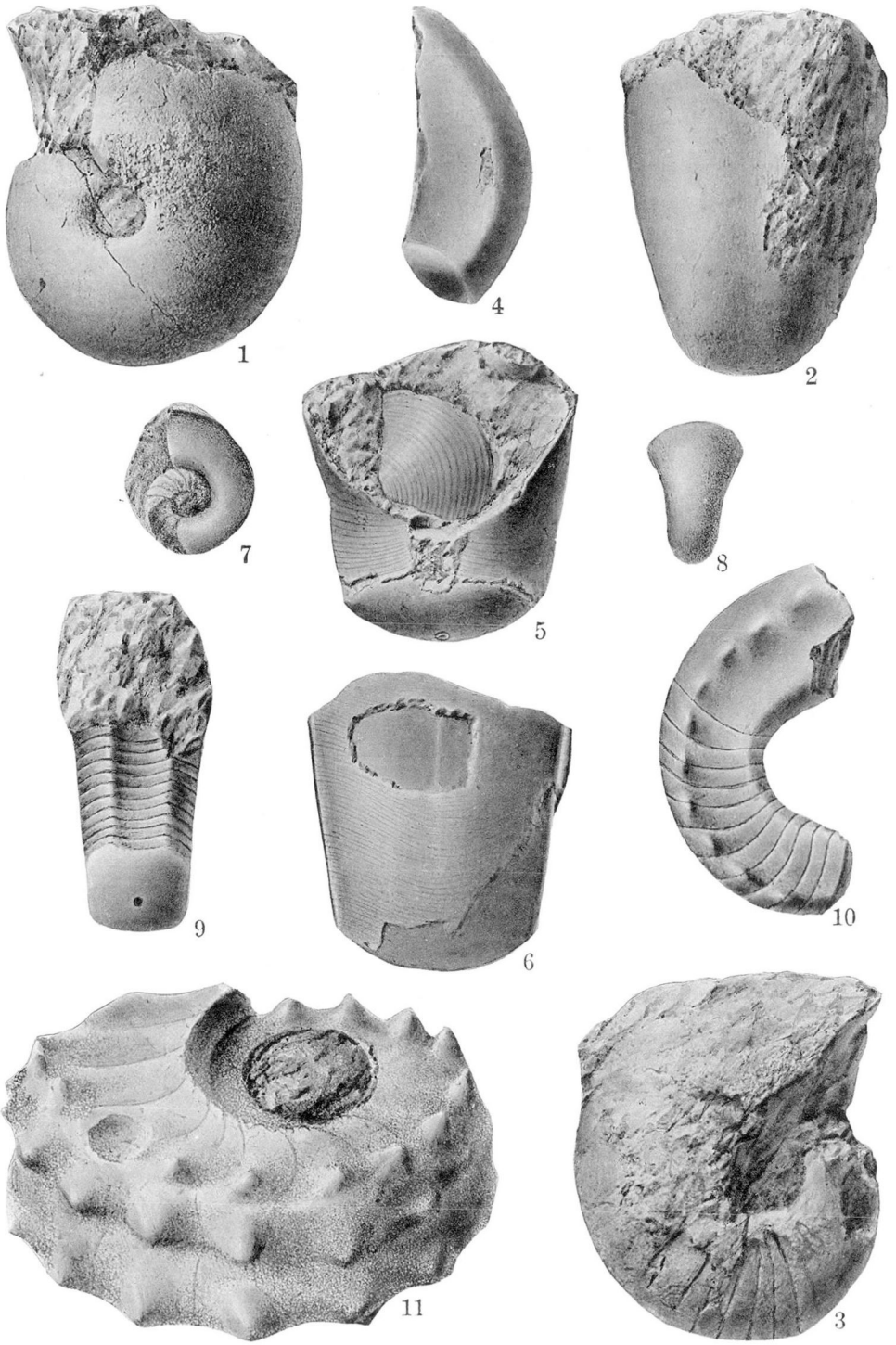
KONINCKIOCERAS BIBBI



COELOGASTEROCERAS, KNIGHTOCERAS, KONINCKIOCERAS, METACOCERAS, AND *TAINOCERAS*

PLATE 11.—*COELOGASTEROCERAS, KNIGHTOCERAS, KONINCKIOCERAS, METACOCERAS,* AND *TAINOCERAS*

Figures

1–3. *Coelogasteroceras mexicanum* Girty 125
The holotype, from the Yeso formation about 2 miles east of the river near Alamillo, New Mexico, × 1. U. S. N. M. After Girty. (*See also* Plate 56.)

4–6. *Knightoceras missouriense* Miller and Owen 37
The holotype, from immediately above the Tebo coal member of the Cherokee formation in the Edwards strip pit (sec. 23, T. 42 N., R. 26 W.), Henry County, Missouri, × 1½. Collected by John Britts Owen. J. B. O. Collection at S. U. I., 13397.

7, 8. *Koninckioceras? eccentricum* (Meek and Hayden) 37
The holotype, from "near the mouth of Smoky Hill fork of Kansas River" in central Kansas, slightly more than × 1. U. S. N. M., 4185. After Meek and Hayden.

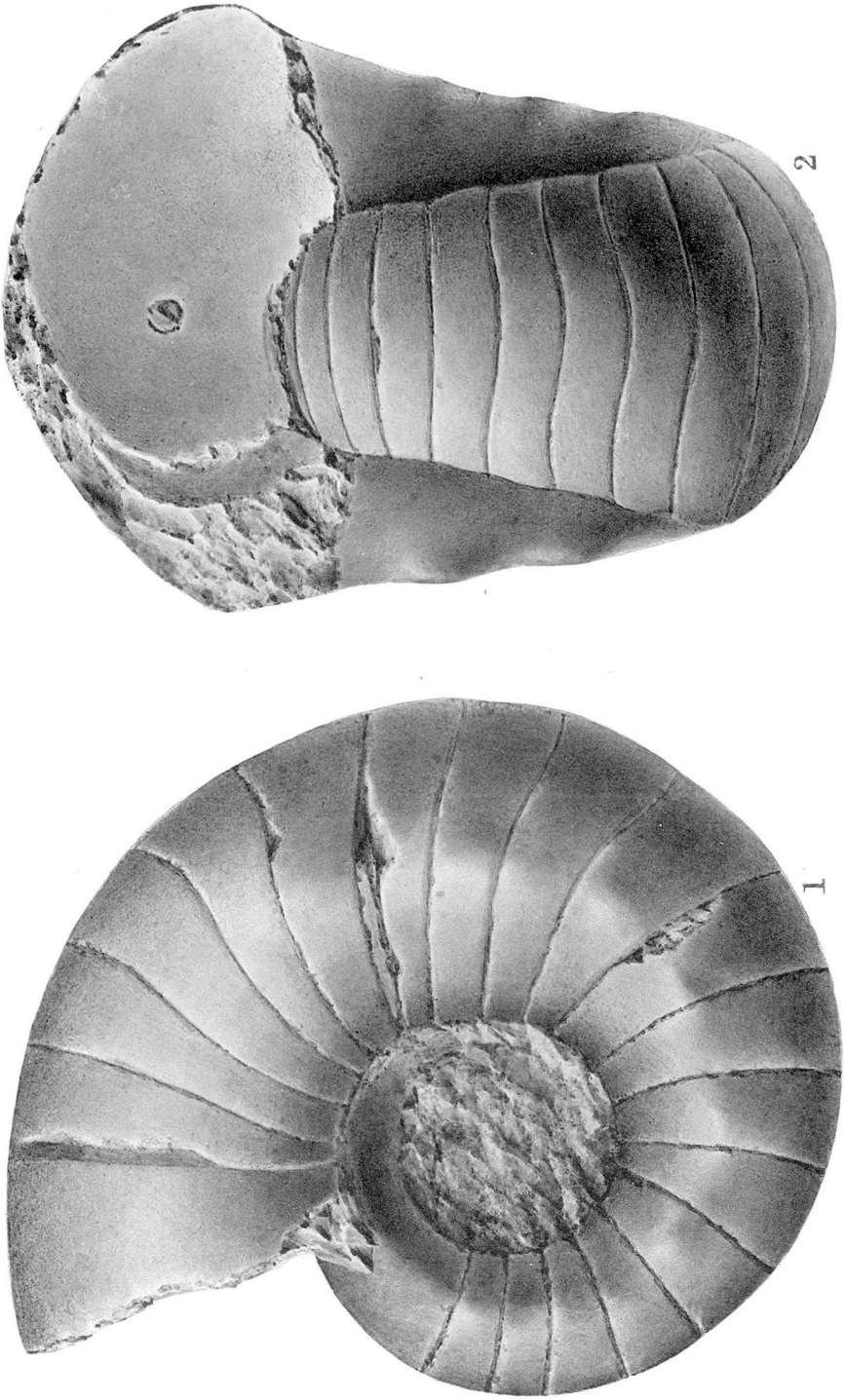
9, 10. *Metacoceras sangamonense* (Meek and Worthen) 104
The holotype, from the McLeansboro formation of Sangamon County, Illinois, × 1. After Meek and Worthen.

11. *Tainoceras quadrangulum* (McChesney) 80
The holotype, from the Pennsylvanian at Grayville, White County, Illinois, presumably × 1. After McChesney.

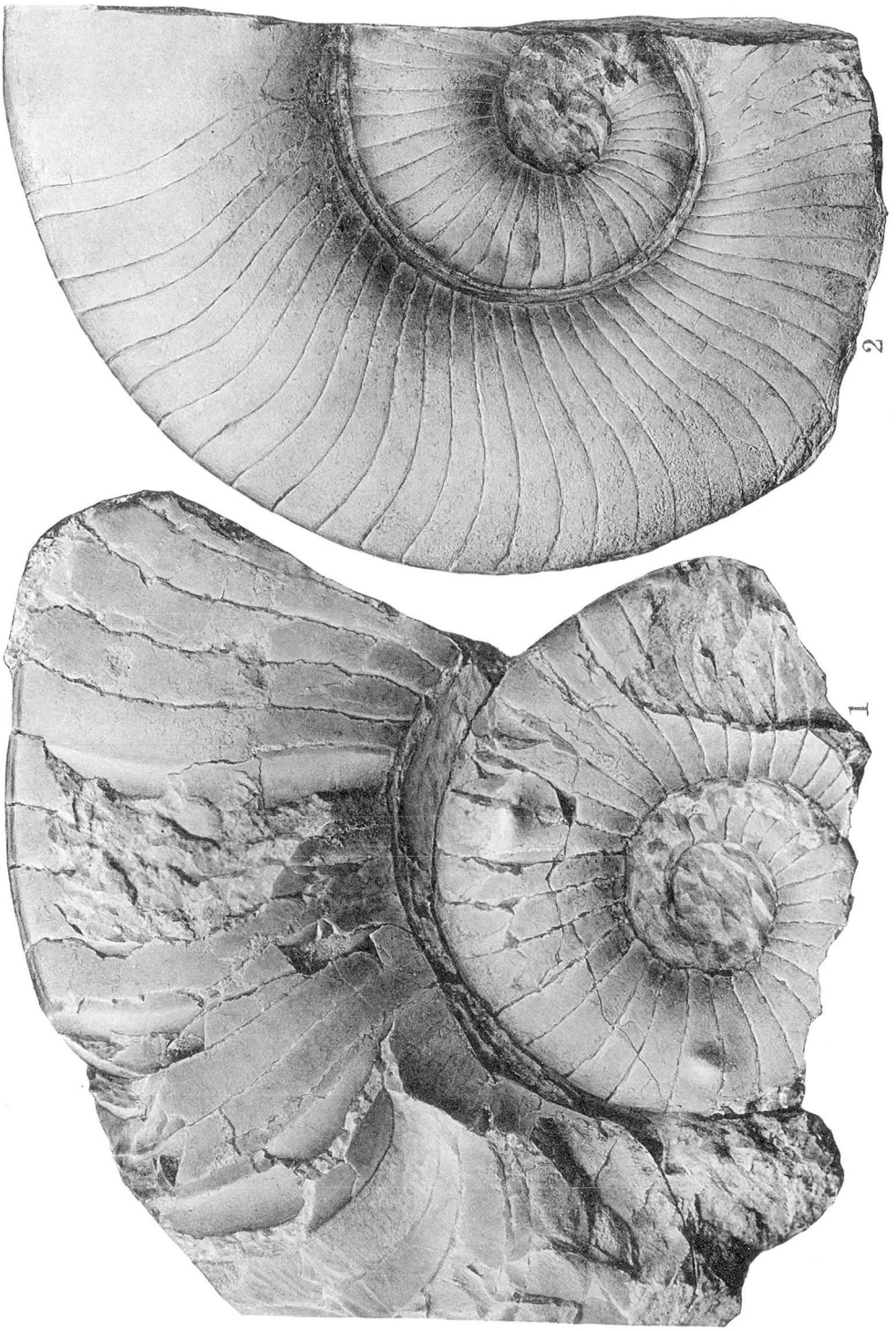
PLATE 12.—*ENDOLOBUS SPECTABILIS*

Figures Page

1, 2. *Endolobus spectabilis* (Meek and Worthen)..... 39
Lateral and ventral views of the only representative of this species that has ever been figured, from the Chester of Randolph County, Illinois, × 1. Adapted from Meek and Worthen.



ENDOLOBUS SPECTABILIS



DOMATOCERAS

PLATE 13.—*DOMATOCERAS*

Figures

PLATE 14.—*TAINOCERAS* AND *DOMATOCERAS*

Figures — Page

1–4. *Tainoceras* cf. *T. schellbachi* Miller and Unklesbay 90
Two views of each of two specimens from the Kaibab limestone in the general vicinity of Flagstaff, Arizona, × 1. Collected by Don B. Gould (Figs. 1, 2). S. U. I., 2122 (Figs. 1, 2); and M. N. A., 570/3060 (Figs. 3, 4). (*See also* Plates 33, 45.)

5, 6. *Domatoceras bradyi* Miller and Unklesbay 44
Lateral and ventral views of the holotype, from the α member of the Kaibab limestone at the Bottomless Pits about 7 miles east of Flagstaff, Arizona, × $\frac{4}{5}$. M. N. A., 811/G2.1517. (*See also* Plate 13.)

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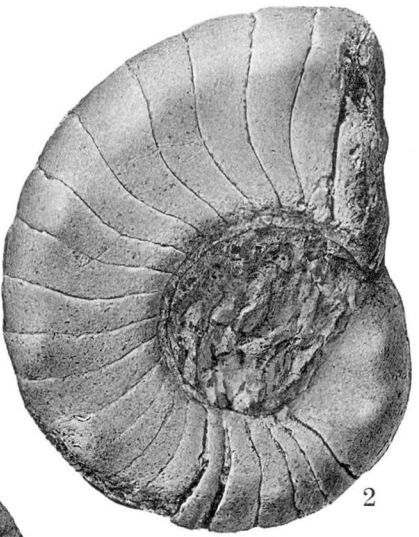
3



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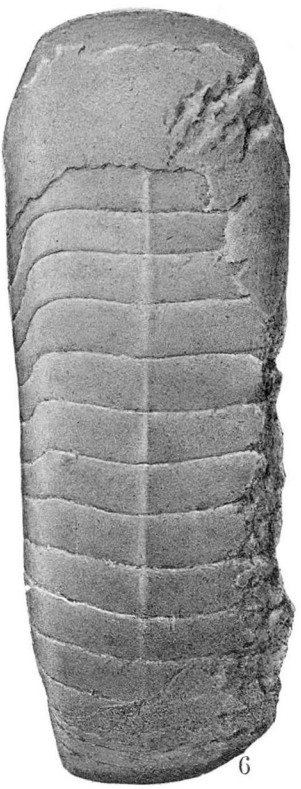

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TAINOCERAS AND *DOMATOCERAS*


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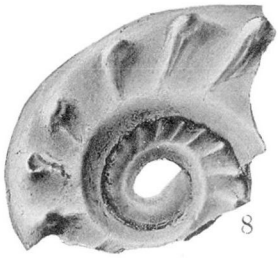
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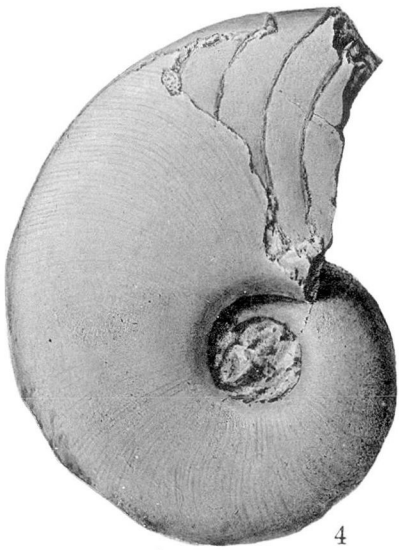
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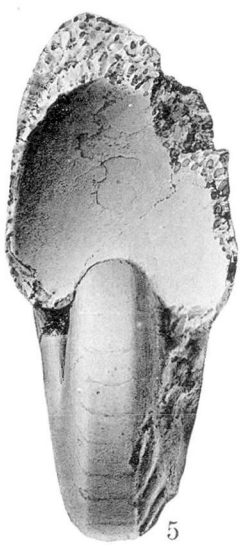
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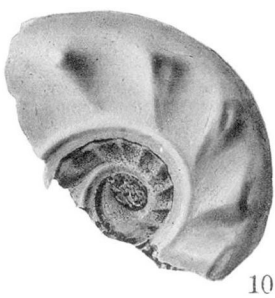
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DOMATOCERAS AND *FOORDICERAS*

PLATE 15.—*DOMATOCERAS* AND *FOORDICERAS*

Figures — Page

1–7. *Domatoceras* sp. 46
Four specimens from the Jacque Mountain limestone near Kokomo, Colorado. Collected by J. S. Williams and A. H. Koschmann. Figure 1 is a lateral view of a small specimen representing the adapical portion of the conch, × 2; 2, 3 illustrate an internal mold of part of one volution of the phragmacone, × 1; 4–6 represent a testiferous specimen, × 1½; and 7 shows a septum, × 1. U. S. G. S., 5207 (Fig. 1), 5208 (Figs. 2, 3), 5210 (Figs. 4–6), 5209 (Fig. 7).

8. *Foordiceras mammiferum* (Miller)? 100
A slightly distorted silicified specimen from the lower portion of the Bone Spring limestone near the mouth of Apache Canyon in the Sierra Diablo of Hudspeth County, Texas, × 1. Collected by J. B. Knight. U. S. N. M. (*See also* Plate 38.)

9, 10. *Foordiceras magnicostatum* (Miller) 99
Two views of a silicified specimen from the lower part of the upper Leonard formation near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 1. Collected by G. A. Cooper. U. S. N. M. (*See also* Plate 38.)

PLATE 16.—*KNIGHTOCERAS, DOMATOCERAS,* AND *STEAROCERAS*

Figures

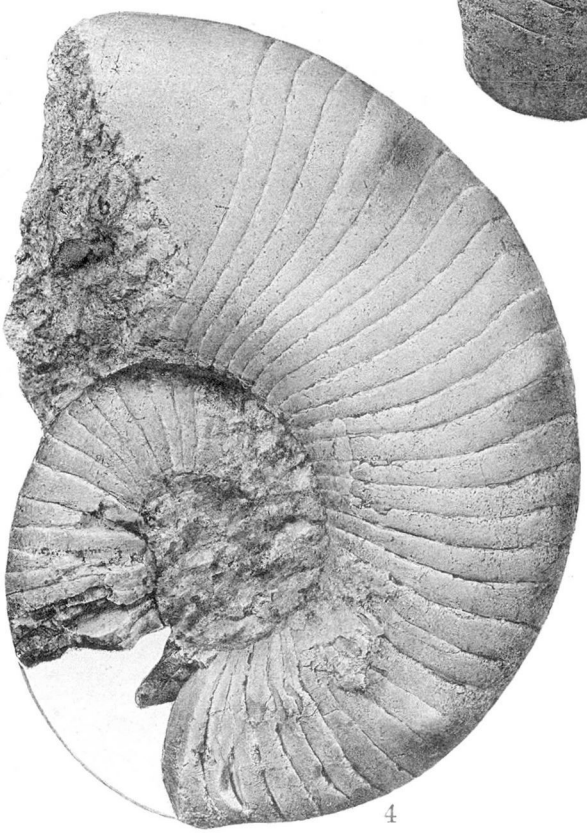
1. *Knightoceras kempae,* n. sp. 38
   Lateral view of a paratype, from the Grape Creek limestone about 1½ miles north of the England schoolhouse and 10 miles east of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plates 55, 58.)
2. *Domatoceras* sp. 48
   Lateral view of a specimen from the same horizon and locality as Figure 1, × ⅚. Collected by Augusta Hasslock Kemp. A. H. K. Collection.
3. *Stearoceras aberrans* (Miller and Unklesbay) 51
   Lateral view of the holotype, from the Chupadera formation near Bluewater Dam, New Mexico, × ⅗. Collected by S. A. Northrop. Same specimen as Figure 3 on Plate 17. U. N. M., 315.

KNIGHTOCERAS, DOMATOCERAS, AND STEAROCERAS

1

3

2



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STENOPOCERAS, STEAROCERAS, AND *DOMATOCERAS*

PLATE 17.—*STENOPOCERAS, STEAROCERAS,* AND *DOMATOCERAS*

Figures Page

1, 2. *Stenopoceras cooperi* Miller and Unklesbay 75
Lateral and ventral views of the holotype, from the upper shaly beds of the Neva limestone (upper Grenola limestone) near Grand Summit, Kansas, × ¾. Collected by B. N. Cooper. S. U. I., 2120.

3. *Stearoceras aberrans* (Miller and Unklesbay) 51
Ventral view of the holotype, from the Chupadera formation near Bluewater Dam, New Mexico, × ⅔. Collected by S. A. Northrop. Same specimen as Figure 3 on Plate 16. U. N. M., 315.

4, 5. *Domatoceras northropi* (Miller and Unklesbay) 44
Lateral and ventral views of the holotype, from the same horizon and locality as the preceding, × 1. Collected by S. A. Northrop. U. N. M., 316.

PLATE 18.—*STEAROCERAS CONCHIFERUM*

Figures | Page

1, 2. *Stearoceras conchiferum* (Hyatt)? 52
Lateral and ventral views of a large specimen from the basal portion of the Lueders formation about 8 miles south of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plate 19.)

2

1

STEAROCERAS CONCHIFERUM

1

2

METACOCERAS AND *STEAROCERAS*

PLATE 19.—*METACOCERAS* AND *STEAROCERAS*

Figures Page

1. *Metacoceras unklesbayi*, n. name 114
   Lateral view of the holotype, from the Kaibab limestone about 2 miles southwest of Flagstaff, Arizona, × ⅔. M. N. A., 563/GZ.1506.
2. *Stearoceras conchiferum* (Hyatt)? 52
   Ventral view of a specimen from the basal portion of the Lueders formation about 8 miles south of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plate 18.)

PLATE 20.—*STEAROCERAS HESPERIUM*

Figures Page

1, 2. *Stearoceras hesperium*, n. sp. 53
Ventral and lateral views of the holotype, from the lower part of the Leonard formation near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 1. Collected by G. A. Cooper. U. S. N. M.

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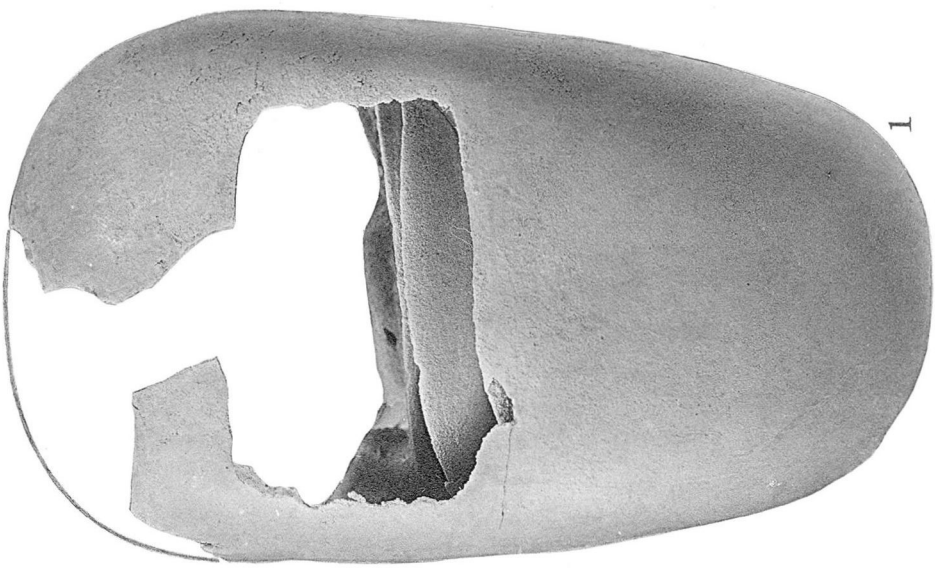

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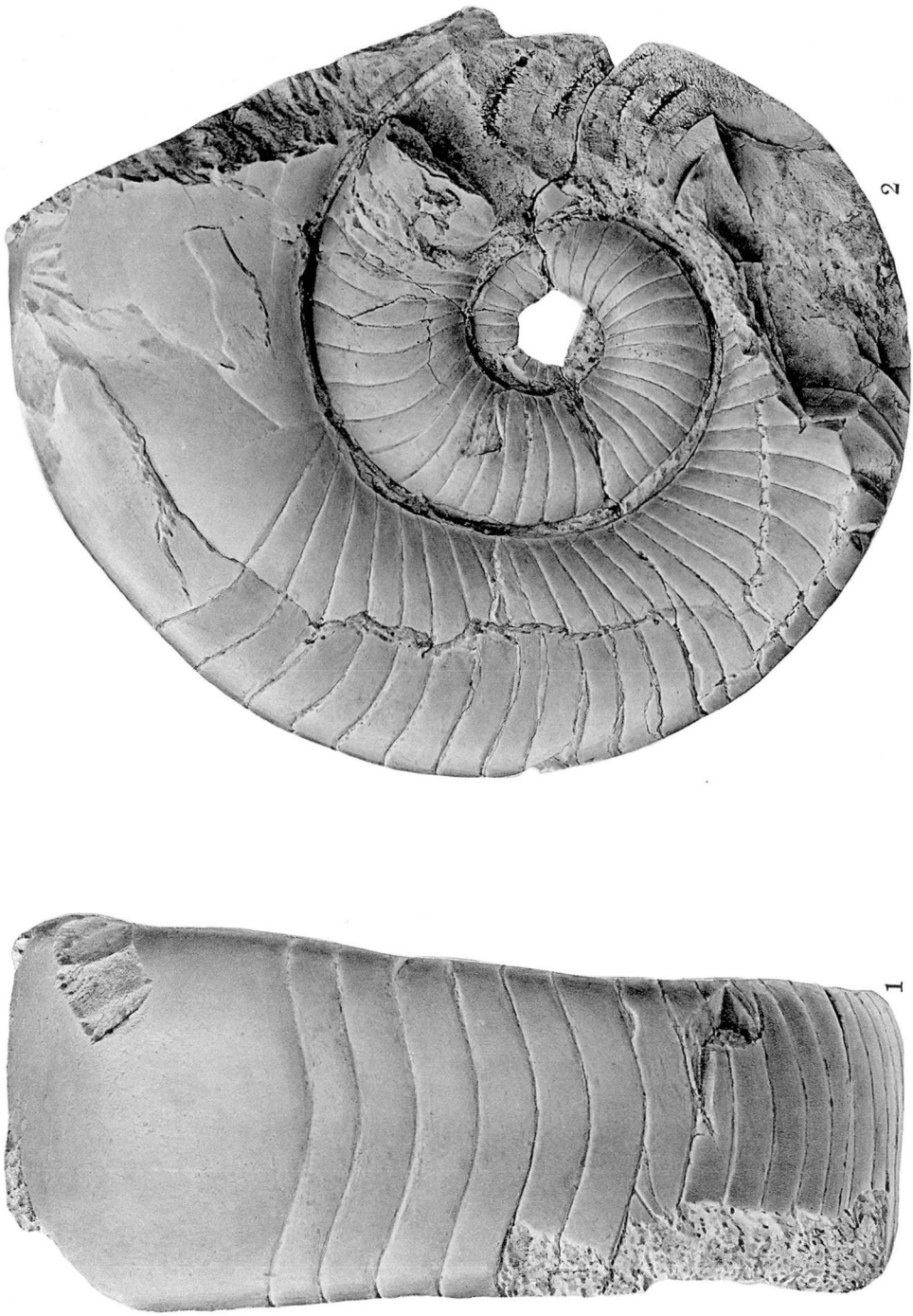
STEAROCERAS HESPERIUM



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STEAROCERAS SANANDREASENSE

PLATE 21.—*STEAROCERAS SANANDREASENSE*

Figures | Page

1, 2. *Stearoceras sanandreasense* (Miller, Dunbar, and Condra)..... 59
Ventral and lateral views of the holotype, from the San Andres limestone on the west side of the Penasco River Valley about 52 miles west of Artesia on the highway to Cloudcroft, New Mexico, × $\frac{5}{7}$. Collected by Ray F. Baker. Y. P. M., 13998.

PLATE 22.—*STEAROCERAS* SP.

Figures | Page

1, 2. *Stearoceras* sp. 68

Lateral and ventral views of a specimen from the Elm Creek limestone along Godwin Creek and about 17 miles east of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plates 48, 58.)

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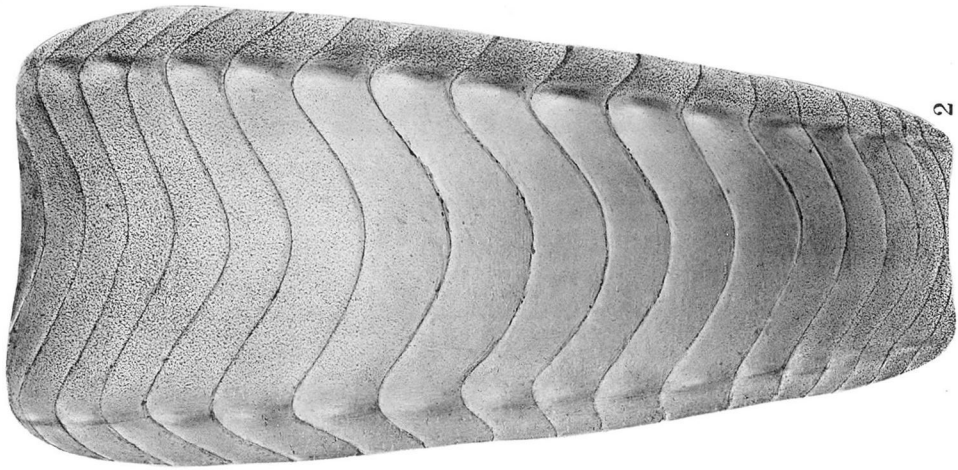
1

STEAROCERAS SP.



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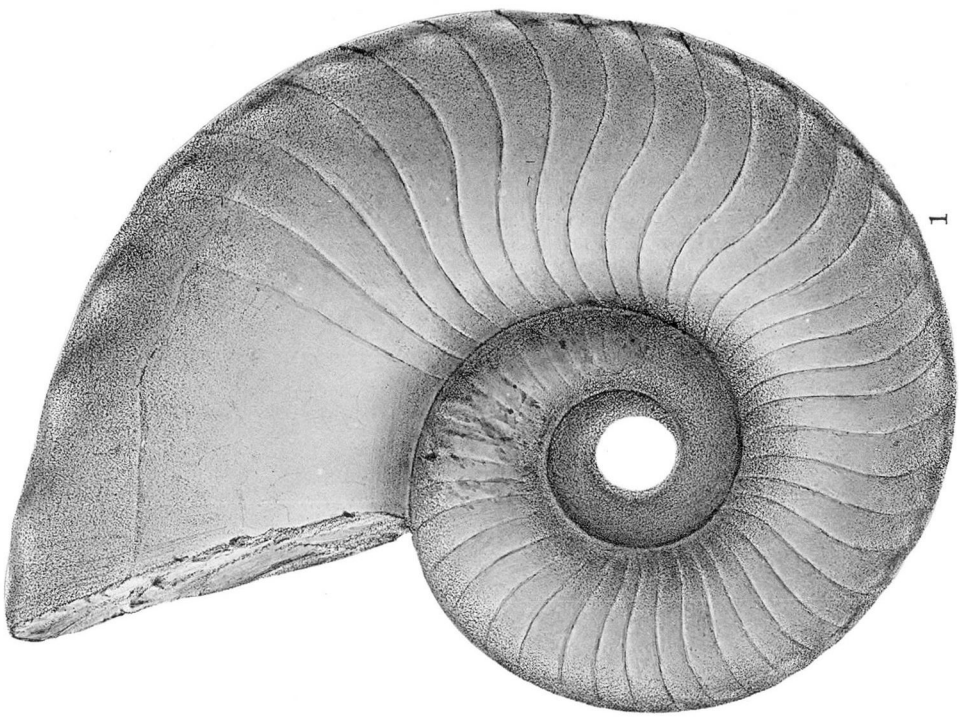

1

TITANOCERAS PONDEROSUM

PLATE 23.—*TITANOCERAS PONDEROSUM*

Figures Page

1, 2. *Titanoceras ponderosum* (White)..... 69
Lateral and ventral views of the only representative of this species, the genotype of *Titanoceras*, that has ever been illustrated, from the Plattsmouth limestone (mid-Pennsylvanian) at Plattsmouth, Nebraska, × ⅞. Collected by Thomas Egleston. U. S. N. M. Adapted from Meek.

PLATE 24.—*STENOPOCERAS ABUNDUM*

Figures Page

1, 2. *Stenopoceras abundum* Miller and Thomas 73
Ventral and lateral views (somewhat restored) of a large mature specimen (a syntype) from the *Stenopoceras* beds of the Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming, × 1. Collected by H. D. Thomas. Drawn by Dan Enich. S. U. I., 1167. (*See also* Plate 25.)

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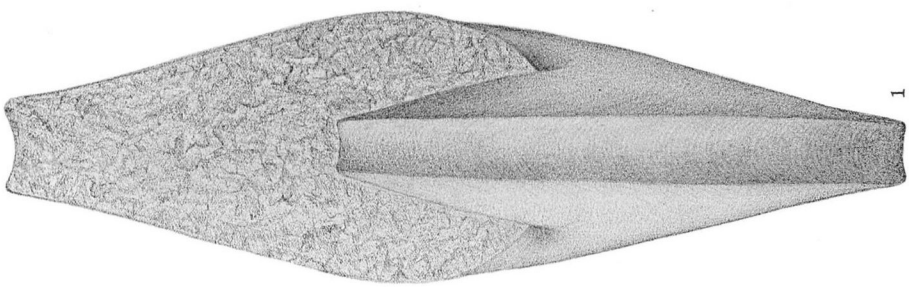

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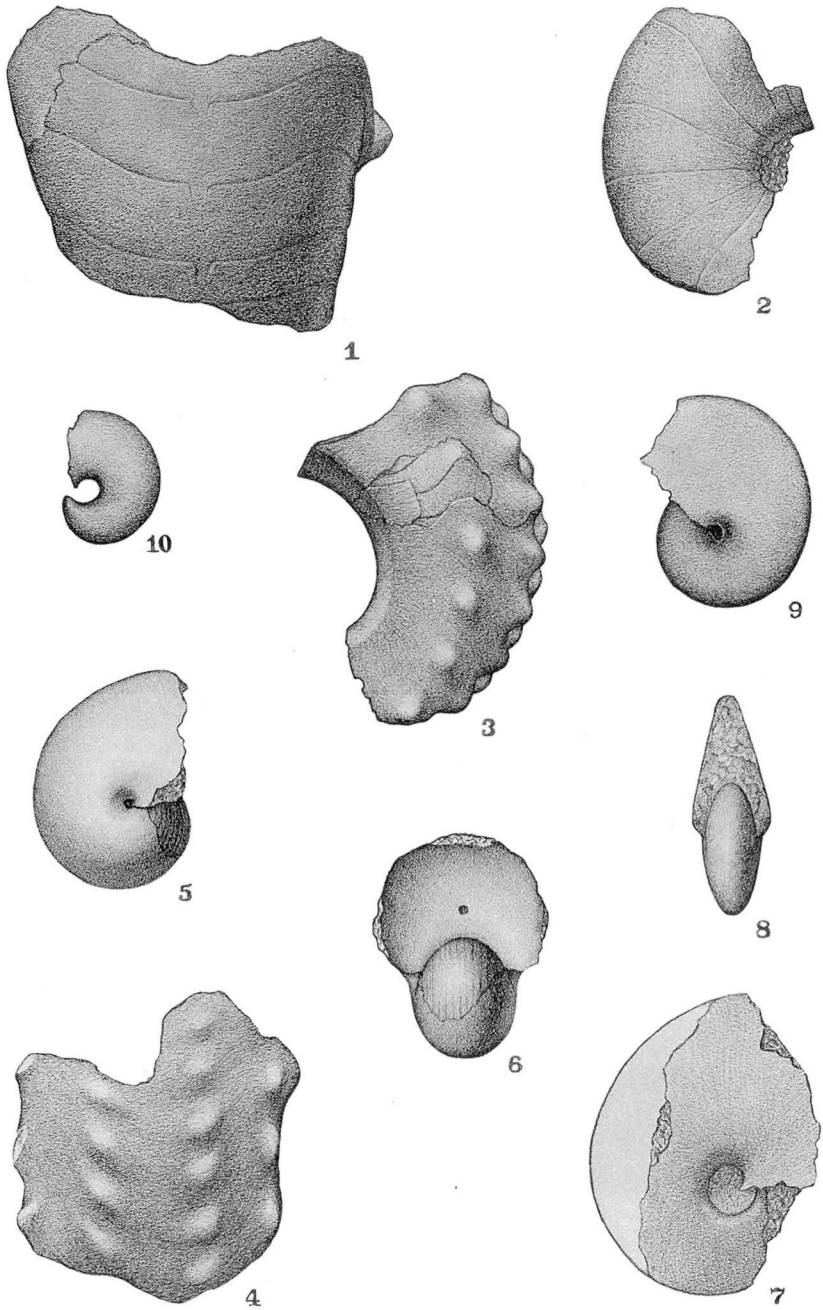
STENOPOCERAS ABUNDUM



SOLENOCHILUS, TAINOCERAS, LIROCERAS, AND *STENOPOCERAS*

PLATE 25.—*SOLENOCHILUS, TAINOCERAS, LIROCERAS,* AND *STENOPOCERAS*

All specimens illustrated on this plate were collected by H. D. Thomas from the *Stenopoceras* beds of the Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming. The drawings are by Dan Enich.

Figures — Page

1, 2. *Solenochilus* cf. *S. brammeri* Miller, Dunbar and Condra 133
Ventral and lateral views of a fairly well preserved but rather small specimen representing a late adolescent or early mature portion of the conch, × 1. S. U. I., 1171.

3, 4. *Tainoceras wyomingense* Miller and Thomas 92
Lateral and ventral views of two of the syntypes, mature specimens, both × 1. S. U. I., 1161 (Fig. 3), 1162 (Fig. 4). (*See also* Plates 7, 47.)

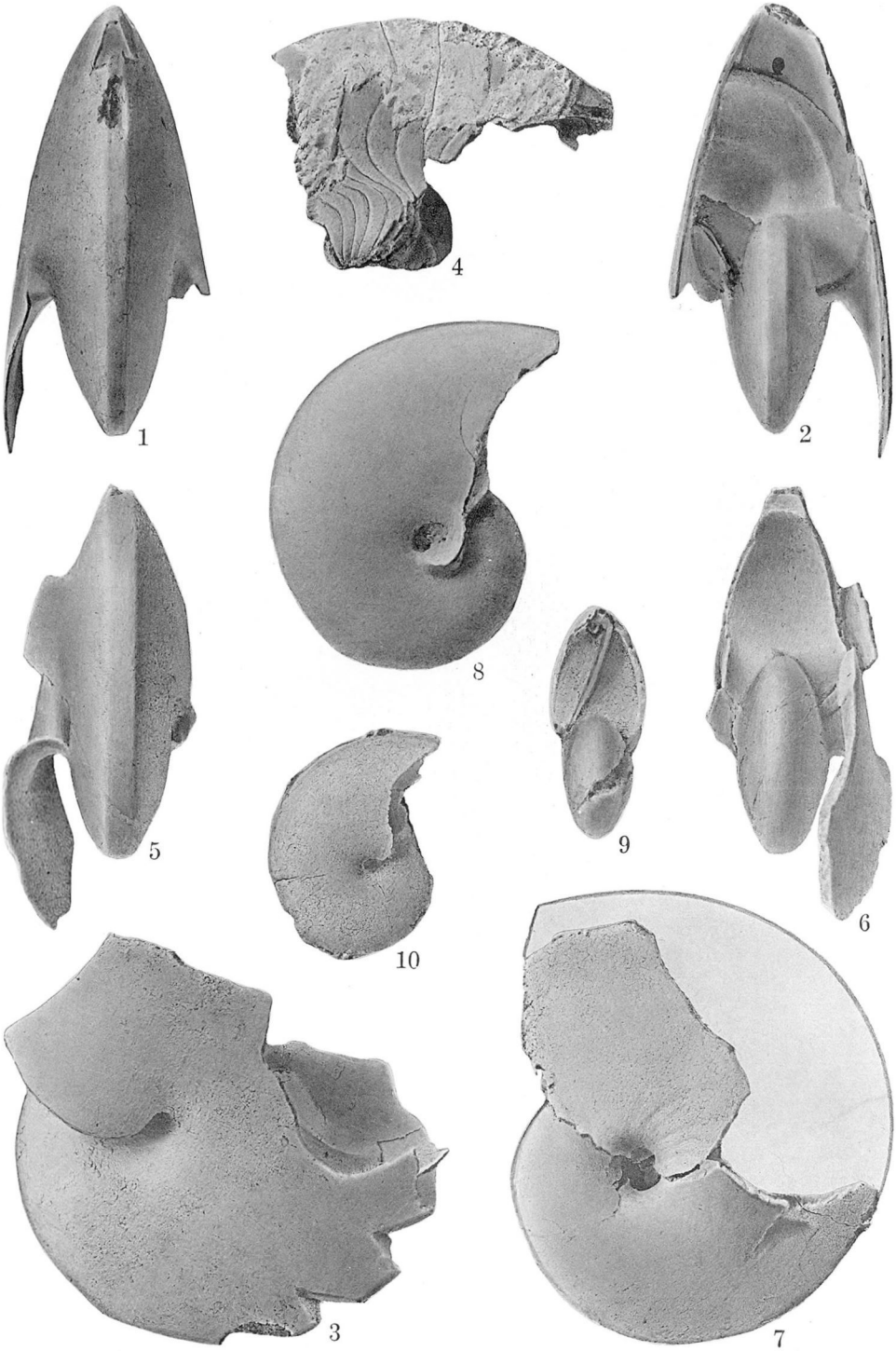
5, 6. *Liroceras* sp. 124
Two views (somewhat restored) of the only representative of *Liroceras* known from the Casper formation, × 2. S. U. I., 1152

7–10. *Stenopoceras abundum* Miller and Thomas 73
Lateral view of an immature specimen (a syntype) of about two volutions showing the start of the abrupt closure of the umbilicus; ventral and lateral views of another syntype of about one and a half volutions showing the shape of the conch, and the perforate umbilicus during early ontogenetic development; and lateral view of extreme adapical portion of conch; all × 1. S. U. I., 1164 (Fig. 7), 1165 (Fig. 8, 9), 1166 (Fig. 10). (*See also* Plate 24.)

PLATE 26.—*STENOPOCERAS INEXPECTANS*

Figures		Page
1–10.	*Stenopoceras inexpectans* Miller.....	75

Four specimens from the middle portion of the upper Leonard formation about half a mile west of Split Tank near the old Word Ranch house in the Glass Mountain region of west Texas. Figures 1–3 represent one specimen, × 1; 4, a second, × 1; 5–8, a third, × 1½; 9, 10, a fourth, × 1½—Figure 8 represents all but the adoral portion of the specimen illustrated by Figures 5–7. Collected by G. A. Cooper. U. S. N. M. (*See also* Plates 6, 40.)



STENOPOCERAS INEXPECTANS

STENOPOCERAS WHITEI

PLATE 27.—*STENOPOCERAS WHITEI*

Figures Page

1–7. *Stenopoceras whitei*, n. sp..... 76

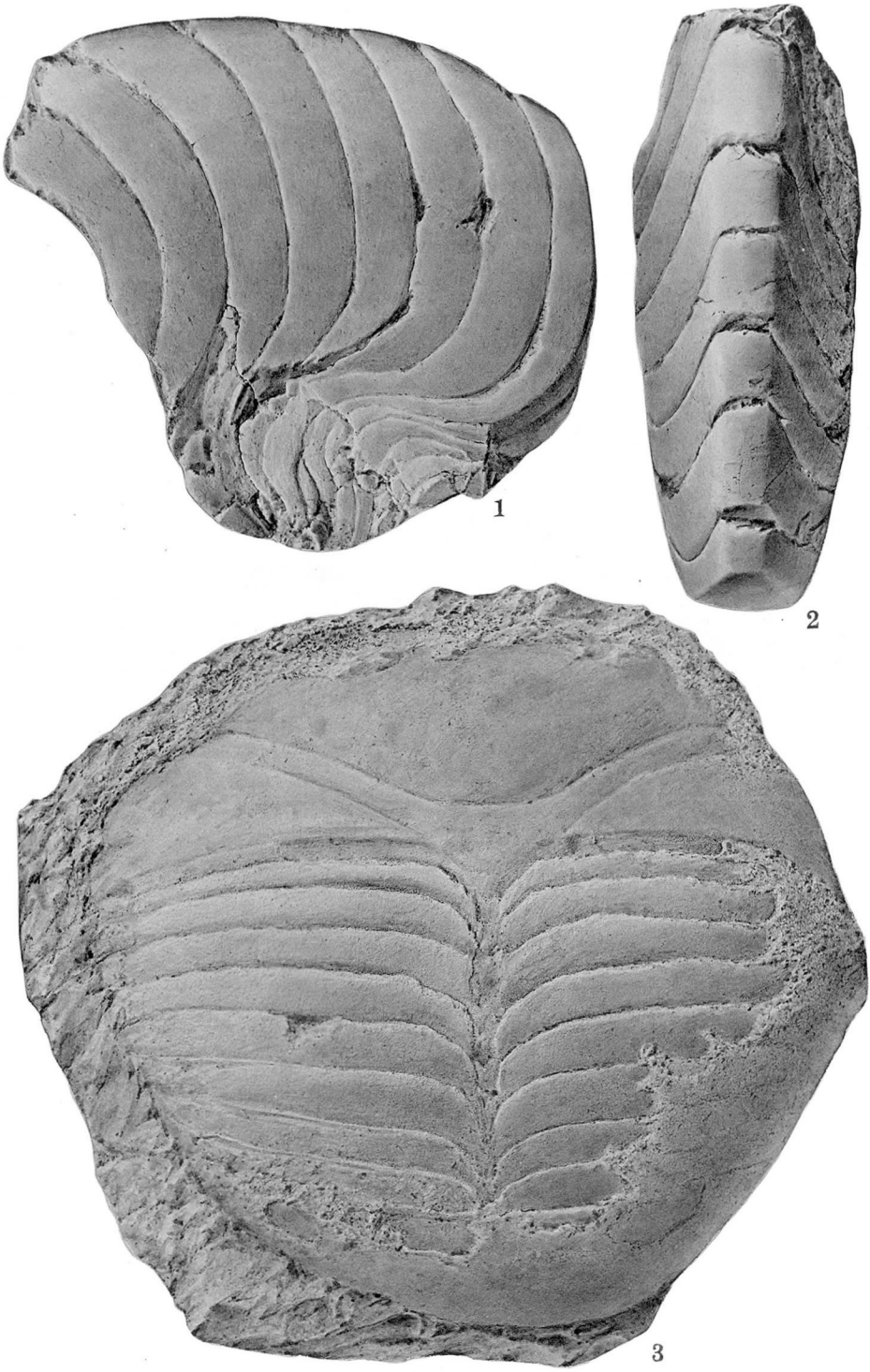
The holotype (Figs. 1, 2) and two of the paratypes, all from the Grape Creek limestone of the Clyde formation about 1½ miles north of the England schoolhouse and about 10 miles east of Seymour, Texas, × 1 (Figs. 1, 2, 5–7) and × 2 (Figs. 3, 4). Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plates 5, 28.)

PLATE 28—*STENOPOCERAS* AND *SOLENOCHILUS*

Figures | Page

1, 2. *Stenopoceras whitei*, n. sp. 76
Two views of an internal mold of part of a phragmacone (a paratype) from a boulder probably of the upper part of the Lueders formation at the Lake Kemp dam, Baylor County, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection 1 (*See also* Plates 5, 27.)

3. *Solenochilus kempae*, n. sp. 33
Ventral view of the holotype, from the lower part of the Lueders formation about 10 miles southeast of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. U. C., 18061.



STENOPOCERAS AND *SOLENOCHILUS*

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TAINOCERAS CLYDENSE

PLATE 29.—*TAINOCERAS CLYDENSE*

Figures | Page

1–4. *Tainoceras clydense* Miller and Kemp 84

Two internal molds (Figures 1, 2 represent one specimen, as do Figures 3, 4) from the basal portion of the Lueders formation about 8 miles south of Seymour, Texas, × $\frac{7}{8}$. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plate 55.)

PLATE 30.—*STEAROCERAS* AND *TAINOCERAS*

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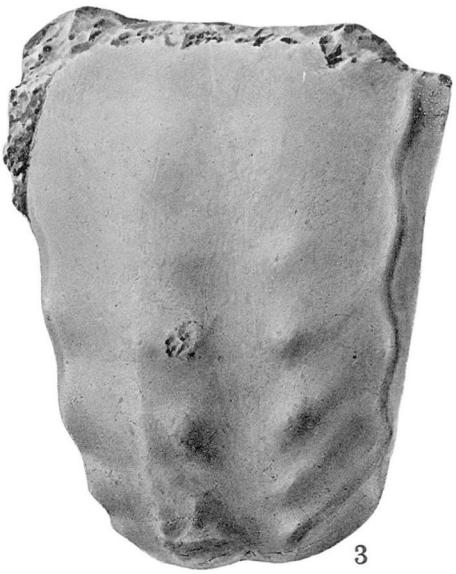

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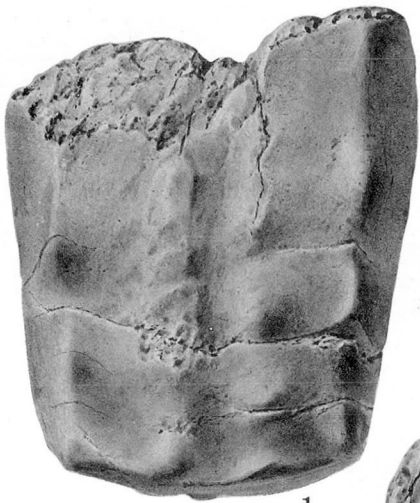
STEAROCERAS AND *TAINOCERAS*



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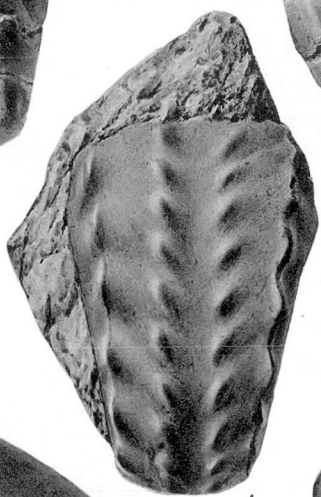

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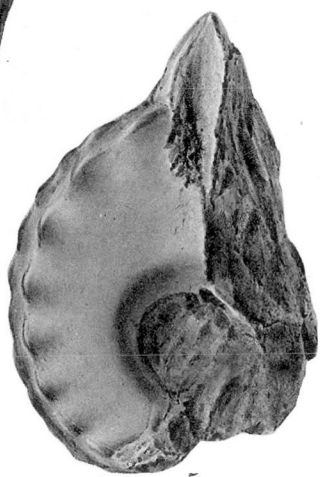

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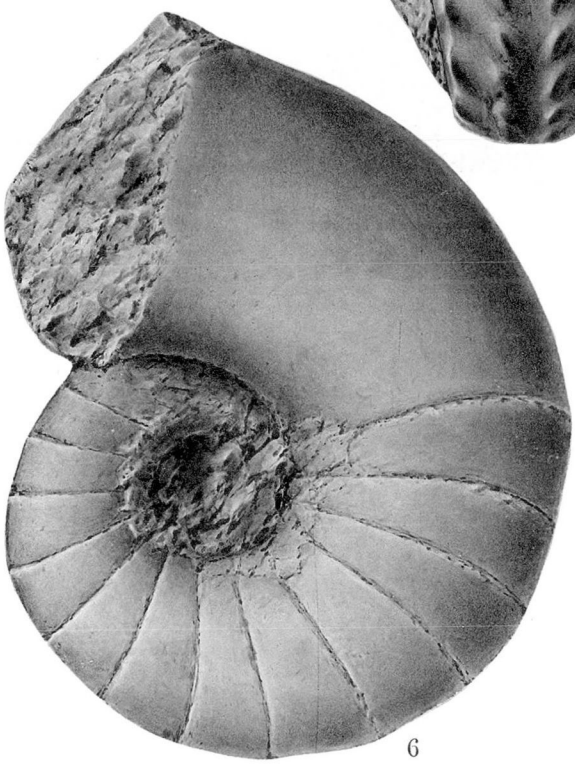

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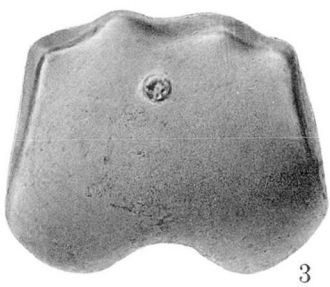

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TAINOCERAS AND *STEAROCERAS*

PLATE 31.—*TAINOCERAS* AND *STEAROCERAS*

Figures — Page

1–5. *Tainoceras nebrascense* Miller, Dunbar, and Condra 88
Two of the syntypes (Figures 1–3 represent one specimen; 4, 5 another), from the Fort Riley limestone at the Beatrice power dam at Barneston, Nebraska, × 1¼. Collected by C. O. Dunbar and N. A. Bengtson. Y. P. M. (*See also* Plates 30, 32.)

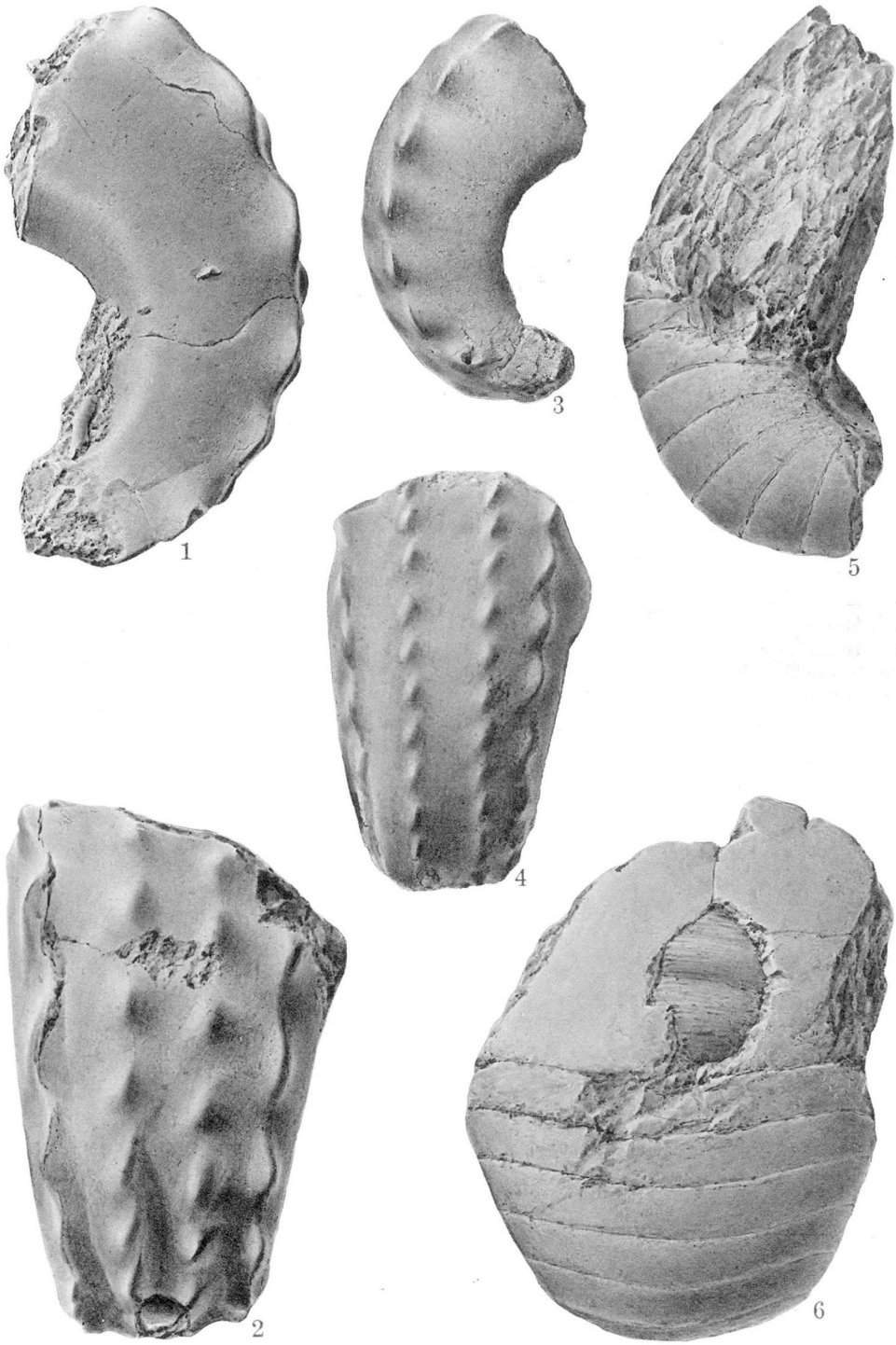
6. *Stearoceras?* sp. 69
A specimen from the uppermost limestone member of the Phosphoria formation in the Wind River or Owl Creek mountains of Wyoming, presumably × 1. Adapted from Branson.

PLATE 32.—*TAINOCERAS* AND *SOLENOCHILUS*

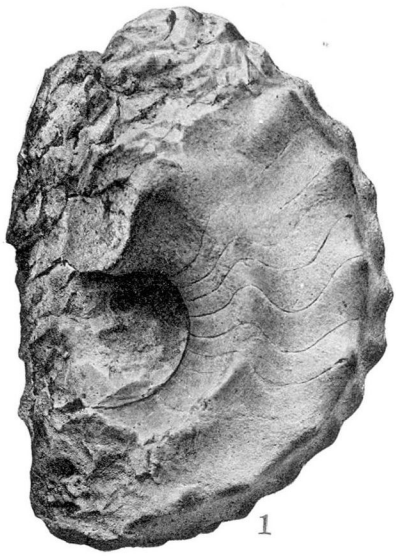
Figures — Page

1–4. *Tainoceras nebrascense* Miller, Dunbar, and Condra 88
Two of the syntypes (Figures 1, 2 represent one specimen; 3, 4 another), from the Fort Riley limestone at the Beatrice power dam at Barneston, Nebraska, × 1¼. Collected by C. O. Dunbar and N. A. Bengtson. Y. P. M. (*See also* Plates 30, 31.)

5, 6. *Solenochilus syracusense* Miller, Dunbar, and Condra 134
The holotype, from the Hughes Creek shale about 1 mile southwest of Syracuse, Nebraska, × 1. Y. P. M., 14004.



TAINOCERAS AND *SOLENOCHILUS*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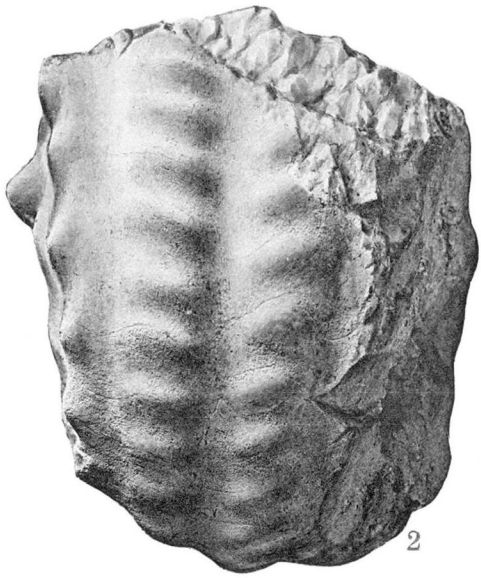
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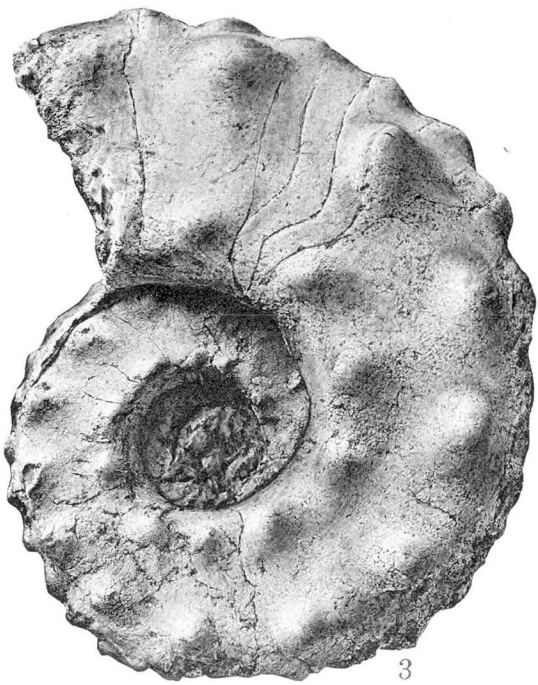
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TAINOCERAS

PLATE 33.—*TAINOCERAS*

Figures | Page

1, 2. *Tainoceras unklesbayi*, n. sp. 91
Two views of the holotype, a well preserved internal mold from the Toroweap formation south of Coconino Point in Grand Canyon, Arizona, × $\frac{2}{3}$. G. C. N. P. M., Fk-764.

3, 4. *Tainoceras schellbachi* Miller and Unklesbay 90
The holotype, from the Kaibab limestone near Hilltop, Grand Canyon, Arizona, × $\frac{7}{8}$. G. C. N. P. M., Fk-653. (*See also* Plates 14, 45.)

PLATE 34.—*AULAMETACOCERAS MCKEEI*

Figures

1, 2. *Aulametacoceras mckeei* Miller and Unklesbay 93
Ventral and lateral views of the holotype, from the Kaibab limestone, about 10 miles southeast of Flagstaff, Arizona, slightly less than × ½. M. N. A., 895/G2.1992.

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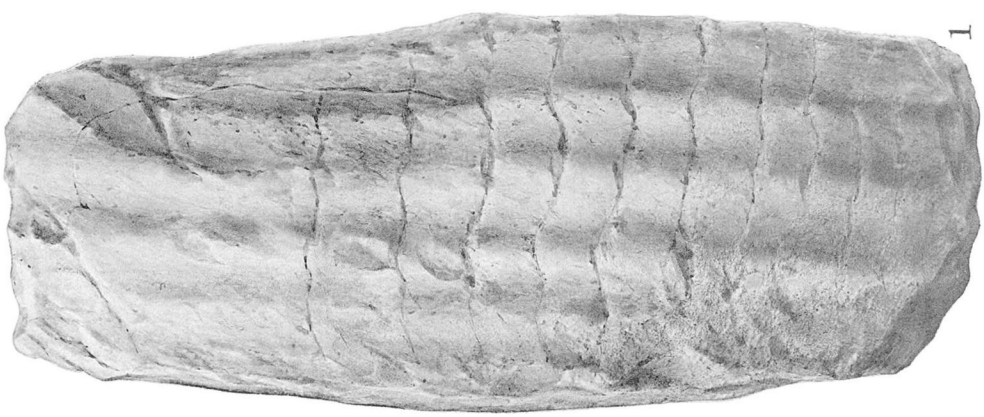

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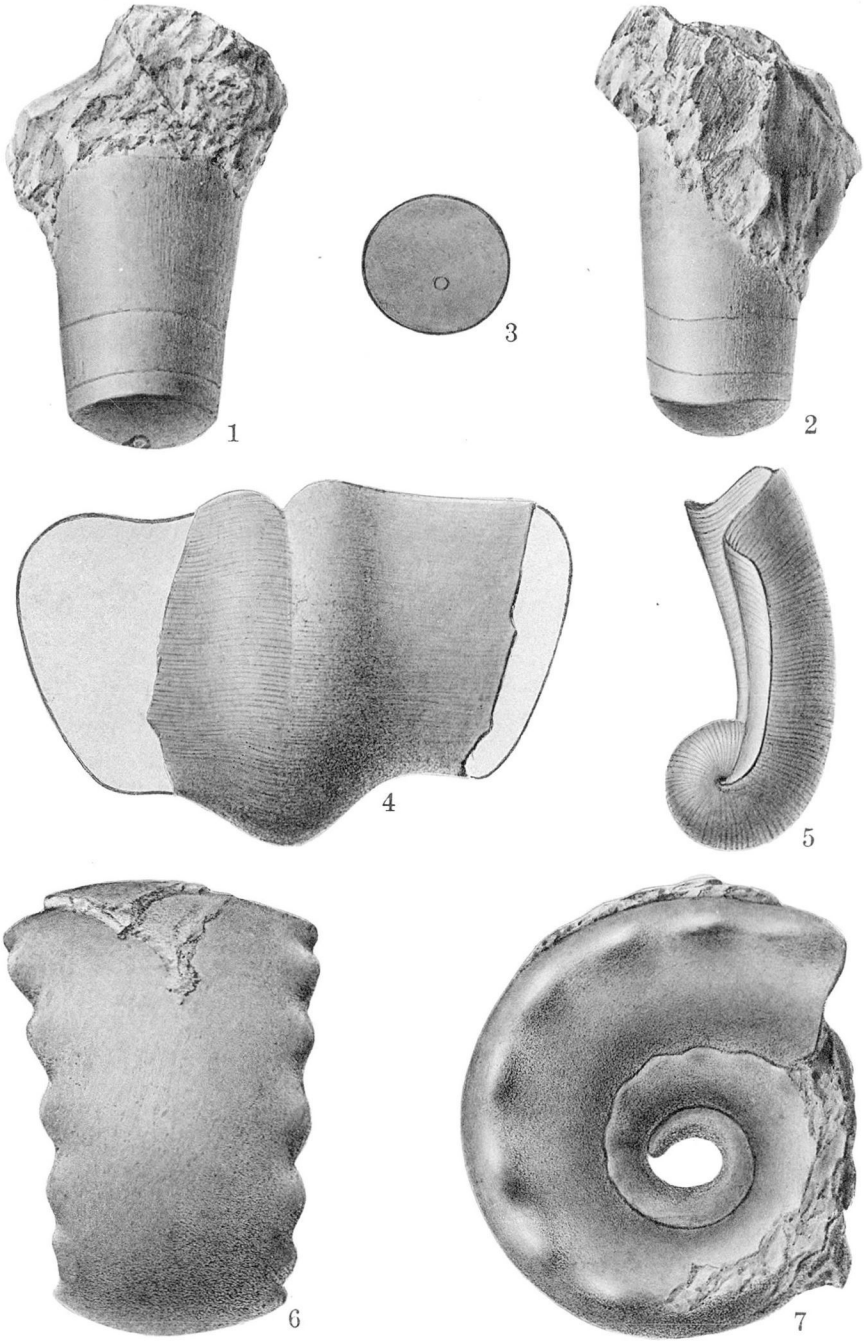
AULAMETACOCERAS MCKEEI



MOOREOCERAS, PTERONAUTILUS, AND *TEMNOCHEILUS*

PLATE 35.—*MOOREOCERAS, PTERONAUTILUS,* AND *TEMNOCHEILUS*

Figures — Page

1–3. *Mooreoceras* sp. 25
An internal mold from the Abo sandstone (about 50 feet above the base of the red beds) at head of Abo Canyon at south end of Manzano Mountains, New Mexico, × 1. Collected by W. T. Lee. U. S. N. M. After Girty. (*See also* Plates 4, 6, 47, 55.)

4, 5. *Pteronautilus seebachianus* (Geinitz) 131
The figured syntype, from the lower Zechstein at Ilmenau, Saxe-Weimar, Germany, × 1. Collected by C. v. Seebach. After Geinitz.

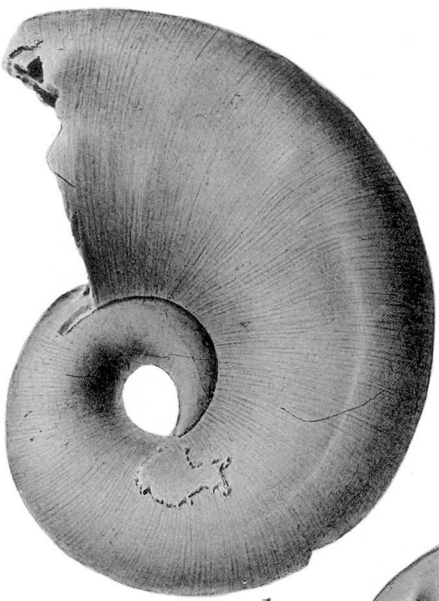
6, 7. *Temnocheilus coronatum* (M'Coy) 94
A typical specimen, from the Lower Carboniferous limestone of Stebden Hill, near Cracoe, Yorkshire, England, × 1. Collected by E. J. Garwood. After Foord.

PLATE 36.—*TEMNOCHEILUS* AND *FOORDICERAS*

Figures | Page

1–4. *Temnocheilus inaequilaterale*, n. sp. 94
Four views of the holotype, from the lower part of the upper Leonard on the south side of the road between the road fork and the Sheep Tank at the old Word Ranch house in the Glass Mountain region of west Texas, × 1. Collected by G. A. Cooper. U. S. N. M.

5. *Foordiceras gregarium* (Miller) 98
A silicified specimen from the middle portion of the upper Leonard formation 0.2–0.5 mile east of Split Tank, 1.5 miles northeast of the bowed fork near the old Word Ranch house in the Glass Mountain region of west Texas, × 1. Collected by G. A. Cooper. U. S. N. M. (*See also* Plates 38–41.)



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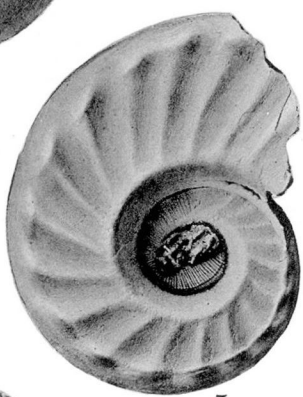

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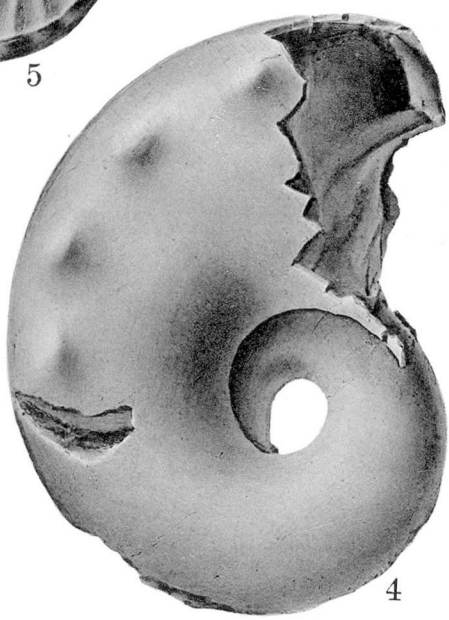

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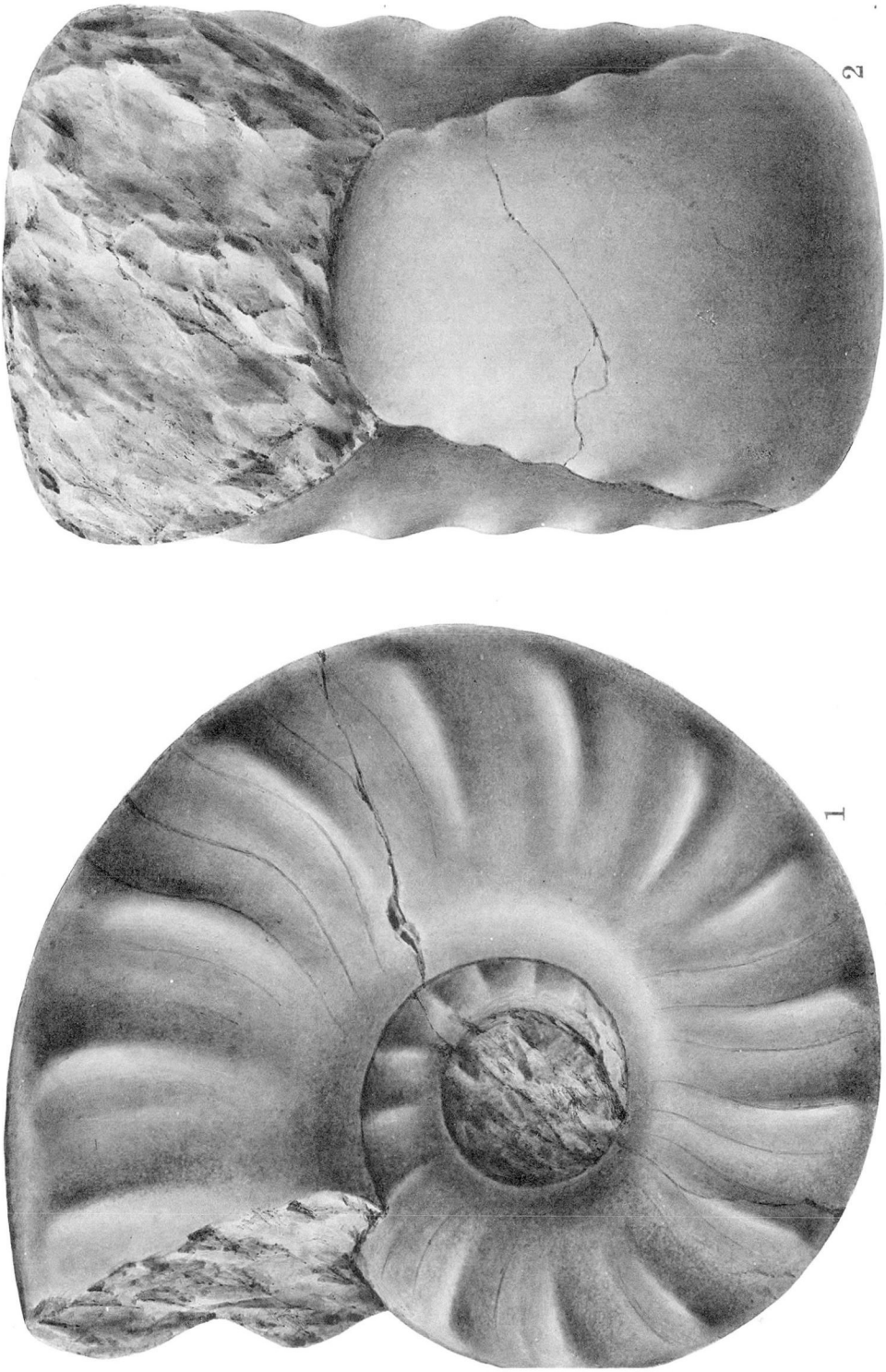
TEMNOCHEILUS AND *FOORDICERAS*



FOORDICERAS GOLIATHUM

PLATE 37.—*FOORDICERAS GOLIATHUM*

Figures Page

1, 2. *Foordiceras goliathum* (Waagen) 96
The larger of the syntypes (somewhat restored), from the Upper Productus limestone at Katwâhi in the Salt Range of India, × ¾. Collected by William Waagen. After Waagen.

PLATE 38.—*FOORDICERAS*

Figures — Page

1. *Foordiceras mutatum* (Miller) 101
The holotype, from the upper part of the Leonard formation 0.2–0.5 mile east of Split Tank, 1.5 miles northeast of the bowed fork near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 1. Collected by G. A. Cooper. U. S. N. M., 111619.

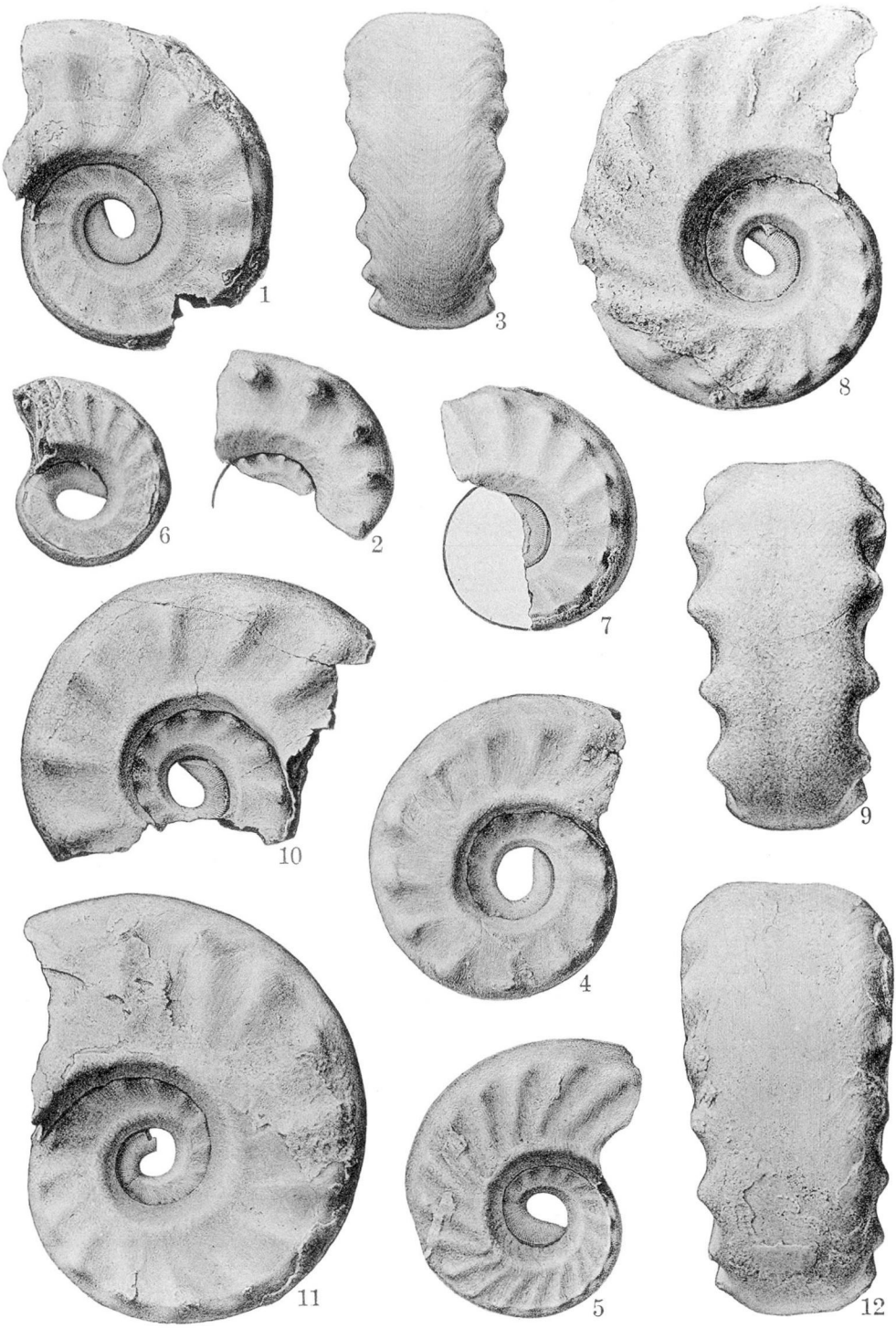
2. *Foordiceras mammiferum* (Miller) 100
The holotype, from the Bone Spring limestone near the mouth of Apache Canyon in the Sierra Diablo of Hudspeth County, Texas, × 1. Collected by Stanislaus Kříž. P. U. (*See also* Plate 15.)

3, 4. *Foordiceras megaporum* (Miller) 100
Two views of the holotype, from the same horizon and locality as Figure 2, × 1. Collected by Stanislaus Kříž. P. U.

5–8. *Foordiceras gregarium* (Miller) 98
Three of the syntypes—Figure 6 represents the adapical part of Figure 5—from the same horizon and locality as Figure 1, all × 1. Collected by G. A. Cooper. U. S. N. M., 111614 (all three specimens). (*See also* Plates 36, 39–41.)

9, 10. *Foordiceras magnicostatum* (Miller) 99
Two views of the holotype, from the same horizon and locality as Figure 1, × 1. Collected by G. A. Cooper. U. S. N. M., 111617. (*See also* Plate 15.)

11, 12. *Foordiceras cooperi* (Miller) 97
Two views of the holotype, from the same horizon and locality as Figure 1, × 1. Collected by G. A. Cooper. U. S. N. M., 111612.



FOORDICERAS

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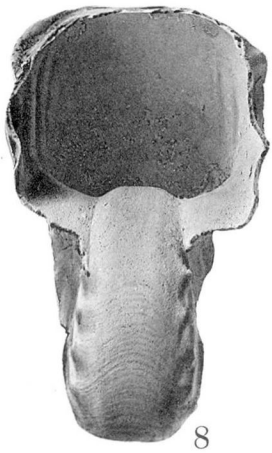

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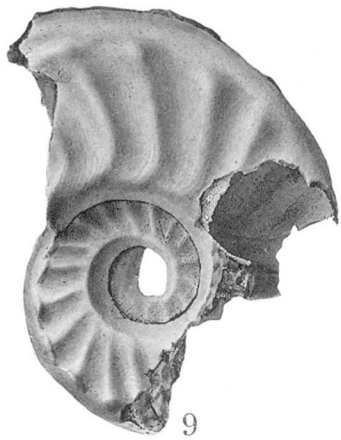

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FOORDICERAS AND *TEMNOCHEILUS*

PLATE 39.—*FOORDICERAS* AND *TEMNOCHEILUS*

Figures — Page

1, 2. *Foordiceras gregarium* (Miller) 98
A silicified specimen from the middle portion of the upper Leonard formation 0.2–0.5 mile east of Split Tank, 1.5 miles northeast of the bowed fork near the old Word Ranch house in the Glass Mountain region of west Texas, × 1. Collected by G. A. Cooper. U. S. N. M. (*See also* Figures 6–9 and Plates 36, 38, 40, 41.)

3–5. *Temnocheilus?* sp. 95
A small immature silicified specimen from the Hueco formation on an isolated hill 0.7 mile south of the railroad station at Orogrande, New Mexico, × 1½. Collected by C. C. Branson. U. S. N. M.

6–9. *Foordiceras gregarium* (Miller) 98
Two specimens—Figures 6 and 7 represent one individual, as do 8 and 9—from the same horizon and locality as Figures 1 and 2 on this plate, all × 1. Collected by G. A. Cooper. U. S. N. M. (both specimens). (*See also* Figures 1, 2 and Plates 36, 38, 40, 41.)

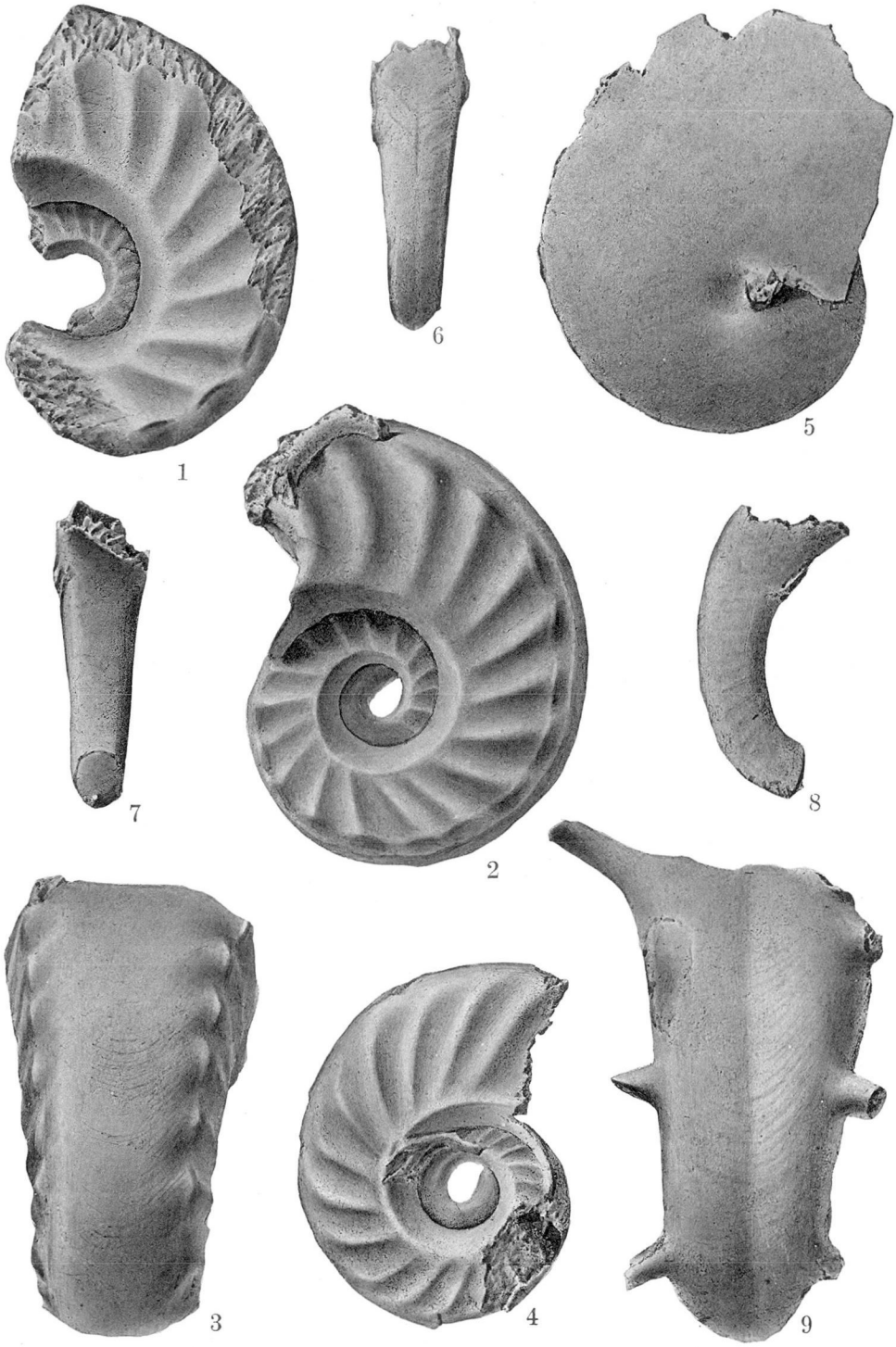
PLATE 40.—*FOORDICERAS, STENOPOCERAS,* AND *COOPEROCERAS*

Figures — Page

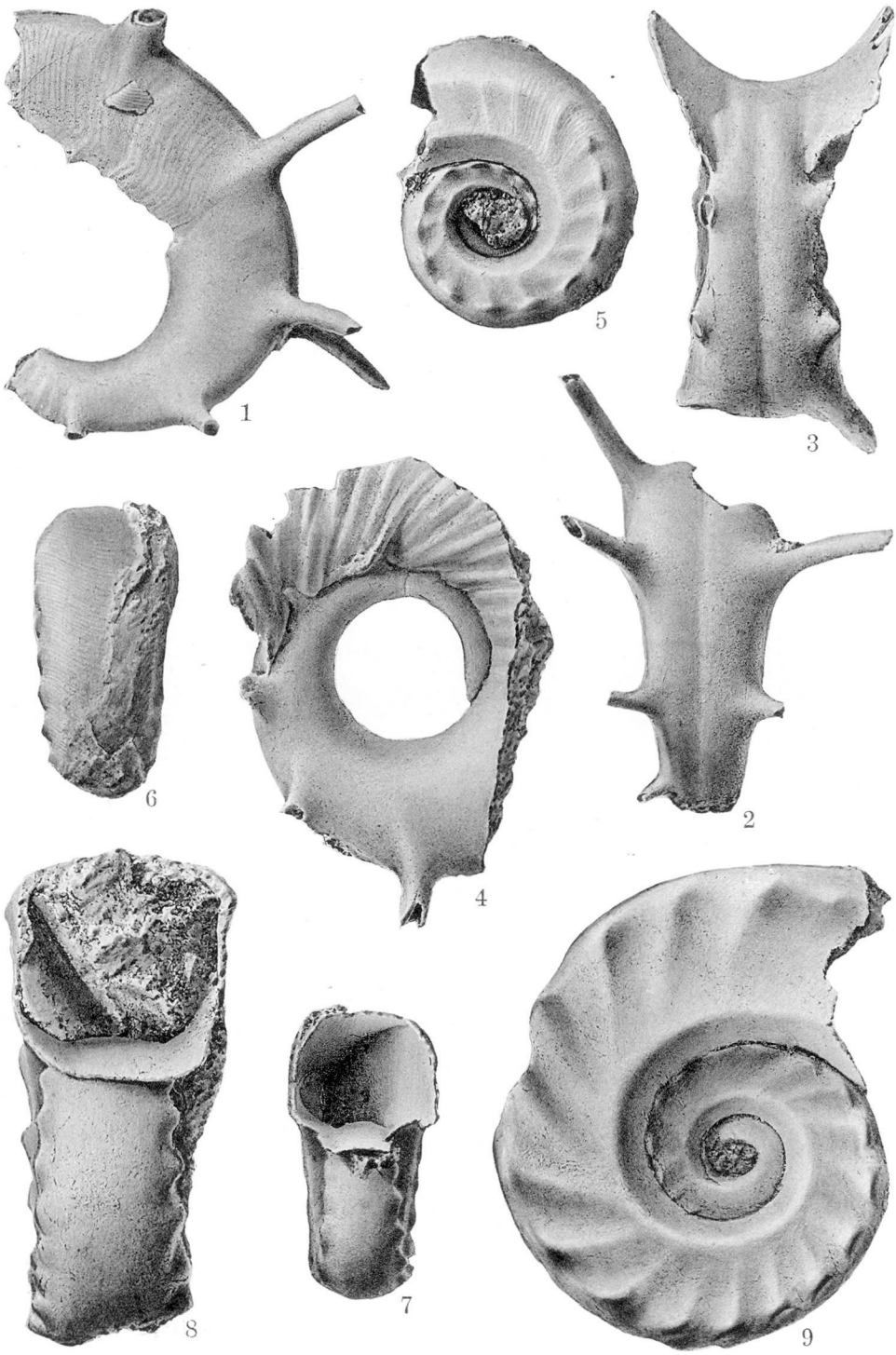
1–4. *Foordiceras gregarium* (Miller) 98
Three specimens—Figures 2 and 3 represent one individual—from the upper part of the Leonard formation at two localities in the Glass Mountains of west Texas: (1) 0.2–0. 5 mile east of Split Tank, 1.5 miles northeast of the bowed fork near the old Word Ranch house (Figs. 1–3); and (2) on the south side of the road between the road fork and the Sheep Tank at the old Word Ranch house (Fig. 4), all × 1. Collected by G. A. Cooper. U. S. N. M. (both specimens). (*See also* Plates 36, 38, 39, 41.)

5. *Stenopoceras inexpectans* Miller 75
Lateral view of all but the extreme adoral portion of the specimen illustrated by Figures 1–3 on Plate 26, from the middle portion of the upper Leonard formation about half a mile west of Split Tank near the old Word Ranch house in the Glass Mountain region of west Texas, × 1. Collected by G. A. Cooper. U. S. N. M. (*See also* Plate 6.)

6–9. *Cooperoceras texanum* Miller 118
An adapical portion of the conch (Figs. 6–8) from the lower part of the upper Leonard formation near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 2; and an early mature specimen (Fig. 9) from the lower portion of the Bone Spring limestone near the mouth of Apache Canyon in the Sierro Diablo of Hudspeth County, Texas, × 1. Collected by G. A. Cooper (Figs. 6–8) and J. B. Knight (Fig. 9). U. S. N. M. (both specimens). (*See also* Plates 1, 6, 41, 49–52.)



FOORDICERAS, STENOPOCERAS, AND *COOPEROCERAS*



COOPEROCERAS AND *FOORDICERAS*

PLATE 41.—*COOPEROCERAS* AND *FOORDICERAS*

Figures — Page

1–4. *Cooperoceras texanum* Miller 118
Two specimens—Figures 1 and 2 represent one individual, as do 3 and 4—from the lower part of the upper Leonard formation near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 1. Collected by G. A. Cooper. U. S. N. M. (both specimens). (*See also* Plates 1, 6, 40, 49–52.)

5–9. *Foordiceras gregarium* (Miller) 98
Two specimens—Figures 5–7 represent one individual, as do 8, 9—from the Leonard formation at two localities in the Glass Mountain region of Brewster County, Texas: (1) about half a mile west of Split Tank near the old Word Ranch house (Figs. 5–7); and (2) on the crest of the hill 3.8 miles airline N. 78° E. of the Hess Ranch house, all × 1. Collected by G. A. Cooper. U. S. N. M. (both specimens). (*See also* Plates 36, 38–40.)

PLATE 42.—*PERIPETOCERAS, FOORDICERAS,* AND *METACOCERAS*

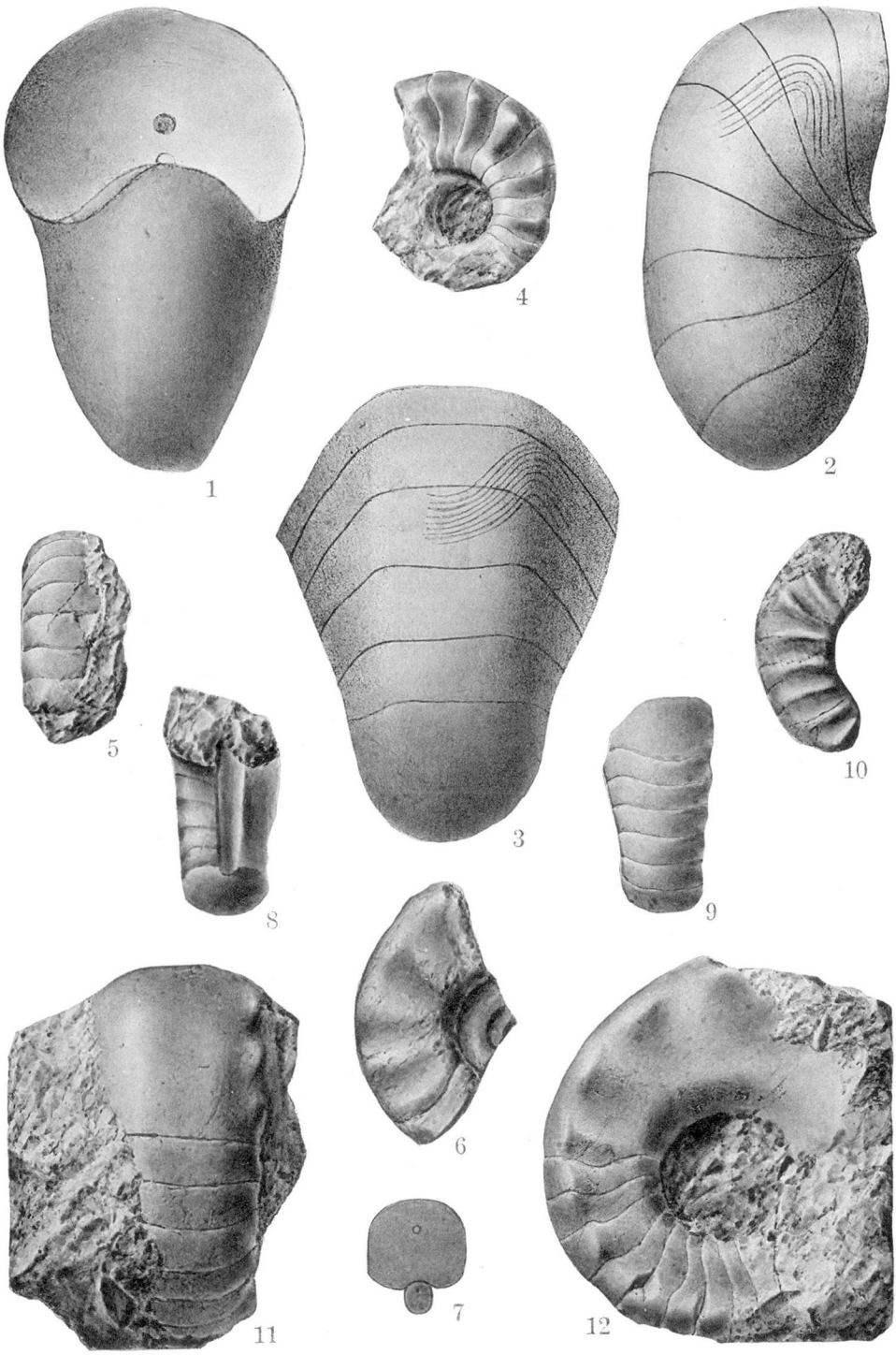
Figures — Page

1–3. *Peripetoceras freieslebeni* (Geinitz) 119
Three views of a representative of the genogtype of *Peripetoceras,* from the lower Zechstein near Gera, east-central Germany, × 1. Redrawn from Geinitz.

4–7. *Foordiceras shumardianum* Girty 103
The figured syntypes—Figures 4, 5 represent one specimen, and 6, 7 another—from the middle part of the Capitan formation just north of El Capitan, Guadalupe Mountains, west Texas, × 1. Collected by B. F. Hill and G. H. Girty. U. S. N. M. After Girty.

8–10. *Foordiceras praecursor* Girty 103
Three views of the figured syntype ("the typical specimen") from near the top of the black limestone member of the Bone Spring formation about 2 miles south of Guadalupe Peak, Guadalupe Mountains, west Texas, × 1. Collected by B. F. Hill and G. H. Girty. U. S. N. M.

11, 12. *Metacoceras* sp. 115
Ventral and lateral views of a specimen from the Fort Riley limestone at the Beatrice power dam at Barneston, Nebraska, × 1¼. Collected by C. O. Dunbar and N. A. Bengtson. Y. P. M.



PERIPETOCERAS, FOORDICERAS, AND *METACOCERAS*

2

1

METACOCERAS BAYLORENSE

PLATE 43.—*METACOCERAS BAYLORENSE*

Figures Page

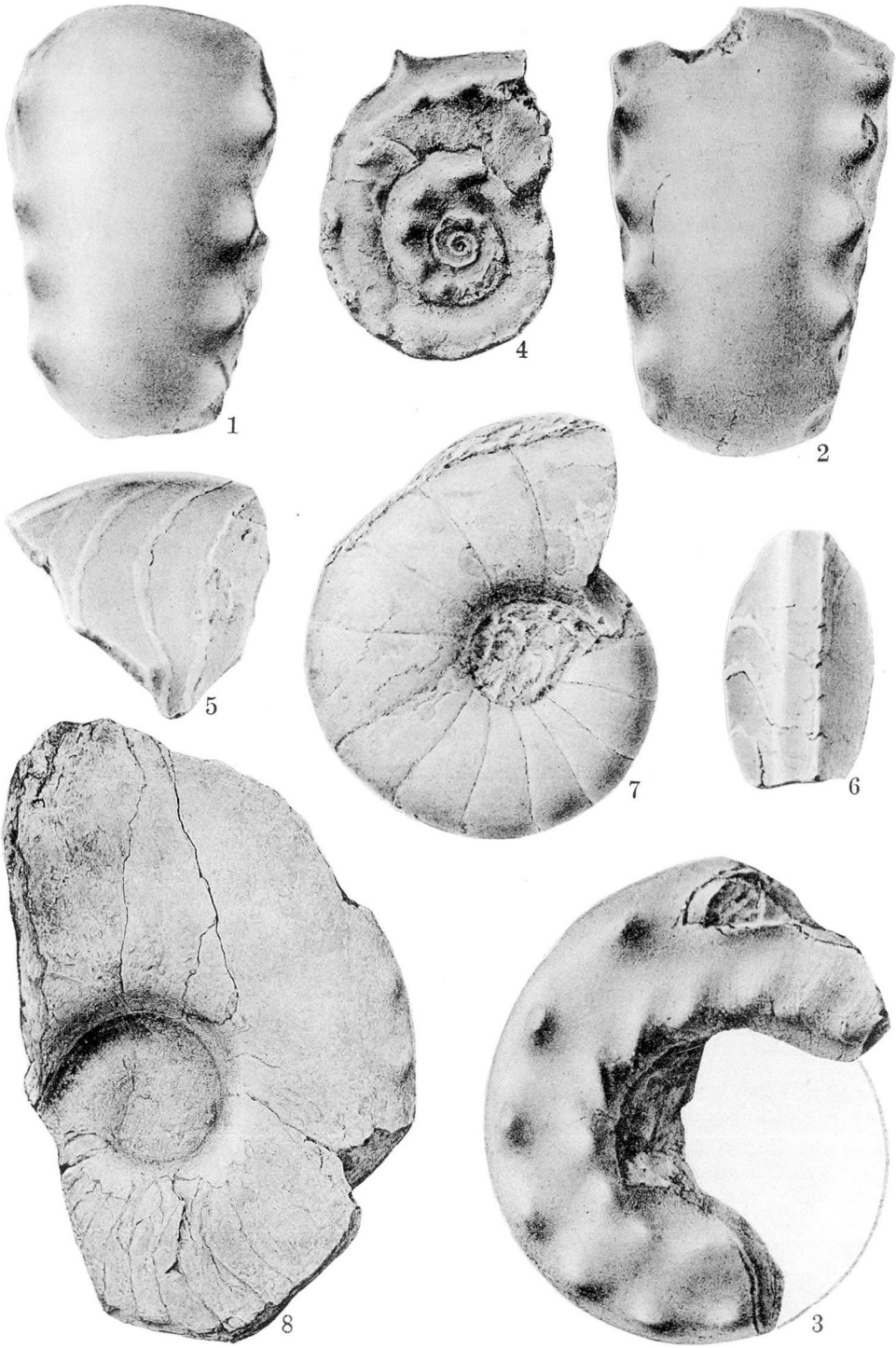
1, 2. *Metacoceras baylorense*, n. sp. 105
Lateral and ventral views of the holotype, from the basal portion of the Lueders formation about 8 miles south of Seymour, Texas, × $\frac{7}{8}$. Collected by Augusta Hasslock Kemp. A. H. K. Collection, B405. (*See also* Plate 44.)

PLATE 44.—*METACOCERAS* AND *STENOPOCERAS*

Figures

1. *Metacoceras baylorense*, n. sp. 105
Lateral view of the paratype, from the basal portion of the Lueders formation about 8 miles south of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plate 43.)
2. *Stenopoceras* sp. 79
Lateral view of a specimen from the Hueco limestone at the north end of Alecran Mountain of the Hueco Mountains, west Texas, × 1. Collected by C. C. Branson. U. S. N. M.

METACOCERAS AND *STENOPOCERAS*



METACOCERAS, TAINOCERAS, STENOPOCERAS, LIROCERAS, AND *DOMATOCERAS*

PLATE 45.—*METACOCERAS, TAINOCERAS, STENOPOCERAS, LIROCERAS,* AND *DOMATOCERAS*

Figures — Page

1–3. *Metacoceras cheneyi* Miller and Youngquist 107
The paratype (Fig. 1) and the holotype (Figs. 2, 3), from the Wildcat Creek shale about 4½ miles south-southwest of Coleman, Texas, × 1. Collected by R. C. Moore. U. S. N. M. (*See also* Plate 46.)

4. *Tainoceras* cf. *T. schellbachi* Miller and Unklesbay 90
An artificial cast of the inner whorls of the conch, from the Kaibab limestone in the Bottomless Pits about 7 miles east of Flagstaff, Arizona, × 1. M. N. A., 811/G2.1512. (*See also* Plates 14, 33.)

5, 6. *Stenopoceras* sp. 78
A small testiferous fragment of a whorl, from the same horizon and locality as Figures 1–3, × 2. Collected by R. C. Moore. U. S. N. M.

7. *Liroceras?* sp. 123
A specimen from the Upper? Permian limestone which caps Cerro Agujito in the Valle de Las Delicias, Coahuila, Mexico, × 1½. Collected by R. E. King. Y. P. M., 16274.

8. *Domatoceras* sp. 47
A specimen from the Middle Permain (zone of *Waagenoceras*) about 60 meters N. 35° E. of La Difunta in the Valle de Las Delicias, Coahuila, Mexico, × ¾. Collected by R. E. King. Y. P. M., 16276.

PLATE 46.—*ENDOLOBUS*, *FOORDICERAS*, *METACOCERAS*, AND *LIROCERAS*

Figures — Page

1, 2. *Endolobus renfroae*, n. sp. 40
Ventral and lateral views of the holotype, from the Lueders formation about 4 miles south of Seymour, Texas, × 1. Renfro Collection.

3–5. *Foordiceras ornatissimum*, n. sp. 102
Ventral and lateral views of the holotype, × 1, and an enlargement of a testiferous ventral portion of the adapical half of the penultimate volution of the same individual (to which adheres a fragment of the dorsal portion of the test of the ultimate volution, showing parts of three internal sutures), × 12, from the Wildcat Creek shale about 4½ miles south-southwest of Coleman, Texas. Renfro Collection.

6–8. *Metacoceras cheneyi* Miller and Youngquist 107
Three views of a specimen from the same horizon and locality as Figures 3–5, × 1. Renfro Collection. (*See also* Plate 45.)

9–11. *Liroceras* cf. *L. globulare* (Hyatt) 121
Three views of a specimen from the same horizon and locality as Figures 3–5, × 1. Renfro Collection. (*See also* Plates 55, 56.)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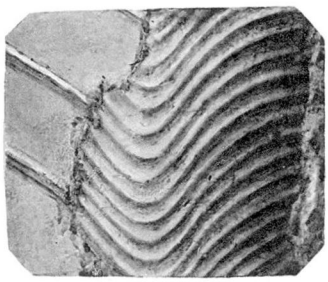
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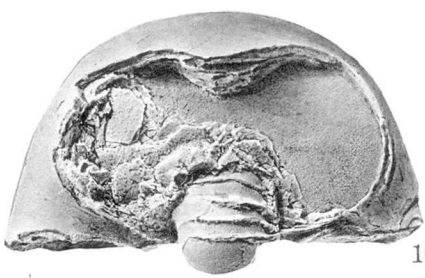
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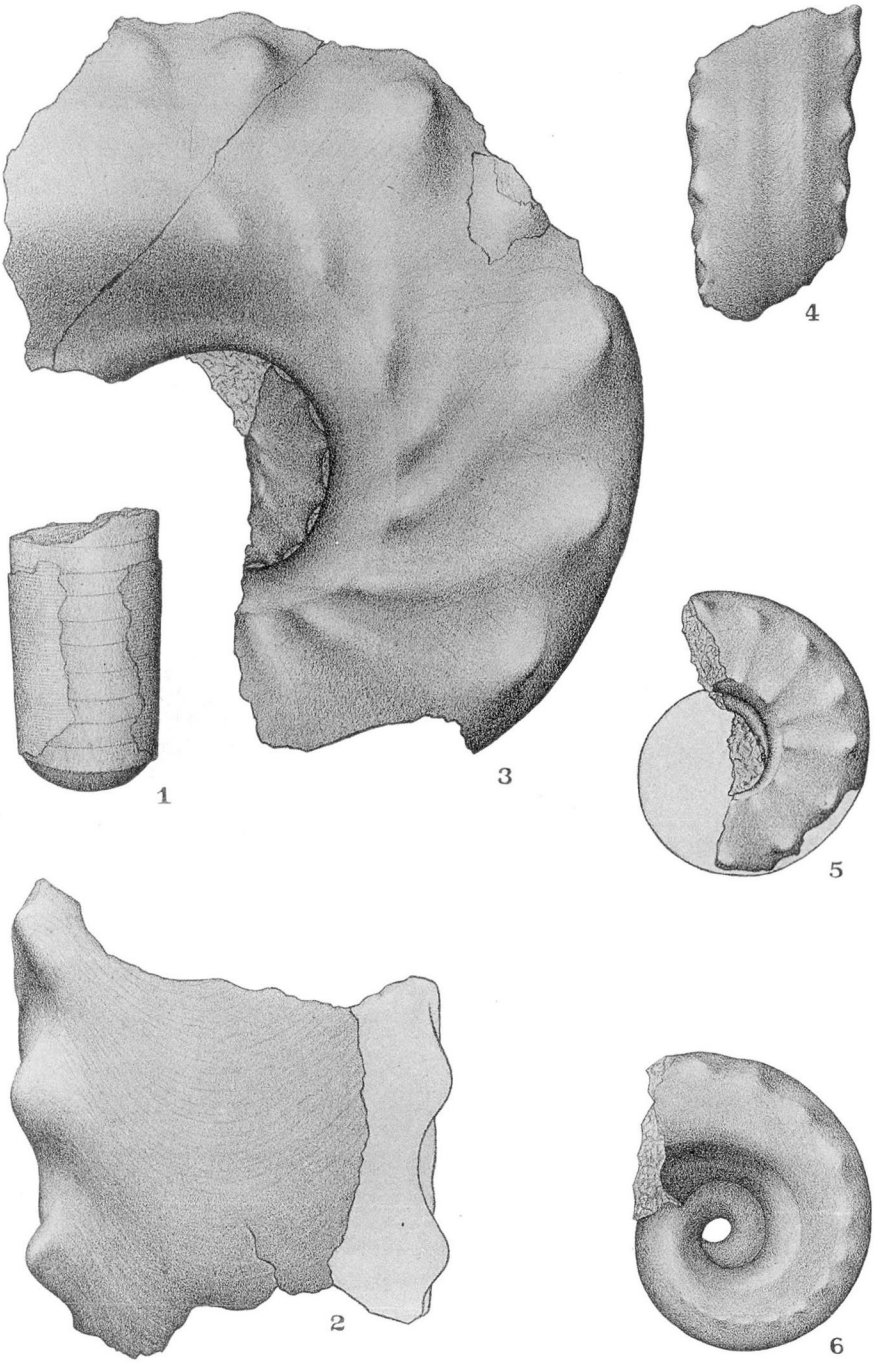
ENDOLOBUS, FOORDICERAS, METACOCERAS, AND *LIROCERAS*



MOOREOCERAS, METACOCERAS, AND *TAINOCERAS*

PLATE 47.—*MOOREOCERAS, METACOCERAS,* AND *TAINOCERAS*

All specimens illustrated on this plate were collected by H. D. Thomas from the *Stenopoceras* beds of the Casper formation in Gilmore Canyon, about 8 miles southeast of Laramie, Wyoming. The drawings are by Dan Enich.

Figures — Page

1. *Mooreoceras* sp. 25
   Ventral view of part of a phragmacone, somewhat restored, × 1. S. U. I., 1150. (*See also* Plates 4, 6, 35, 55.)

2, 3. *Metacoceras knighti* Miller and Thomas 112
   Ventral and lateral views (somewhat restored) of a syntype, × 1. S. U. I., 1155.

4, 5. *Metacoceras sulciferum* Miller and Thomas 113
   Ventral and lateral views of a syntype, × 1. S. U. I., 1157.

6. *Tainoceras wyomingense* Miller and Thomas 92
   Lateral view of an immature individual, a paratype, showing the umbilical perforation, the gradual development of the ventrolateral nodes, and the appearance of the ventral nodes near the adoral end of the specimen, × 1. S. U. I., 1160. (*See also* Plates 7, 25.)

PLATE 48.—*STEAROCERAS* AND *METACOCERAS*

Figures — Page

1, 2. *Stearoceras* sp. 68
Apertural and lateral views of a specimen from the Elm Creek limestone along Godwin Creek about 17 miles east of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plates 22, 58.)

3, 4. *Metacoceras* sp. 115
Lateral and ventral views of a specimen from the Lueders formation south of Miller Creek about 10 miles south of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection.

STEAROCERAS AND *METACOCERAS*

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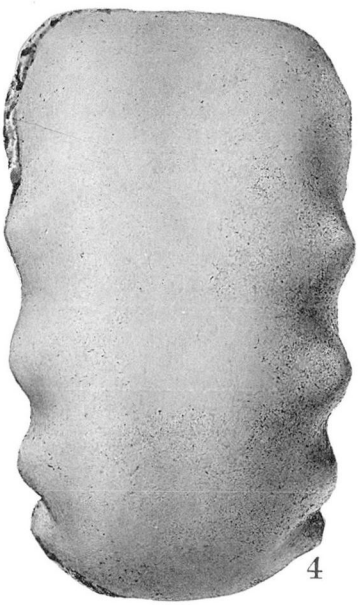

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COOPEROCERAS AND *METACOCERAS*

PLATE 49.—*COOPEROCERAS* AND *METACOCERAS*

Figures — Page

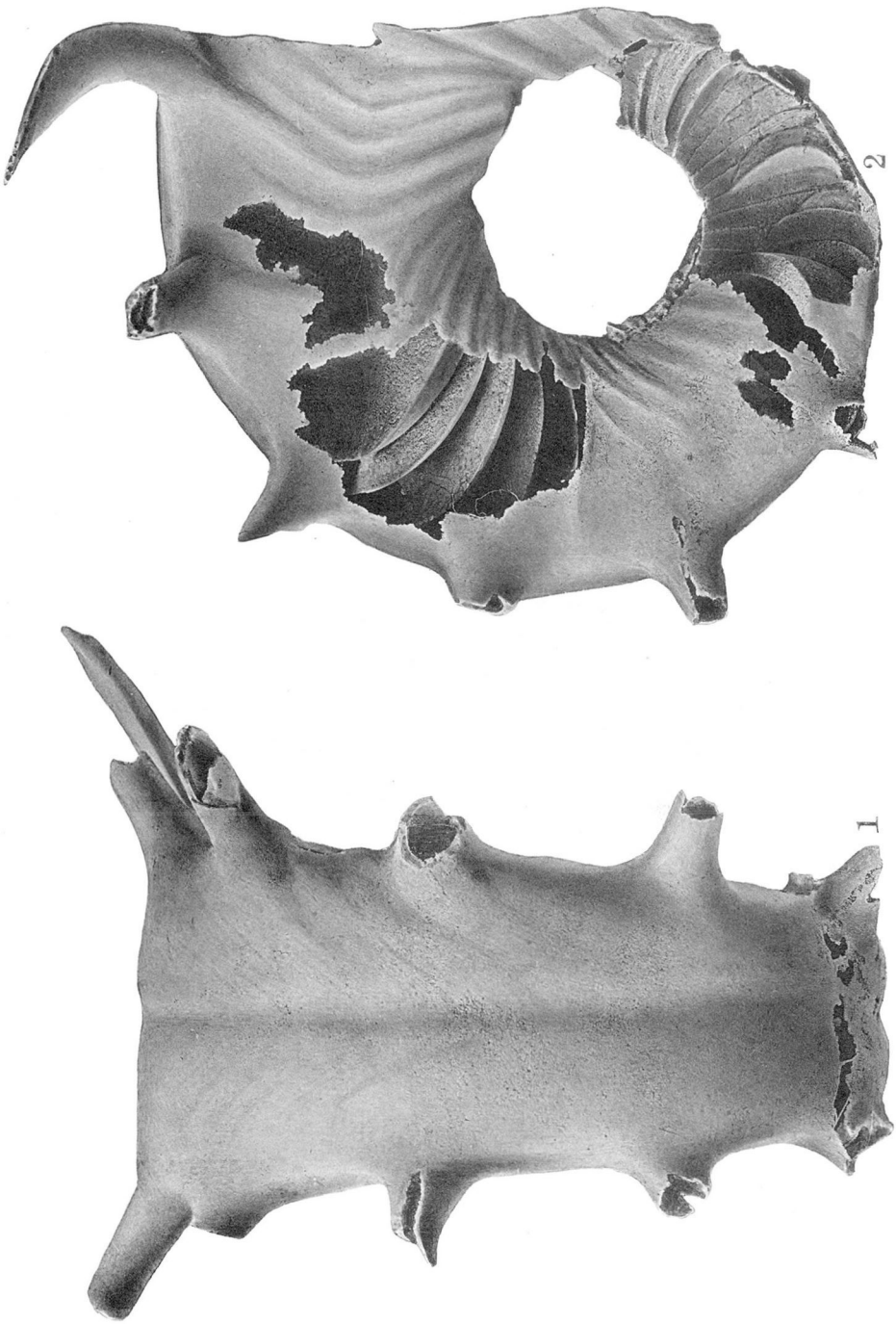
1, 2. *Cooperoceras texanum* Miller 118
Part of a mature whorl, from the lower portion of the upper Leonard formation near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 1. Collected by G. A. Cooper. U. S. N. M. (*See also* Plates 1, 6, 40, 41, 50–52.)

3, 4. *Metacoceras bituberculatum*, n. sp. 106
The holotype, from the same horizon and locality as the preceding, × 1. Collected by G. A. Cooper. U. S. N. M.

PLATE 50.—*COOPEROCERAS TEXANUM*

Figures | Page

1, 2. *Cooperoceras texanum* Miller 118
Two views of a specimen representing a mature volution of the conch and showing partial cameral fillings, from the lower part of the upper Leonard formation near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 1—same specimen as Figures 1 and 2 on Plate 51. Collected by G. A. Cooper. U. S. N. M. (*See also* Plates, 1, 6, 40, 41, 49, 52.)



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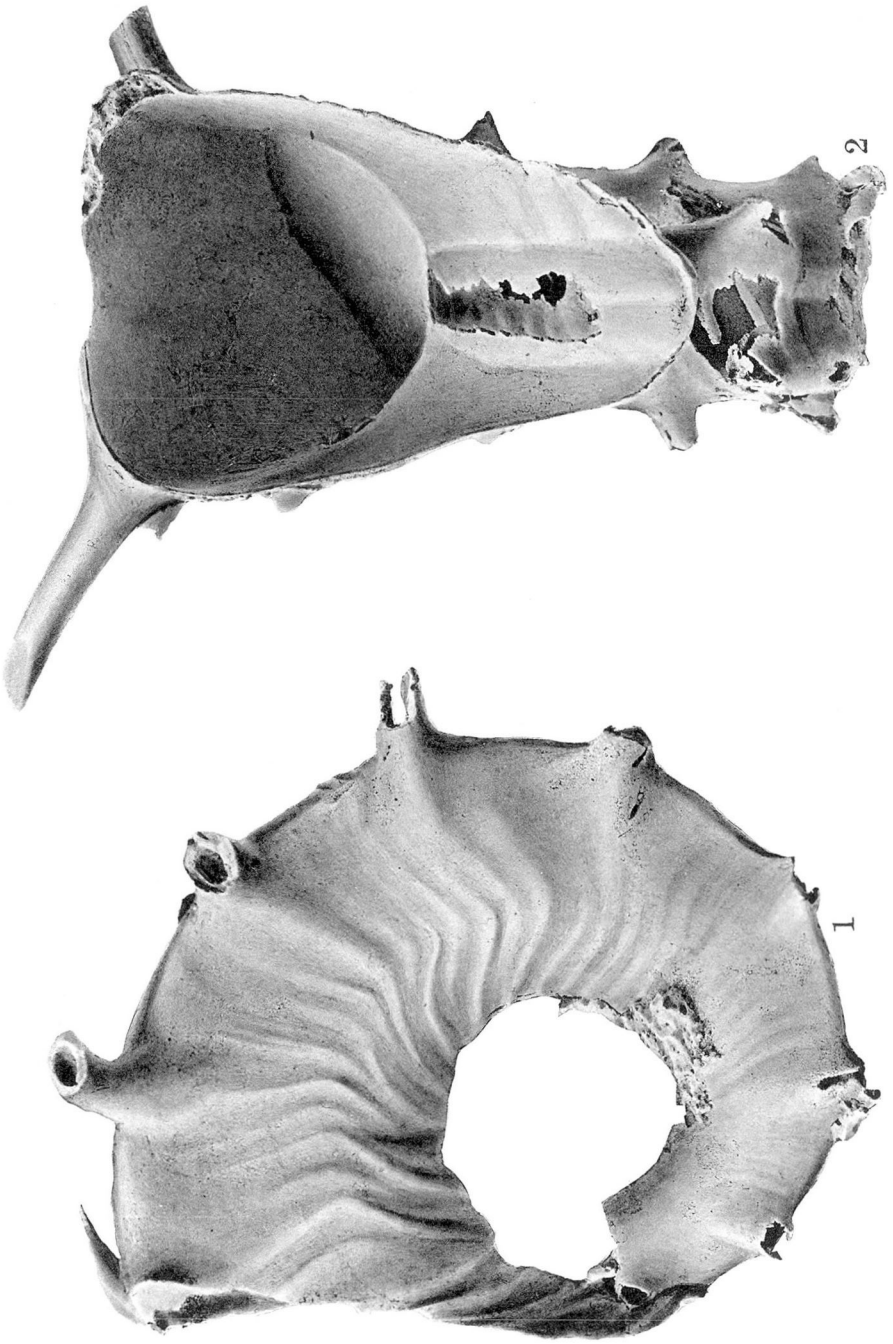


COOPEROCERAS TEXANUM

PLATE 51.—*COOPEROCERAS TEXANUM*

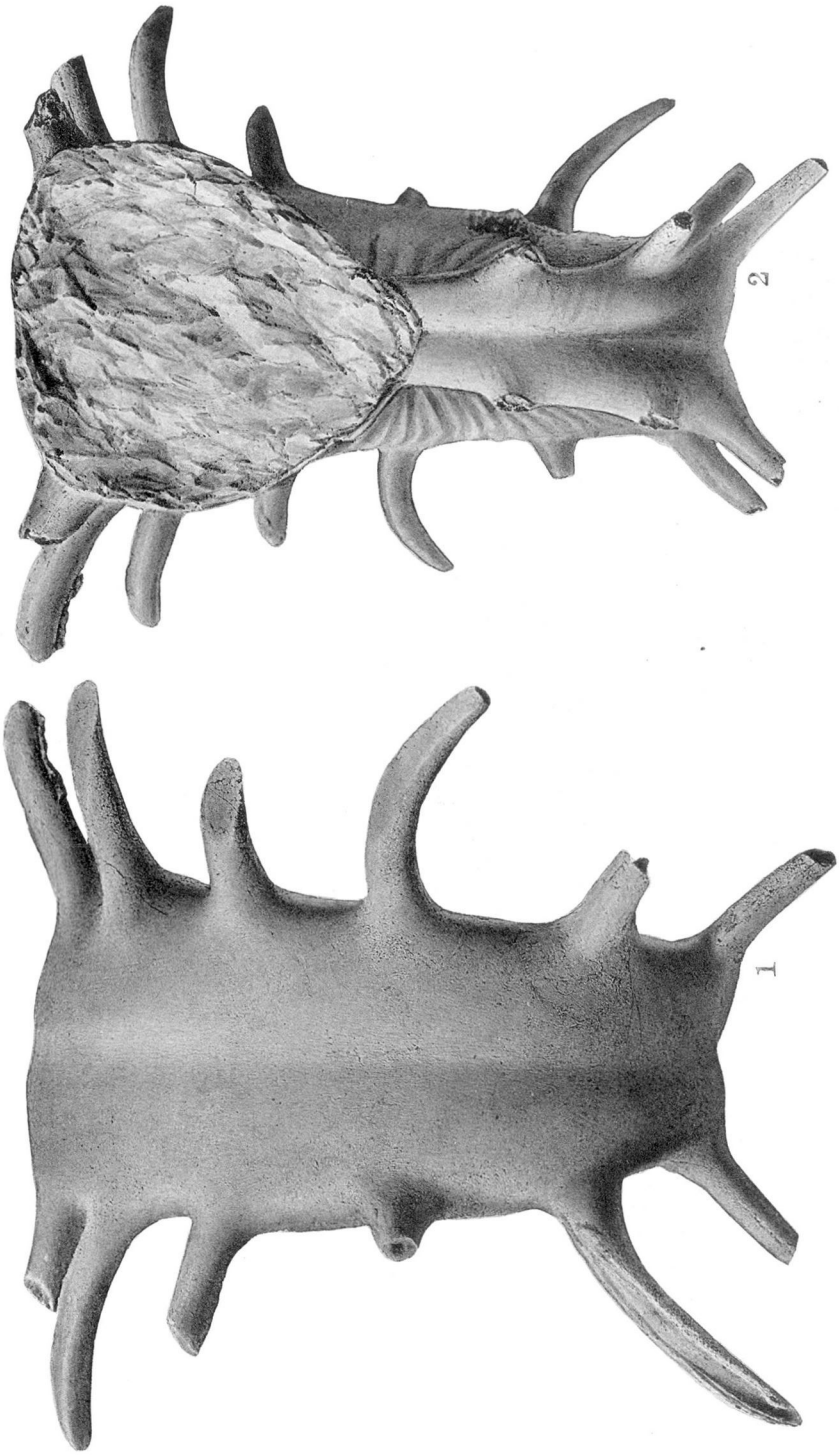
Figures Page

1, 2. *Cooperoceras texanum* Miller 118
Lateral and apertural views of the specimen illustrated on Plate 50, from the lower part of the upper Leonard formation near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × 1. Collected by G. A. Cooper. U. S. N. M. (*See also* Plates 1, 6, 40, 41, 49, 52.)

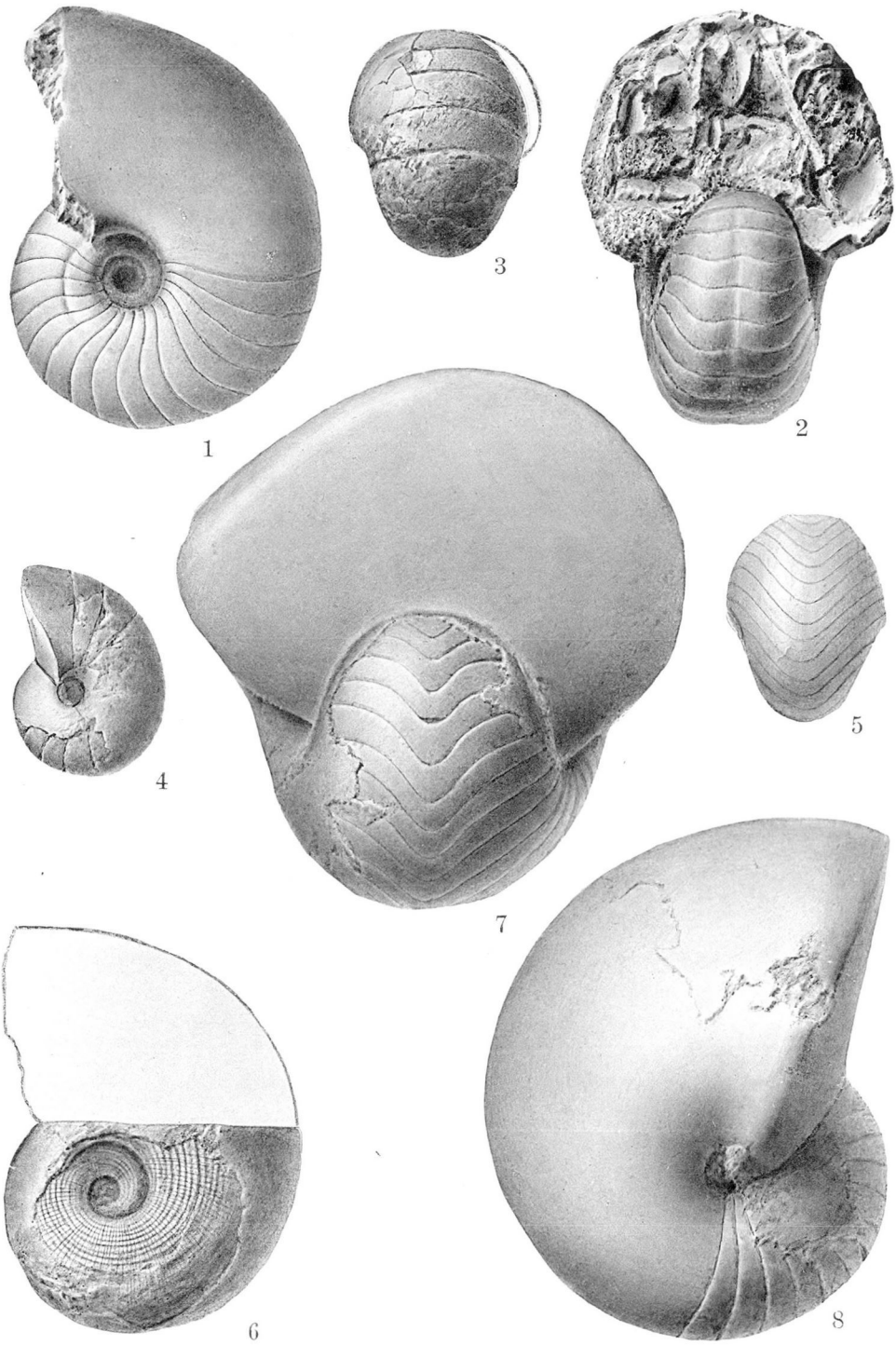
PLATE 52.—*COOPEROCERAS TEXANUM*

Figures | Page

1, 2. *Cooperoceras texanum* Miller 118
Two views of the specimen illustrated on Plate 1 (Frontispiece), from the lower part of the upper Leonard formation near the old Word Ranch house in the Glass Mountain region of Brewster County, Texas, × $\frac{7}{8}$. Collected by J. B. Knight. U. S. N. M. (*See also* Plates 6, 40, 41, 49–51.)



COOPEROCERAS TEXANUM



COELOGASTEROCERAS, LIROCERAS, AND *EPHIPPIOCERAS*

PLATE 53.—*COELOGASTEROCERAS, LIROCERAS,* AND *EPHIPPIOCERAS*

Figures — Page

1, 2. *Coelogasteroceras canaliculatum* (Cox) 124
An essentially complete internal mold from the Lower Pennsylvanian near the Nolin Iron works, Edmonson County, Kentucky, × 1. Y. P. M., 6020.

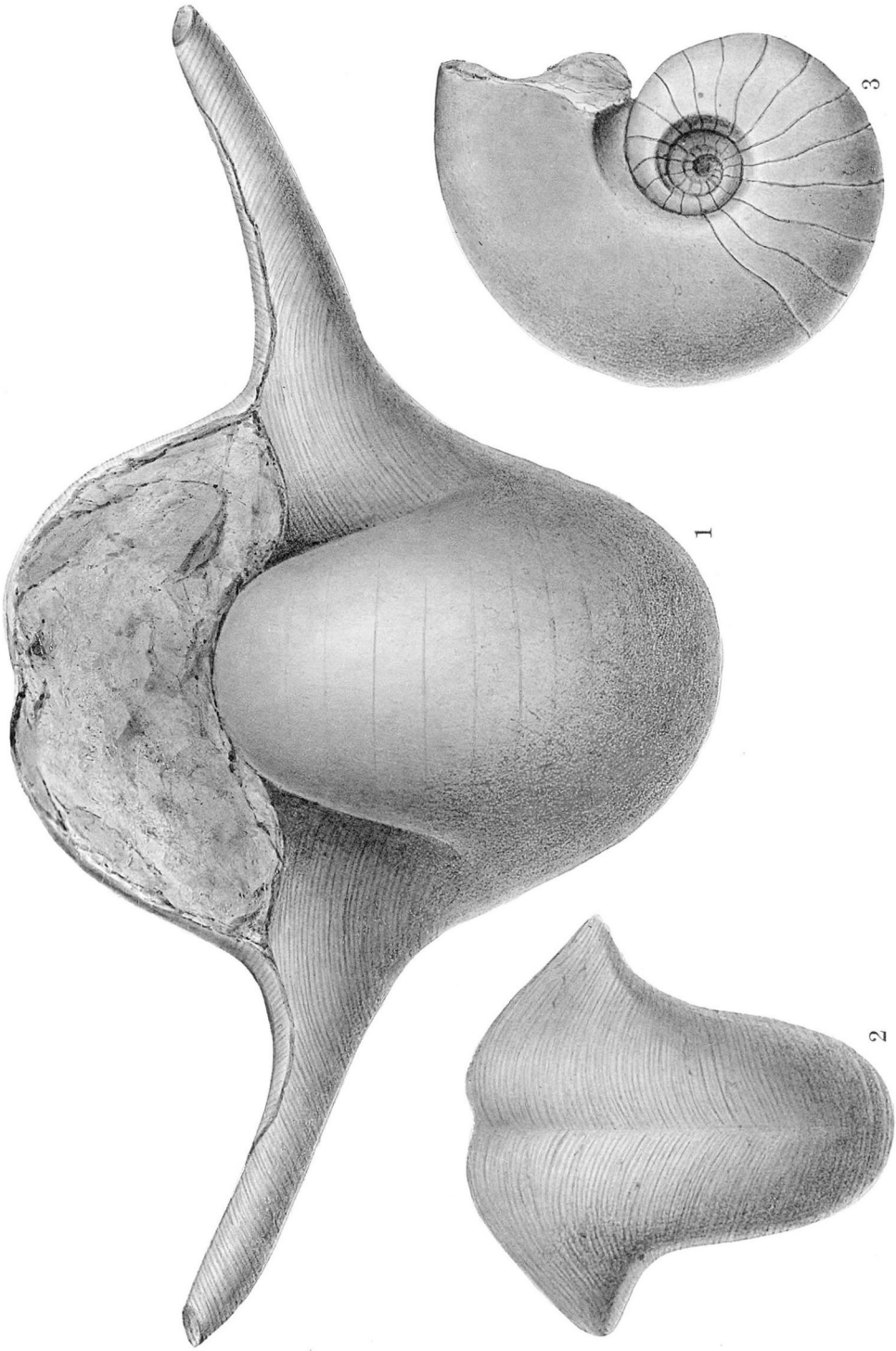
3–6. *Liroceras liratum* (Girty) 120
Mature internal mold (Figs. 3, 4) and testiferous specimen (Fig. 5), × 1; and immature testiferous individual (Fig. 6), × 3; all from the middle shale of the Wewoka formation in sec. 2, T. 6 N., R. 9 E., Wewoka quadrangle, Oklahoma. U. S. N. M. After Girty.

7, 8. *Ephippioceras ferratum* (Cox) 129
An essentially complete internal mold from the Winterset limestone at Kansas City, Missouri, × 1. U. K., 4922.

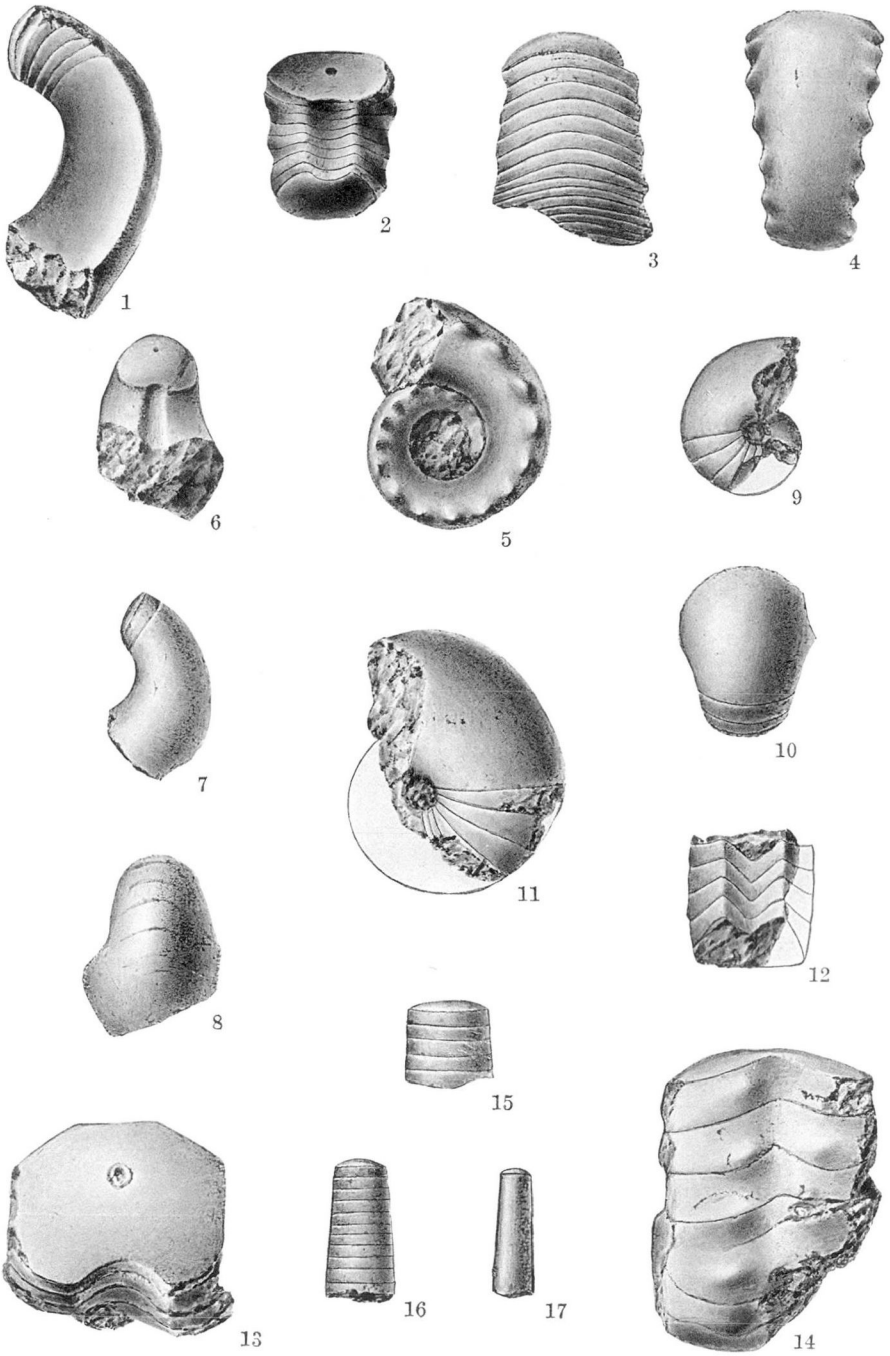
PLATE 54.—*ACANTHONAUTILUS CORNUTUS*

Figures | Page

1–3. *Acanthonautilus cornutus* (Golovkinsky) 120
Two of the syntypes, from the Upper? Permian near the village of Krasnovidof, on the Volga between Bourtas and Antovka, U. S. S. R., presumably × 1. Redrawn from Golovkinsky.



ACANTHONAUTILUS CORNUTUS



KNIGHTOCERAS, TEMNOCHEILUS, LIROCERAS, TAINOCERAS, AND *PSEUDORTHOCERAS*

PLATE 55.—*KNIGHTOCERAS, TEMNOCHEILUS, LIROCERAS, TAINOCERAS,* AND *PSEUDORTHOCERAS*

With one exception (figs. 6–8) all specimens illustrated on this plate are from the Grape Creek limestone of the Clyde formation at the "Old Military Crossing" of the Big Wichita River in Baylor County, Texas. The individual represented by figures 6–8 is from the Elm Creek limestone of the Admiral formation along Godwin Creek near the middle of the eastern boundary of the same county. All illustrations are × 1, and all are redrawn from White, his orientation being retained. The specimens were collected by W. F. Cummins, and presumably they are in the U. S. National Museum.

Figures — Page

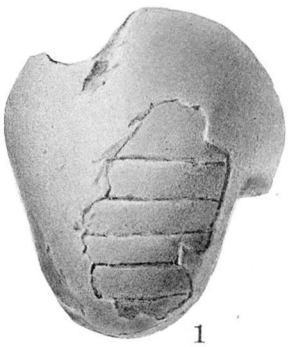
1. *Knightoceras kempae*, n. sp. 38
   Lateral view of a paratype. (*See also* Plates 16, 58.)
2–5. *Temnocheilus* sp. 95
   Three small specimens. Figures 4, 5 represent one individual.
6–11. *Liroceras globulare* (Hyatt) 121
   Three specimens. Figures 6–8 represent one individual; 9, 10 another; and 11 a third. (*See also* Plates 46, 56.)
12–14. *Tainoceras clydense* Miller and Unklesbay 84
   A small fragment of uncertain affinities (Fig. 12) and one of the syntypes (Figs. 13, 14). (*See also* Plate 29.)
15–17. *Pseudorthoceras knoxense* (McChesney) and/or *Mooreoceras* sp. 18, 25
   Three small specimens. (*See also* Plates 2, 3, and/or 4, 6, 35, 47.)

PLATE 56.—*LIROCERAS* AND *COELOGASTEROCERAS*

Figures — Page

1–5. *Liroceras globulare* (Hyatt) 121
Two specimens—Figures 1, 2 represent one individual, 3–5 another—from the Wildcat Creek shale member of the Admiral formation about 4½ miles south-southwest of Coleman, Texas, × 1. Collected by R. C. Moore. U. S. N. M. (*See also* Plates 46, 55.)

6–13. *Coelogasteroceras mexicanum* (Girty) 125
Two views of each of four specimens from the "Minnekahta" limestone in the Shirley Mountains of Wyoming (Figs. 6–11), and the Phosphoria formation west of Lander, Wyoming (Figs. 12, 13), × 1½ (Figs. 6, 7, 10, 11) and × 1 (Figs. 8, 9, 12, 13). S. U. I., 2121 (Figs. 6–11) and U. W. (Figs. 12, 13). (*See also* Plate 11.)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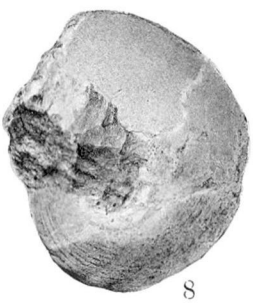
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LIROCERAS AND *COELOGASTEROCERAS*

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COELOGASTEROCERAS AND *STEAROCERAS*

PLATE 57.—*COELOGASTEROCERAS* AND *STEAROCERAS*

Figures — Page

1, 2. *Coelogasteroceras thomasi* Miller and Cline 127
Two views of the holotype, from the Ervay limestone tongue of the Phosphoria formation at the head of Casper Creek in the Rattlesnake Hills of central Wyoming, × 1½. Collected by H. D. Thomas. S. U. I., 701.

3, 4. *Stearoceras sublaeve* (Miller, Dunbar, and Condra) 64
Lateral and ventral views of the holotype, from the Neva limestone about 1¼ miles northeast of Roca, Nebraska, × 1. Y. P. M., 13995.

5, 6. *Coelogasteroceras* sp. 128
Ventral and lateral views of a specimen from the Satanka formation at Gypsum Butte, near Red Mountain in southern Albany County, Wyoming, × 1½. Collected by H. D. Thomas. S. U. I., 714.

PLATE 58.—*KNIGHTOCERAS, DOMATOCERAS, EPHIPPIOCERAS,* AND *STEAROCERAS*

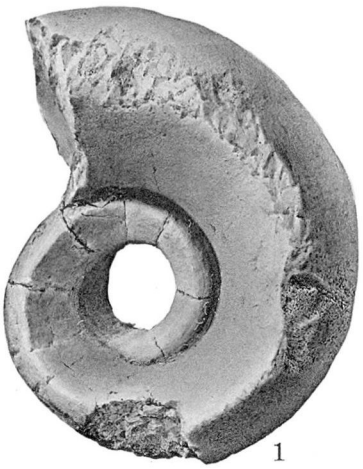
Figures — Page

1, 2. *Knightoceras kempae,* n. sp. 38
Lateral and ventral views of the holotype, from the Grape Creek limestone about 1½ miles north of the England schoolhouse and 10 miles east of Seymour, Texas, × 2. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plates 16, 55.)

3. *Domatoceras* sp. 46
Lateral view of a specimen from the Middle Permian (zone of *Perrinites*) on north side of Quebrada Manaure about 4½ km. east of the village Manaure, Colombia, × 1. Collected by J. Wyatt Durham. U. Cal., 32897.

4–7. *Ephippioceras inexpectans* Miller and Youngquist 129
Two views of the holotype (Figs. 6, 7) and the paratype (Figs. 4, 5), both from the Camp Creek formation 1.2 miles south and 0.6 mile west of the mouth of Saddle Creek in Mc Culloch County, Texas, × 1. Collected by R. C. Moore. U. S. N. M.

8, 9. *Stearoceras* sp. 68
Lateral and ventral views of a specimen from the Elm Creek limestone along Godwin Creek about 17 miles east of Seymour, Texas, × 1. Collected by Augusta Hasslock Kemp. A. H. K. Collection. (*See also* Plates 22, 48.)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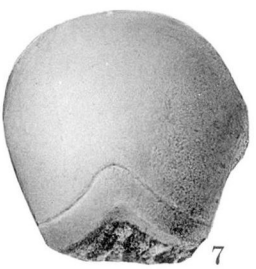
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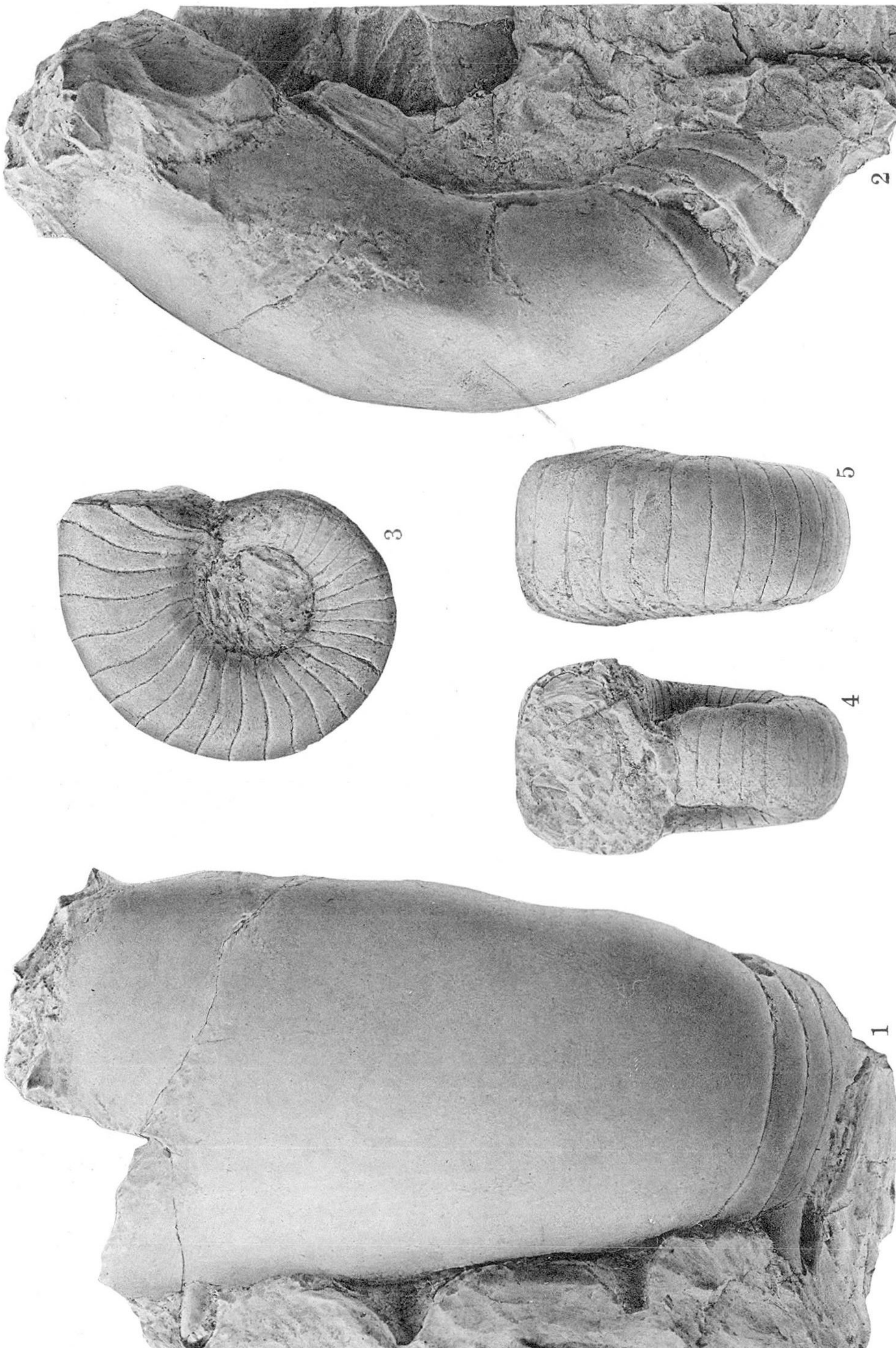
KNIGHTOCERAS, DOMATOCERAS, EPHIPPIOCERAS, AND *STEAROCERAS*



TEMNOCHEILUS AND *STEAROCERAS*

PLATE 59.—*TEMNOCHEILUS* AND *STEAROCERAS*

Figures Page

1, 2. *Temnocheilus* sp. 137
A specimen from the uppermost portion of the α member of the Kaibab limestone on East Pocket Knob (west side of Oak Creek) about 10 miles south of Flagstaff, Arizona, × 1½. Collected by L. F. Brady. M. N. A.

3–5. *Stearoceras* sp. 137
Part of a phragmacone from the San Andres limestone in Last Chance Canyon, some 25 miles southwest of Carlsbad, New Mexico, × 1. Collected by H. M. Goodman. S. U. I., 1052.