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BY

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Reprinted from
JOURNAL OF PALEONTOLOGY
Vol. 37, No. 5, September, 1963

JOURNAL OF PALEONTOLOGY, v. 37, NO. 5, P. 1028–1041, PLS. 133, 134, 3 TEXT-FIGS., SEPTEMBER, 1963

TWO NEW CRINOIDS FROM LOWER MISSISSIPPIAN ROCKS IN SOUTHEASTERN KENTUCKY

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ABSTRACT—Among specimens collected many years ago by the senior author and his students near Mill Springs, Kentucky, are a new species of *Agaricocrinus* and a new species of *Actinocrinites*. Although only one specimen of each is known, it is well preserved. The new *Agaricocrinus* bears a resemblance to *A. ponderosus* Wood, and the new *Actinocrinites* to four species described by Miller & Gurley: *A. spergenensis*, *A. botruosus*, *A. gibsoni*, and *A. sharonensis*. A preliminary survey of species assigned to *Agaricocrinus* suggests that revision of the genus is overdue.

Although the occurrence of the specimens leaves some doubt as to their stratigraphic position, we conclude that they both probably weathered from the Fort Payne formation and rolled down the slope onto the New Providence, where they were found. The sites where the crinoids were picked up are now deeply inundated by water impounded by the Wolf Creek dam on the Cumberland River.

INTRODUCTION

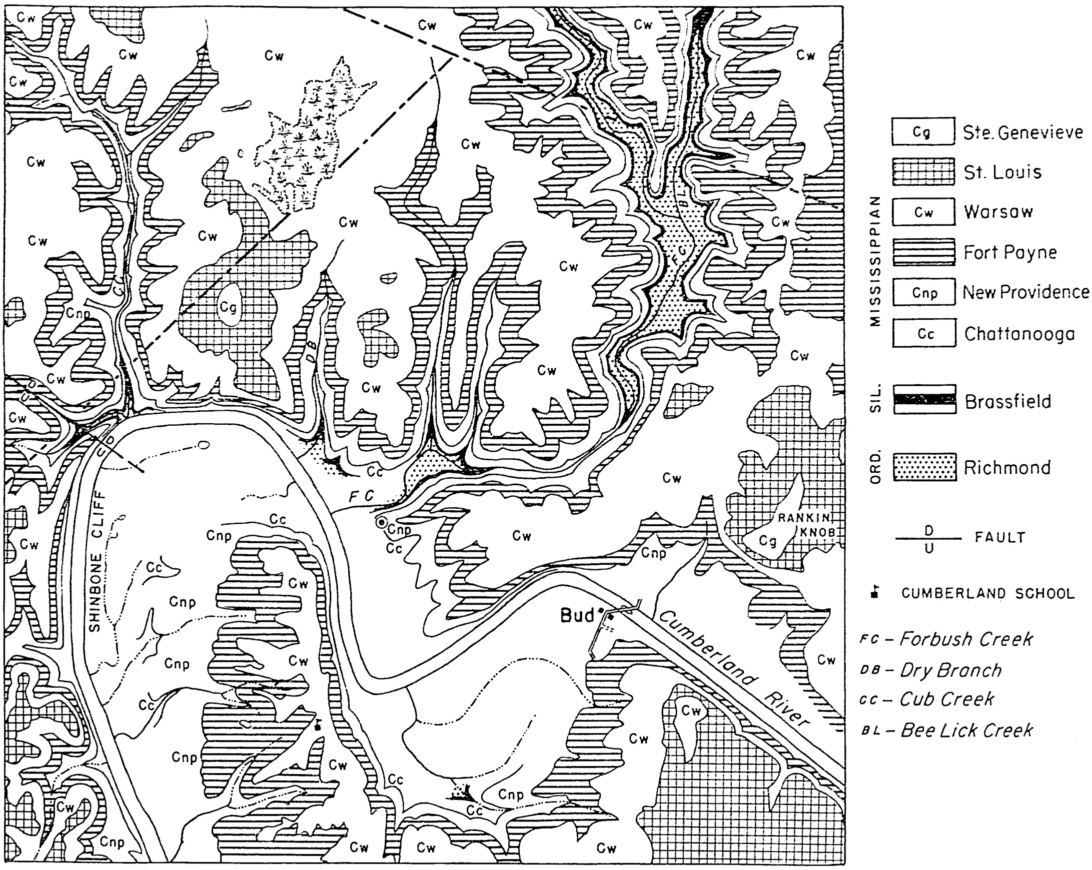
BOTH of the new crinoids described here are from Lower Mississippian rocks in the valley of the Cumberland River in Wayne and Russell Counties, Kentucky. They were among numerous fossils collected by the senior author and his students in the 1920's, when the University of Michigan conducted its summer field course in geology from Mill Springs, Kentucky. We believe these were picked up in 1926.

The sites from which the two crinoids were obtained has since been inundated by Lake Cumberland, created when the water of the Cumberland River was impounded behind Wolf Creek dam. As explained below, there is reason to believe that the specimens weathered from the Fort Payne formation, and rolled down the slope onto the New Providence, where they were found. At present, both the New Providence formation and the basal beds of the Fort Payne are underwater at the type locality of the new *Actinocrinites*. Because parts of the area are no longer accessible for collecting, we feel that the description of the new species should not be delayed any longer, despite the lack of additional material.

OCCURRENCE

To explain the occurrence of the two crinoids, it is necessary to present a brief summary of the stratigraphy along this part of the Cumberland River valley. In 1926, the following formations were exposed in beds of tributary streams, valley walls, and nearby uplands (see text-fig. 1):

	Thickness (feet)
Mississippian system	
Ste. Genevieve limestone—light gray, oolitic and finegrained limestone layers, fossiliferous......	100
St. Louis limestone—bluish to gray, finegrained to lithographic limestone, 20-foot coarsely crystalline layer at top, fossiliferous........	110–120
Warsaw formation—massive, dark gray to bluish-gray, argillaceous to coarsely crystalline limestone; bluish-gray laminated chert layers near base; 20-foot gray, thin bedded Somerset shale unit about 60 feet above base; fossiliferous........	90–120
Fort Payne formation—gray, coarsely crystalline, and argillaceous limestone with numerous chert layers and geodes; 9-foot gray shale bed about 25 feet above the base, fossiliferous...........	100–120
New Providence formation	
Upper member—greenish-gray, soft, laminated calcareous shale, weathering to sticky clay, some fossils........	35–50
Beaver Creek oil "sand" member—rather massively bedded impure limestone, cavernous or porous where yielding oil, fossiliferous with crinoid columnals........	5–10
Lower member—like upper member, fossils scarce; black to dark gray phosphate nodules at base	32–50
Chattanooga shale—black shale weathering to gray........	33–50
Silurian system	
Brassfield limestone—gray to brown, massive dolomitic limestone, arenaceous to sandy, weathers to light reddish-gray, fossiliferous with many fluted cystoid columnals........	8–15
Ordovician system	
Richmond formation—greenish to brownish-gray, interbedded nodular argillaceous limestone and shale layers, bedding thinner and more even in lower half; lower half unfossiliferous, upper half with few fossils........	45–50



TEXT-FIG. *1*—Geologic map of a small area northwest of Mill Springs, Kentucky, measuring four miles on each side. Area includes parts of Pulaski County (northeast corner), Russell County (northwest corner), and Wayne County (southern part). The encircled dot represents the site where the specimen of *Agaricocrinus podagricus*, n. sp., was picked up. The Cumberland River and its tributaries are shown as they were in 1926. At present, Lake Cumberland covers most of the New Providence and all the older formations. Compiled from field map of the senior author, supplemented by structure map of Knapp & Twinem (1933, map 51).

Nearby, the Middle Silurian Crab Orchard formation, interbedded greenish shale and greenish-gray to buff limestone, rests disconformably on the Brassfield.

Incidentally, the stratigraphic assignment of the strata here included in the upper member of the New Providence formation has been questioned. In his unpublished doctor's thesis (1937), Klepser called the lower and Beaver Creek members the "Forbush Creek facies" of the New Providence. This was later endorsed by Stockdale (1939, p. 77). Inasmuch as the strata superjacent to the Beaver Creek member are by lithology, fauna, and age allied to the underlying beds and not to the overlying Fort Payne, we can see no reason to remove them from the New Providence formation. Therefore, our interpretation of stratigraphy follows that of Butts (1922) rather than Klepser (1937) and Stockdale (1939). As for Klepser's statement, quoted by Stockdale (1939, p. 55), that southward from central Kentucky the Chattanooga shale may be as young as St. Louis, we believe that Weller *et al.* (1948, p. 165) properly judged it as "untenable" because of the presence of fossils of "Warsaw, Osagean, and possibly Kinderhookian" age in strata above it.

As could be seen before the damming of the Cumberland River, erosion of the soft lower and upper members of the New Providence formation produced steep exposures below the ledges of the resistant Beaver Creek member and the Fort Payne formation. On many of the small tributaries of the Cumberland River, the soft shales of the New Providence were undercut so that the basal Fort Payne chert beds and the Beaver Creek hard limestone capped waterfalls. Many of these exposures are now below the sur-

TABLE *1*—SELECTED CHARACTERISTICS IN SPECIES OF *Agaricocrinus*

Species	Plates in Dorsal Cup	PostL-PostR Diam. (mm)	$IBrBr_1$	Last Plate Against IBr_1	Number of $IBrBr_2$	L/W *RR*	L/W PBr_2	Tegmen	Age*	Arm Formula‖
podagricus	smooth, slightly convex, no plates granulose	23 1/2	very long, about 2 1/2 x *RR*	TBr_2 or SBr_3 or SBr_2	3, side plates medium	about 3/4	about 3/5	H < 1/2 W, very low	*K*	4-3-2
convexus (Hall) 1860	flat	23	very large, 2 1/2 x *RR*	(SBr_1) or SBr_2	2	1	1/2(?)	¶	B	2-2-2
profundus Miller & Gurley 1895	plates beyond SBr_1 strongly inflated, others smooth	39	large, > 3x *RR*	SBr_1 or (SBr_2)	2	about 1	about 1	H=W	*K*	4-2-2
ponderosus Wood 1909	basal excav. smooth, arm bases and tegmen coarsely granulose	38	medium width, long	SBr_3 or TBr_2	3, side plates large	?	variable	moderate height	*K*	4-3-2
nodosus Meek & Worthen 1860	†	21(?)	2 1/2 x *RR*	SBr_2	2, long, narrow	2/3(?)	< 1	?	B	3-2-2
tuguriinus Miller & Gurley 1897	smooth	46	very large, > 3x *RR*	SBr_1 or SBr_2 (?)	2, very small	1	1/2	H= about 4/5 W, pyramidal	*K*	3-2-2
illinoisensis Miller & Gurley 1896	smooth	19	slightly < *RR*	SBr_2	1 or 2(?)	1 1/2	1/3	very low, H= < 1/2 W	B	2-2-2
attenuatus Wood 1909	?	30	wide as PBr_1, long	PBr_2 or SBr_1	2, small plates	about 1	1/2	H= greatest diam., slender projecting arm bases	*K*	4-3-2
americanus (Roemer) 1852	finely granulose	20(?)	narrow, very long	SBr_1 (?)	2	> 1 on some	2/5	hemispherical	*K*,K, B	3(4)-2-2
montgomeryensis Peck & Keyte 1938	?	27 +	?	?	?	?	?	?	C	2-2-2 (?)
bullatus Hall 1858	smooth	25	2x *BB*, one plate 2x *RR*	SBr_1 or SBr_2	2	2/3 or less	3/5 +	depressed pyramidal	B	2-2-2
crassus Wetherby 1881	smooth, slightly convex	37	about = PBr_2, 1 1/2 x larger than *PostR*	PBr_2 or SBr_1	2	3/4 to 1	1/2	H= 1/2 W, very low	*K*,K	4-2-2
tuberosus (Troost) 1849	convex	29 1/2	narrow, long, about 2 1/2 x *RR*	SBr_1	2, narrow	1/2	1	?	*K*,K	3-2-2
gracilis Meek & Worthen 1861	smooth or finely granulose, suff. convex to bring out suture lines	14	2x *BB*, 3x *RR*	PBr_1	2	1	1/2 or less	high, calyx wider than high	B	3-2-2
planoconvexus Hall 1861	flat, smooth	17 1/2	small, about = *RR*	PBr_2 or SBr_1	2	> 1	1/2	depressed	B,C	2-2-2
blairi Miller 1894	smooth	19	slightly > *RR*	SBr_2	2, fairly long	about 1	< 1/2	very low, H= about 1/3 W	C	2-2-1 (?)
stellatus (Hall) 1858	granulose	13	about same size as *RR*	SBr_1	2, high plates	about 1	1/2 to 3/5	hemispherical	B	2-2-2
bellatremus (Hall) 1861	smooth, shallow	24(?)	1 1/2 x *BB*, 3 to 4x *RR*	SBr_1	2	2/5 to 1/2	3/5	high	B	2-2-2
inflatus (Hall) 1861	smooth	24 1/2	large, 2x *BB* 3x *RR*	SBr_1	2	1/2	1/2 1/3	high as wide	B	2-2-2
arculus Miller & Gurley 1895	smooth, PBr_2 and *SBrBr* slightly convex	26	> 2x *RR*, short	PBr_2 or SBr_1	2	about 1	< 1	H= slightly less than width, subconical	*K*	2-2-2
sampsoni Miller 1894	smooth	14	medium, = *RR*	SBr_1	?	4/5	1/2	"apparently short"	C	2-2-2

face of Lake Cumberland.

At various places along and near the banks of the river, the senior author and his students at the University of Michigan summer camp during the 1920's found crinoid specimens loose on the slopes of the lower member of the New Providence. Among the species were *Alloprosallocrinus conicus* Casseday & Lyon and the two new species described here. *Alloprosallocrinus* has only been found in place in rocks of Keokuk age. In Tennessee and southern Kentucky, *A. conicus* occurs in the Fort Payne cherty limestone. Its presence on the slope of New Providence soft shale strongly suggests that at least some of the crinoids weathered out and rolled down the slope from Fort Payne outcrops. Certainly, this could have been the situation at the Forbush Creek locality (text-fig. 1), near the mouth of Wolf Creek, and other places in the area.

On the other hand, there is no assurance that the new species of *Agaricocrinus* came from the Fort Payne formation. Butts (1922, p. 56) listed "*Agaricocrinus* undes. sp. Burlington type" from the Beaver Creek member of the New Providence in a road exposure 1¾ miles southeast of Parnell, Wayne County (about 9 miles southwest of the site where our specimen of *Agaricocrinus* was picked up). We are unable to understand what Butts meant by "Burlington type" and we cannot locate his specimen or specimens. Butts also reported (1922, p. 52,55) *Agaricocrinus* sp. from the New Providence shale at Kenwood Hill and Buttonmold Knob (5 and 12 miles south of Louisville) and Meshack Creek (about 10 miles east of Tompkinsville). Bassler & Moodey (1943) record no *Agaricocrinus* species

TABLE *1* (*cont'd*)

Species	Plates in Dorsal Cup	PostL-PostR Diam. (mm)	$IBrBr_1$	Last Plate Against IBr_1	Number of $IBrBr_2$	L/W *RR*	L/W PBr_2	Tegmen	Age*	Arm Formula‖
pyramidatus (Hall) 1858	smooth	15 1/2	large, about = *RR*	SBr_1	2	1+	2/3 to 1/2	about 2x as high as wide, pyramidal	B	2-2-2
praecursor Rowley 1902	relatively smooth	17 1/2	large, about 1 1/2 x *RR*	SBr_1	?	about 1	2/5	hemispherical	F	2-2-2
elegans Wetherby 1881	slightly tumid, except *BB* and *RR*	27	> *RR*, (one smaller)	PBr_1 or PBr_2	2	1 or less	4/5(?)	depressed	*K*,K	3(4)-2-2
fiscellus (Hall) 1861	strongly convex	14 1/2	large, about = *RR*	PBr_2	2(?)	almost 1	1/3(?)	very short, depressed hemispherical	B	3-2-2
conicus Wachsmuth & Springer 1897	inflated	(29)	?	PBr_1 or PBr_2	2	?	1/2(?)	rather high H/W = 5/6	K	4(?)-2-2
geometricus (Hall) 1859	granulose	18 1/2	about = *RR*	PBr_1	2	< 1	> 1/2	hemispherical	B	2-2-2 (?)
louisianensis Rowley 1900	‡	13	elongate, about = *RR* (?)	SBr_1 (?)	?	3/4	1/3	H = 2/3 W or less	B	2-2-2
brevis (Hall) 1858	§	16	large, about = *RR*	SBr_1	2	> 1	2/3 or less	calyx wider than high, dorsal cup and tegmen of = height	B	2-2-2
excavatus (Hall) 1861	smooth, PBr_2 inflated	32	short (one long), variable	PBr_2 or SBr_1	2, irregular, one follows other	1	1/2	pyramidal, a little wider than high	B	2-2-2
splendens Miller & Gurley 1890	smooth	22 1/2	= or < *RR*	PBr_2	2	1(?)	< 1 to 1/2	H = 3/5 W, depressed pyramidal	K	3-2-2
coreyi (Lyon & Casseday) 1860	smooth, convex	30	large, about = *RR*	SBr_1 or (PBr_2)	2	3/4	2/5	dorsal cup rather high for genus	*K*,K	2-2-2
whitfieldi Hall 1858	smooth	34 1/2	broad, wider than PBr_1 about = *RR*	PBr_2	2, very high plates	< 1	3/5	depressed hemispherical	*K*,K	2-2-2
wortheni Hall 1858	smooth, knobs on $PBrBr_2$ on one specimen, convex on others	43	small, about = or < *RR*	PBr_1	2, very large	1	1	depressed pyramidal	*K*,K	2-2-2
hodgsoni Miller & Gurley 1896	strongly sculptured	26	circular, 2/3 to 1/2 *RR*	SBr_1	2, very narrow and long	< 1	< 1/2	H = 2/3 W	B	3-2-2
adamsensis Miller & Gurley 1896	*RR* pyramidal, others strongly inflated	21	small, subcircular, 2/3 *RR*	SBr_2	2	< 1	1/2	H = about 2/3 W, low	B	3-2-2
iowensis Miller & Gurley 1897	*SBr* and *TBr* strongly inflated	29	small, about = *RR*	PBr_2	2 or 1	about 1	?	H = slightly > 1/2 W	K	4(3)-3-2
nodulosus Worthen 1889	$SBrBr_2$ and succeeding plates inflated	32 1/2	about = *RR*	SBr_1	2	about 1	2/5 to 1/2	broadly pyramidal	*K*,K	4(3)-4(3)-2
keokukensis Miller & Gurley 1897	*SBr* and *TBr* strongly inflated	33	small, about = *RR*	PBr_2	1 or 2	about 1	< 1/2	H = about 2/3 W, subconical	K	3(4)-4(3)-2

* *K* = Ft. Payne K = Keokuk B = Burlington F = Fern Glen C = Chouteau
† smooth through PBr_1 and inner half IBr_1; PBr_2 very inflated, and outer ends of IBr_1 strongly convex
‡ "All *RR* have strong central ridge-like node and the interradials are almost wart-like."
§ all plates below arm regions thickened, rising above suture lines in nodose or tuberculous extensions, especially IBr_1
¶ dorsal cup depressed saucer-shaped, ventral disc irregular hemispheric, bulging at posterior side
‖ Formula represented by sequence of arms in *L* or *RPost*, *L* or *RAnt*, and *Ant*

from the New Providence, but they list 12 species from the Fort Payne (see tables 1 and 2 herein).

Butts described an occurrence of crinoids very similar to that of ours. On Roaring River, Overton County, Tennessee, he (1922, p. 82) collected, among other crinoids, *Alloprosallocrinus conicus* and *Agaricocrinus americanus* from the "slope on the shale and limestone, of the New Providence." Because he regarded *Alloprosallocrinus conicus* and *Agaricocrinus americanus* as guide fossils of Keokuk strata, Butts concluded that the examples of these species had rolled down the slope from the "heavy basal limestone of the Fort Payne," which at that locality extended to the top of the cliff. As identified by Mr. Frank Springer, however, the crinoid fauna also included *Cattillocrinus tennesseeae* Shumard and *Stemmatocrinus trautscholdi* Wachsmuth & Springer, both of which Springer decided were "distinctly New Providence forms" (Butts, 1922, p. 82).

We do not know the source of the two crinoids described here. Studies by Butts (1922, p. 50) and others indicates that the New Providence formation is older than Keokuk and probably does not contain beds younger than the lower Burlington. The Fort Payne is generally correlated with the Keokuk. Our new species of *Agaricocrinus* is definitely more closely related to Keokuk species than to Burlington. Furthermore, the specimens of *Alloprosallocrinus conicus*, *Agaricocrinus podagricus*, n. sp., and *Actinocrinites tripus*, n. sp., seem to be preserved in the same manner. Hence, although the possibility of their occurrence in the New Providence cannot be ruled out, we are inclined to think that they weathered out of the Fort Payne and rolled down the slope to the places where they were found.

SYSTEMATIC DESCRIPTIONS

Subclass CAMERATA Wachsmuth & Springer 1885

Order MONOBATHRA Moore & Laudon 1943

In describing the two new camerate crinoids, we elect to follow the terminology, suprageneric taxa, and classification used by Moore & Laudon (1943).

Family DESMIDOCRINIDAE Angelin 1878

Genus AGARICOCRINUS Hall 1858

Without reviewing the regrettable handling of the Troost manuscript (Wood, 1909, p. 1–3), we acknowledge James Hall as the legal author of the genus (as did Bassler & Moodey, 1943, p. 284).

The adequately substantiated species of *Agaricocrinus* are compared in tables 1 and 2. The data were compiled mostly from published descriptions and illustrations, supplemented for a few species with observations of specimens in the Museum of Paleontology of the University of Michigan.

For most species we accept the synonymy given by Bassler & Moodey (1943), but we regard *A. geometricus*, described by Hall in 1859 (p. 56), as a distinct species rather than a junior synonym of *A. stellatus* Hall 1858. The tabular comparisons emphasize the strong similarities between certain species. We are convinced that *Agaricocrinus adamsensis* Miller & Gurley 1896b is a junior synonym of *A. hodgsoni* Miller & Gurley 1896a, and that *A. keokukensis* Miller & Gurley 1897 is a junior synonym of *A. nodulosus* Worthen 1889. Other species show close resemblances, presumably because of close relationships.

In table 1, the species are compared with respect to the following: (1) The ornamentation and convexity of the plates in the dorsal cup. In some species, such as *A. stellatus* and *A. geometricus*, the plates are granulose; in others, such as *A. americanus*, they are finely granulose; in *A. hodgsoni* (=*A. adamsensis*) the plates are strongly sculptured, particularly the *RR;* many are smooth; and some have different kinds of ornamentation on the various parts of the cup. Plates of the dorsal cup also vary according to convexity: in some species, all plates are strongly convex; in some, all are slightly convex; in others all are smooth; and in few, typified by *A. iowensis* and *A. nodulosus* (=*A. keokukensis*), the central plates are smooth but the *SBrBr* and *TBrBr* are strongly convex.

(2) The minimum diameter of the calyx measured through the *PostL-PostR* interradii. This measurement is listed only as a general indication of the size of calices that have been described. We do not doubt that for many species, especially those based on one or two specimens, the known calices are immature. Nevertheless, *A. stellatus* seems to be very small and *A. wortheni* very large. During the geologic range of *Agaricocrinus*, species appear to have evolved toward larger size.

(3) The form of $IBrBr_1$. The species are listed in both table 1 and table 2 by decreasing relative length of $IBrBr_1$. For most species, the size of an IBr_1 is compared with that of the average for the *RR*. Thus, the IBr_1 is 3 to 4 times the size of one *R* in *A. bellatremus*, but it is only $\frac{1}{2}$ to $\frac{3}{5}$ times the size of an *R* in *A. hodgsoni.*

(4) The most distal plates of the dorsal cup in contact with $IBrBr_1$. This characteristic expresses the relation of bordering plates to $IBrBr_1$, as well as the length of $IBrBr_1$. The distal plate does not always accord with the relative length of $IBrBr_1$. For example, the $IBrBr_1$ in *A. gracilis* are relatively long but they do not project beyond $PBrBr_1$, whereas the $IBrBr_1$ in *A. hodgsoni* (=*A. adamsensis*) are relatively short but they extend as far as $SBrBr_1$ or $SBrBr_2$.

(5) The number of $IBrBr_2$. Our terminology of plates may at first appear confused, inasmuch as those plates which lie beyond $IBrBr_1$ in *A. ponderosus*, *A. convexus*, *A. podagricus*, and a few other species are definitely on the tegminal side of the calyx. Nevertheless, these plates are homologous with those beyond $IBrBr_1$ in *A. hodgsoni* (=*A. adamsensis*), *A. iowensis*, and other species, which are confined to the dorsal side of the calyx. Hence we feel justified in referring to any plates immediately beyond $IBrBr_1$ as the $IBrBr_2$, regardless of their position on the calyx. Only two species have three $IBrBr_2$ in each interradius: *A. ponderosus* and our new species, *A. podagricus*. In each interradius in most species, the two $IBrBr_2$ are about equal, but in one or more interradii in a few species, the plates do not share the interradius equally, so that one IBr_2 is broad and the other narrow; in extreme instances, one plate displaces the other entirely in the proximal part of their extent.

(6) The length/width ratio of the *RR*. In only one species, *A. illinoisensis*, is the length of each *R* significantly greater than its width. In a few, such as *A. tuberosus*, *A. bellatremus*, and *A. inflatus*, the length of each *R* is only half its width. In the majority of species, the length and width of *RR* are equal. The ratio does not appear to be correlated with any other characteristic of the calyx.

(7) The length/width ratio of the $PBrBr_2$. As with the ratio of length/width of the *RR*, that of the $PBrBr_2$ is independent of other characteristics. The maximum ratio is about 1, in *A. profundus*, *A. tuberosus*, and *A. whitfieldi;* the

TABLE 2—SELECTED RATIOS IN SPECIES OF *Agaricocrinus*

Species	IBr_1 Length	IBr_1 Width	Diagonal $PBrBr_2$	Max. diam. between arm bases	Diam. BB	Average length *LPost* and *RPost*: R	PBr_1	PBr_2	Max. Width XX_1	L/W IBr_1	Length R / Diam. BB	Max. diam. / PB_1Br_2 diagonal	Age*
	Ratio of measurement / *PostL-PostR* diameter												
podagricus	.46	.12	.83	1.53	.21	.12	.10	.14	.40	3.8	0.6	1.84	*K*
convexus	.41	.24	1.07	1.26	.20	.18	.13	.14	?	1.7	0.9	1.18	B
profundus	(.38)	.17	.80	1.21	.12	.14	.08	.18	.37	2.3	1.0	1.51	*K*
ponderosus	(.37)	.14	.89	1.47	?	?	?	.13	?	(2.5)	?	1.65	*K*
nodosus	.36	.20	.95	1.52	.19	.14	.10	.24	(.19)	1.8	0.7	1.60	B
tuguriinus	(.35)	.24	1.07	1.17	.15	.16	.13	.14	.51	1.5	1.1	1.09	*K*
illinoisensis	(.34)	.21	1.97	1.32	.13	.24	.11	.08	.45	1.6	1.8	1.36	B
attenuatus	.34	.18	.13	1.73	.22	.18	.13	.13	.50	1.8	0.8	1.53	*K*
americanus	.33	.20	1.05	1.35	.13	.20	.08	.15	.50	1.4	1.6	1.29	*K*,K,B
montgomeryensis	.33	.17	1.28	1.39	.52	.19	.10	.10	.36	2.0	0.4	1.09	C
bullatus	.32	.18	.90	1.32	.14	.13	.10	.14	.40	1.8	0.9	1.47	B
crassus	(.32)	.16	1.16	1.43	.20	.19	.15	.14	.57	2.1	0.9	1.23	*K*,K
tuberosus	.31	.10	.78	1.53	.25	.07	.05	.15	.36	3.0	0.3	1.96	*K*,K
gracilis	(.29)	.18	1.08	1.21	.11	.21	.18	.07	.46	1.6	2.0	1.11	B
planoconvexus	.29	.17	.94	1.37	.14	.19	.11	.12	.34	1.7	1.4	1.46	B,C
blairi	.29	.16	1.00	1.32	.11	.18	.16	.11	.37	1.8	1.8	1.32	C
stellatus	.27	.19	1.15	1.39	.16	.23	.15	.15	.42	1.4	1.5	1.21	B
bellatremus	.27	.23	1.12	1.29	.19	.25	.13	.10	.46	1.2	1.3	1.15	B
inflatus	.27	.18	.78	1.15	.18	.14	.06	.10	.33	1.5	0.8	1.47	B
arculus	.27	.17	.85	1.08	.12	.13	.12	.15	.37	1.6	1.2	1.27	*K*
sampsoni	.26	.19	1.04	1.61	.28	.19	.11	.11	.43	1.4	0.6	1.55	C
pyramidatus	.26	.19	.92	1.23	.13	.20	.09	.10	.36	1.3	1.5	1.34	B
praecursor	.26	.21	.89	1.20	.23	.14	.06	.09	.46	1.3	1.2	1.35	F
elegans	.26	.15	1.06	1.59	.15	.15	.15	.19	.33	1.8	1.0	1.50	*K*,K
fiscellus	.24	.24	1.20	1.24	.37	.21	.10	.10	.59	1.0	0.5	1.03	B
conicus	(.24)	(.16)	(.92)	(1.28)	?	?	?	(.17)	?	1.6	?	1.39	K
geometricus	.24	.17	1.18	?	.23	.17	.12	.17	.49	1.4	0.8	?	B
louisianensis	.23	.13	.96	1.23	.23	.19	.08	.12	.36	1.8	0.8	1.28	B
brevis	.22	.19	.97	1.19	.13	.25	.10	.12	.44	1.2	2.0	1.23	B
excavatus	.20	.11	.67	1.22	.14	.09	.06	.09	.27	1.9	0.7	1.82	B
splendens	.18	.13	.78	1.22	.18	.11	.09	.10	.38	1.3	0.6	1.57	K
coreyi	.17	.22	.93	1.17	.33	.20	.07	.07	.55	0.7	0.6	1.26	*K*,K
whitfieldi	.16	.10	.67	1.33	.14	.09	.09	.11	.28	1.6	0.6	1.99	*K*,K
wortheni	.14	.10	.91	1.37	.12	.13	.13	.17	.31	1.3	1.1	1.50	*K*,K
hodgsoni	.13	.15	.77	1.12	.25	.13	.06	.08	.40	0.8	0.5	1.46	B
adamsensis	.12	.17	.76	1.14	.29	.14	.05	.09	.43	0.7	0.5	1.50	B
iowensis	.12	.14	.58	1.52	.17	.12	.05	.05	.31	0.9	0.7	2.62	K
nodulosus	.12	.12	.54	1.29	.15	.11	.04	.06	.31	1.0	0.7	2.39	*K*,K
keokukensis	.11	.12	.49	1.30	.14	.09	.06	.03	.29	0.9	0.7	2.65	K

* *K*=Ft. Payne K=Keokuk B=Burlington F=Fern Glen C=Chouteau

minimum is less than $\frac{1}{2}$, in *A. illinoisensis*, *A. americanus*, *A. blairi*, *A. inflatus*, *A. praecursor*, *A. fiscellus*, and others.

(8) The shape of the tegmen. This feature deserves low priority as a specific character, because we have observed that in a particular species the relative height of the tegmen tends to increase with the size of the calyx. Undoubtedly, in our opinion, the ontogenetic differences are as great as some of the differences reported between species. On the other hand, such low tegmens as those described in *A. blairi*, *A. splendens*, and *A. iowensis* probably never attained heights comparable with those reported in *A. pyramidatus* and other species, even in gerontic individuals.

(9) The geologic age. This is entered more or less as recorded in literature. It has not been corrected to accord with recent stratigraphic revisions of Lower Mississippian formations. However, the oldest species are those listed from the Chouteau (C); for the most part, those recorded from Fern Glen (F) and Burlington (B) are intermediate in age; and those from Keokuk (K, and from the Fort Payne, *K*) are the youngest.

(10) The arm formula. In the formula which we have adopted to express the number and distribution of arms, the first figure is the number of arms in the *LPost* or *RPost* ray, the second figure is the number of arms in the *LAnt* or *RAnt* ray, and the third the number in the *Ant* ray. In species in which the number is known to vary between left and right rays or between individuals, the number of arms in the minority of occurrences is added in parentheses. Because the number of arms differs on opposite sides of the same specimen in some species, we do not

follow the practice of Miller & Gurley, who in their several papers created new species to accommodate each discovered anomaly in the number and distribution of arms. Instead, we distinguish three basic types: 2-2-2, 3-2-2, and 4-3-2. The earliest known *Agaricocrinus* species had a 2-2-2 type, with two arms issuing from each ray. Later, some of the crinoids evolved to a 3-2-2 or 4-2-2 when in each of the *LPost* and *RPost* rays one or two plates beyond PBr_2 became axillary. Apparently still later, a few other species came to a 4-3-2, 4-4-2, or 3-3-2 when in each of the *LAnt* and *RAnt* rays the posterior plate or both plates beyond PBr_2 became axillary. In no known species did the *Ant* ray ever possess more than two arms. Although throughout the geologic range of the genus some species retained the primitive 2-2-2 arm pattern, no Chouteau species reached the 3-2-2 stage and only one Burlington species is known to have attained the 4-3-2 stage. The most variable development of arms occurs in the Keokuk species *A. nodulosus* (=*A. keokukensis*).

In table 2, the species are compared by proportions of plates and calyx rather than by absolute size. The standard diameter selected for comparison in the first eight columns of the table is the minimum diameter of the calyx through the *PostL-PostR* interradii. This parameter was found to have the least individual variation within a species, and seems to increase regularly during ontogeny. In table 2, the following ratios are considered: (1) The length of IBr_1/*PostL-PostR* diameter. This is the most significant of all the ratios, we believe, inasmuch as the $IBrBr_1$ vary more from species to species than do the other plates. For example, the $IBrBr_1$ in *A. profundus* are so long that they extend far onto the tegminal side of the calyx, whereas those in *A. hodgsoni* (=*A. adamsensis*) are subcircular, wider than long. The significant relationship emphasized by table 2 is that, although the length of $IBrBr_1$ ranges from .11 to .46, it varies continuously and no demarkation can be drawn between the species with long $IBrBr_1$ and those with short $IBrBr_1$.

(2) The width of IBr_1/*PostL-PostR* diameter. As might be expected, this ratio varies less than the ratio involving the length of IBr_1. This may be readily explained as the natural result of the restriction of the $IBrBr_1$ to the interradii, the spaces not occupied by plates of the rays.

(3) The length/width of IBr_1 (table 2, col. 10). This ratio is nearly proportional to the length of IBr_1, inasmuch as the width of IBr_1 does not vary greatly. Its maximum is 3.8 in *A. podagricus* and its minimum 0.7 in *A. hodgsoni*.

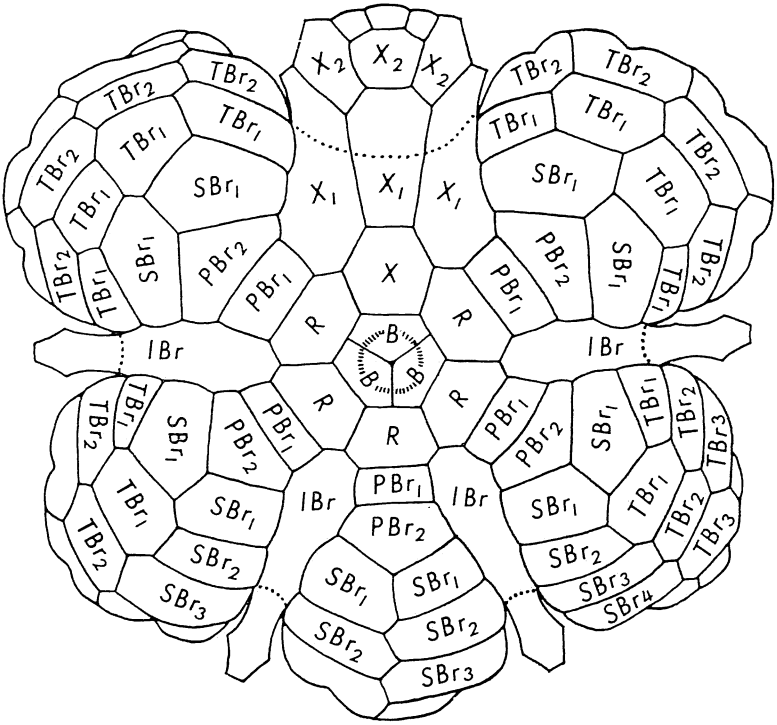
(4) The diagonal between apices of $PBrBr_2$/*PostL-PostR* diameter. The diagonal, measured between distal tips of *LPost* and *RAnt* or between tips of *RPost* and *LAnt* $PBrBr_2$, is shorter than the *PostL-PostR* diameter in some species and longer in others (table 2, col. 3). It is shorter in *A. nodulosus* (=*A. keokukensis*) (ratio about 0.5) and considerably longer in *A. montgomeryensis* (ratio about 1.3). There is no correlation between this ratio and the relative length of IBr_1. Actually, the ratio given in the table compares the relative size of *BB*, *RR*, $PBrBr_1$, and $PBrBr_2$ together to the interradial diameter of the dorsal cup. It shows at a glance how much of the cup lies within the span of the first four plates in each ray.

(5) The maximum diameter between arm bases/*PostL-PostR* diameter. The maximum diameter, measured diagonally from *LPost* to *RAnt* or from *RPost* to *LAnt*, is much longer than the minimum *PostL-PostR* diameter in some species and only slightly longer in others (table 2, col. 4). In *A. attenuatus* the maximum diameter between arm bases is about 1.7 times the interradial diameter, whereas in *A. arculus* it is only about 1.1 times. In *A. attenuatus* the arm bases project far beyond the interradial indentations, so that the cup has the shape of a pentagram, but in *A. arculus* the bases extend only slightly beyond the interradii, so that the cup has the shape of a pentagon. This ratio shows no correlation with any other.

(6) The diameter of the *BB* (measured between opposite corners of the *BB* hexagon) shows considerable variation, but no correlation with other parameters (table 2, col. 5). The smallest *BB* (*A. gracilis* and *A. blairi*) are about 0.1 the *PostL-PostR* diameter, and the largest (*A. montgomeryensis*) are about 0.5. In most species the subjacent columnal of the stem is larger than the *BB*. *A. gracilis* and *A. brevis* have *BB* at the bottom of a columnar cavity. In specimens retaining part of the stem in such species as *A. praecursor*, *A. nodulosus*, and *A. coreyi*, only the edges of the *BB* can be seen projecting beyond the columnal, whereas in *A. illinoisensis*, *A. planoconvexus*, *A. bellatremus*, *A. inflatus*, *A. arculus*, *A. elegans*, *A. conicus*, *A. splendens*, and others, the basals are completely hidden.

Additional ratios listed on table 2 may be used to compare species of *Agaricocrinus*. They appear to have random associations with other ratios and characters.

Although there are obvious misfits, certain evolutionary trends may be suggested. From the earliest known species of the genus, which possessed the simple 2-2-2 arm pattern and $IBrBr_1$ of average length, there developed two distinct specialized groups by Keokuk time. Both groups attained the multiple 4-3-2 arm pattern, but they differed drastically in the



TEXT-FIG. 2—*Agaricocrinus podagricus*, n. sp. Diagram of plates labeled with conventional symbols. Outline of calyx as seen in basal view is indicated by dotted lines in *IBrBr* areas. Based on holotype.

lengths of $IBrBr_1$. In one group, characterized by *A. iowensis*, *A. nodulosus*, and *A. hodgsoni*, the $IBrBr_1$ became short and subcircular; in the other, characterized by *A. ponderosus* and our new species, *A. podagricus*, the $IBrBr_1$ became exceptionally elongate, extending around the sides of the calyx into the tegminal area, accompanied by concomitant displacement of the $IBrBr_2$. Not all *Agaricocrinus* became specialized; certain of the Keokuk species retained the primitive 2-2-2 arm development. Another trend is the increase in size (see table 1). Of the species which attained a *PostL-PostR* interradial diameter in excess of 35 mm. all are Keokuk in age; and of those exceeding 25 mm. in this diameter, one is pre-Burlington, three are Burlington, and 14 are Keokuk. Insofar as we know, only one *Agaricocrinus* species having the combination of long $PBrBr_1$ and 4-3-2 arm pattern has been reported in pre-Keokuk strata; this exception is *A. americanus*, which has been listed from Upper Burlington strata in Missouri as well as from Keokuk beds in Tennessee, Kentucky, Missouri, Iowa, and other states.

AGARICOCRINUS PODAGRICUS, n. sp.
Pl. 133, figs. 1–6; text-fig. 2

Description.—Based on holotype, the only known specimen. Calyx preserved only to arm bases. Calyx relatively low; as viewed posteriorly its width nearly $2\frac{1}{2}$ times its height (pl. 133, fig. 1). Tegmen gently convex and dorsal cup rather strongly concave; hence, central part of calyx thin. As seen in basal view (pl. 133, fig. 5), calyx unequally pentalobate, with left-posterior and right-posterior rays (*LPost* and *RPost*) very large and expanded distally, left-anterior and right-anterior rays (*LAnt* and *RAnt*) medium and very slightly expanded, and anterior ray (*Ant*) small and tapering. Anal area wide, but other interbrachial areas relatively very narrow and U-shaped (pl. 133, figs, 4,5). Each ray of the cup somewhat inflated beyond PBr_1, so that the calyx placed on a level surface rests upon $SBrBr_1$ and $TBrBr_1$. *LPost* and *RPost* free at $TBrBr_2$ and beyond; *LAnt* and *RAnt* free posteriorly at $TBrBr_2$ and anteriorly at $SBrBr_3$ and beyond; and *Ant* free at $SBrBr_2$ or $SBrBr_3$.

BB rather large for the genus, apparently extending beyond the impression of the columnal, together forming a hexagon slightly larger than one of the *RR* (text-fig. 2; pl. 133, fig. 5). *RR* and *X* forming an inverse, truncated, low pyramid, the surface of each plate nearly flat. Anterior *R* (4.0 mm. wide) smaller than other *RR* (each 4.8 mm. wide). Length/width ratio of each

R about $\frac{3}{4}$. Each *R* hexagonal, its two proximal sides more than twice as long as its two distal sides.

X slightly larger than any *R*, a little longer than wide. Each of the three XX_1 large, extending around the edge of the cup onto the tegminal side of the calyx, its greatest width about equal to that of *X* (text-fig. 2). Central X_1 an elongate hexagon with very long proximal sides. Each lateral X_1 tapering distally, bordered by X_2, the central X_1, *X*, *R*, PBr_1, PBr_2, SBr_1, TBr_1, TBr_2, and one or two small tegminal plates, hence having 10 or 11 sides. XX_2 consisting of three plates spread fan-wise around the end of the central X_1 and between the ends of the lateral XX_1; central X_2 shorter than lateral XX_2, surmounted by three small plates (XX_3?) to form a subdued anal bulge (pl. 133, fig. 1).

$PBrBr_1$ quadrangular, only slightly narrower than adjacent *RR*, each with length/width ratio about $\frac{3}{5}$. $PBrBr_2$ pentagonal with short proximal sides, each about as wide or slightly wider than the corresponding *R* and covering an equal area, its length/width ratio about $\frac{1}{2}$. $PBrBr_1$ and $PBrBr_2$ in *LPost* and *RPost* slightly larger than those in *LAnt*, *RAnt*, and *Ant*. Each $PBrBr_2$ axillary.

$SBrBr_1$ relatively large; those in *LPost* and *RPost* and in the posterior halves of *LAnt* and *RAnt* axillary, pentagonal, slightly larger than $PBrBr_2$; those in anterior halves of *LAnt* and *RAnt* and *Ant* subtrapezoidal, about the same size as adjacent $PBrBr_2$. Hence, of the plates distal to $SBrBr_1$, those in *LPost* and *RPost* biserial in both half-rays; those in *LAnt* and *RAnt* biserial in the posterior half-ray and uniserial in the anterior half-ray; and those in *Ant* uniserial in both half-rays (text-fig. 2). In other words, each symmetrical half of the dorsal cup with its three posterior half-rays biserial and its two anterior half-rays uniserial.

In each biserial half-ray, the dichotomy on $SBrBr_1$ asymmetrical, with the *TBrBr* on the outer side of the ray distinctly wider and shorter than those on the inner. *TBrBr* alternating along the midline of the half-ray. Three or four *TBrBr* in each row, graduated in decreasing length distally. $TBrBr_2$ and distal plates extending around free edge of the ray base onto tegminal side of the ray.

In each uniserial half-ray, $SBrBr_1$ succeeded by three or four additional *SBrBr*, graduated in slightly decreasing length distally. In *LAnt* and *RAnt*, the *SBrBr* alternating somewhat irregularly with the *TBrBr* of the posterior half-ray. In *Ant*, the *SBrBr* of the two sides alternating regularly. $SBrBr_3$ or $SBrBr_2$ and distal plates extending around free edge of the ray base onto tegminal side of the ray.

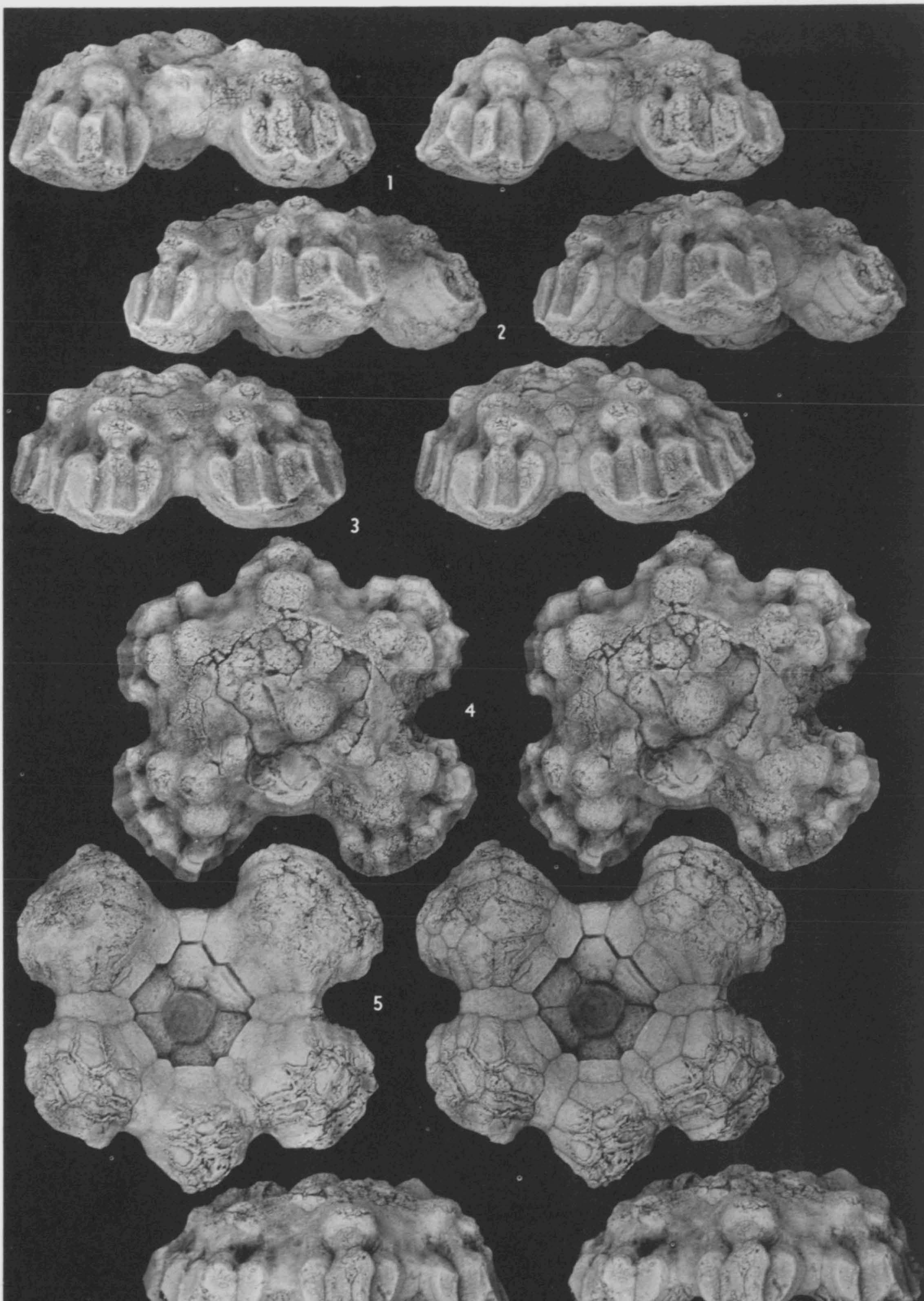
Each IBr_1 exceptionally long and narrow (text-fig. 2), curved around edge of dorsal cup onto tegmen (pl. 133, figs. 3–6). Each IBr_1 proximally acuminate (its end inserted between two *RR*), expanded distally to attain greatest width between $PBrBr_2$, constricted at periphery of the cup, enlarged slightly on tegminal side of calyx, tapered between lateral $IBrBr_2$, and truncated by middle IBr_2. Length/width ratio about 2.6. Greatest width of IBr_1 about $\frac{2}{3}$ that of an adjacent PBr_1. In postero-left and postero-right interrays (*PostL* and *PostR*), IBr_1 bordered by 15 plates: 2 *RR*, 2 $PBrBr_1$, 2 $PBrBr_2$, 2 $SBrBr_1$, 2 $TBrBr_1$, 2 $TBrBr_2$, and 3 $IBrBr_2$, In antero-left and antero-right interrays (*AntL* and *AntR*), IBr_1 bordered by 14 plates: 2 *RR*, 2 $PBrBr_1$, 2 $PBrBr_2$, 2 $SBrBr_1$, 2 $SBrBr_2$, 1 SBr_3 (on posterior side), and 3 $IBrBr_2$. Three $IBrBr_2$ above each IBr_1, about equal in size, each much longer than wide.

Plates of the dorsal cup smooth and well preserved as far out as $PBrBr_2$, corroded in distal parts of rays, with the surface layer gone from some plates (pl. 133, fig. 5). Rough surface of *SBrBr* and *TBrBr* probably the result of corrosion rather than original tuberculate ornament. Specimen mostly silicified; hence, some of the rough surface likely due to differences in preservation. Posterior region smooth.

EXPLANATION OF PLATE 133

All figures $\times 1\frac{3}{4}$

FIGS. *1–6*—*Agaricocrinus podagricus*, n. sp. Stereograms of holotype, UMMP No. 44456, in *Post*, *RPost*, *PostR*, tegminal, basal, and *Ant* views.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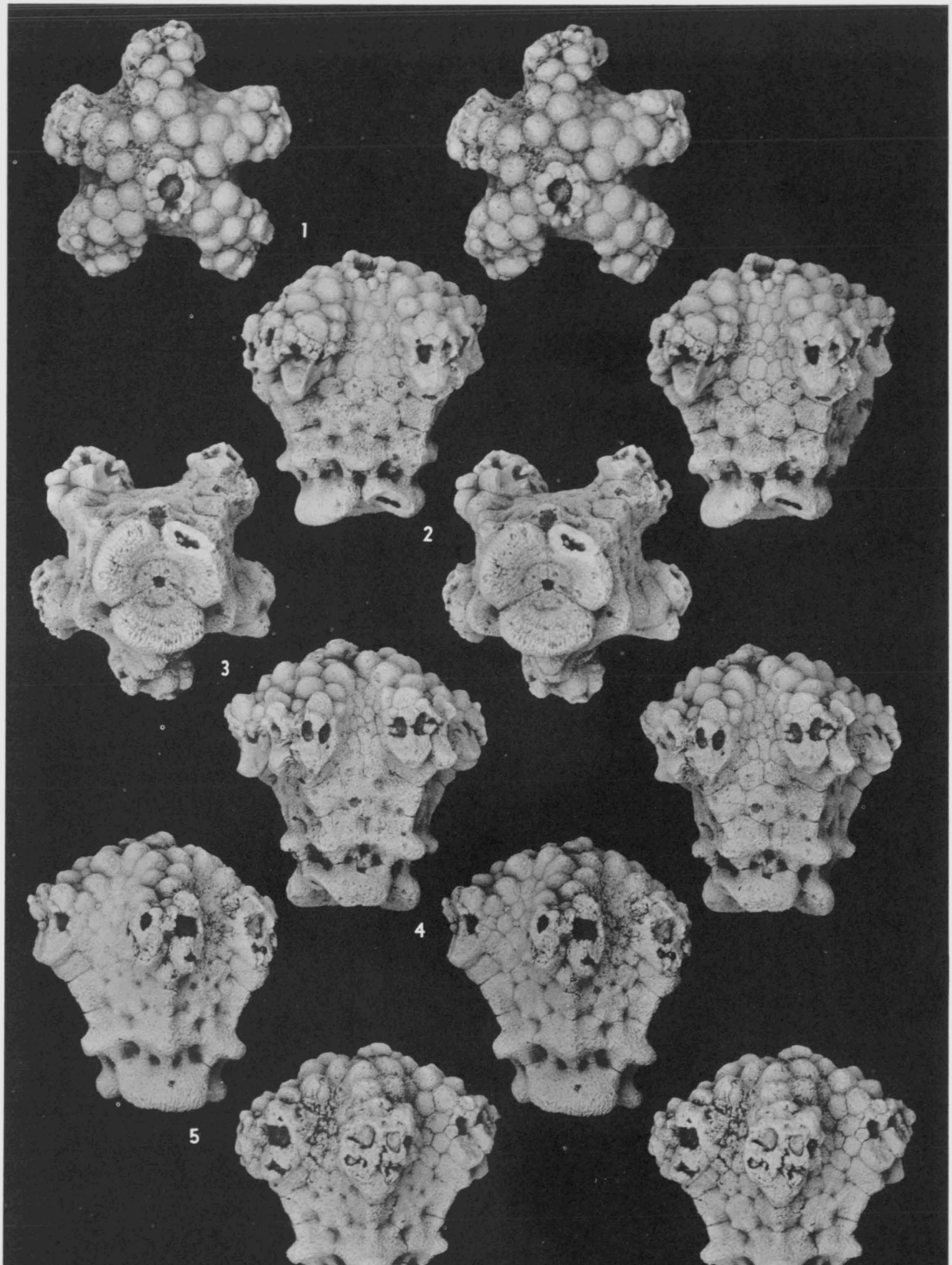
1
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Tegmen low, with 7 nodose plates in the middle, 11 nodose plates near the margin, and relatively smooth plates in the interambulacral areas (pl. 133, fig. 4). Posterior oral bearing the largest node, central, forming the ventral apex, slightly larger than the combined *BB* below. Node on each of the other four orals about half as large, not covering all the surface of the plate, situated above the junctions of *RR* in the dorsal cup. Small node separated from the orals on a so-called "radial dome" plate of each posterior ambulacrum, overlying the R/PBr_1 junction in the cup. Large nodes (nearly as large as that on the posterior oral) on so-called "radial dome" plates near the tegminal margin, placed above the corresponding $SBrBr_1$ of the cup: three in a cluster over *LPost* and *RPost*, two over *LAnt* and *RAnt*, and one over *Ant*. Of the nodes over *LPost* and *RPost*, the two dorsal placed side-by-side with a ridge leading from each to the junction of the two arms in the half-ray, and the third centered ventral and proximal atop them. Of the nodes over *LAnt* and *RAnt*, the dorsal situated above the biserial half-ray with a ridge leading to the junction of the two arms in the half-ray, and the second situated ventral, proximal, and anterior to the first, more or less above the middle of the uniserial half-ray. The single node over *Ant* centered above the ray with a ridge leading dorsally to the junction of the two arms. Surfaces of all nodes rough, like those of *SBrBr* and *TBrBr*, probably not originally tuberculate.

Anal bulge subdued. Area between anus and posterior oral plate crushed, not well preserved.

Entry of each ambulacrum into tegmen expressed as a vertically elongate, deep indentation ventral to the thick arm bases (pl. 133, figs. 1–4,6). Details of arms and stem unknown.

Remarks.—As can be noted in Tables 1 and 2, the new species can be readily distinguished from all other species of *Agaricocrinus* except *A. ponderosus* by its three (instead of two) $IBrBr_2$ in each interray. In addition to the number of $IBrBr_2$, *A. podagricus* and *A. ponderosus* share several other characteristics in common: sixteen arms disposed according to formula 4-3-2, long $IBrBr_1$, rather broad posterior interray, large areas of the rays extending beyond the interrays, smooth basal concavity, nodose oral and "radial dome" plates on the tegmen, interrays extending beyond tips of $PBrBr_2$, and slight convexity of the distal plates (beyond $SBrBr_1$) in the dorsal cup. *A. podagricus* differs from *A. ponderosus*, however, in having narrower $IBrBr_1$, lower tegmen, and more broadly expanded rays. Furthermore, in the distal parts of the rays (beyond the intervening *PostL*), the adjacent edges of *LPost* and *LAnt* form a very small angle in *A. podagricus*, whereas the corresponding edges form nearly a right angle in *A. ponderosus*. (In each species, of course, this angle is duplicated on the opposite side of the calyx, between the edges of *RPost* and *RAnt* where they project beyond *PostR*.) Similarly, beyond the intervening *AntL*, the adjacent edges of *LAnt* and *Ant* form a noticeably smaller angle in *A. podagricus* than in *A. ponderosus* (as do the adjacent edges of *RAnt* and *Ant* beyond *AntR*).

The name of this species is derived from the Greek adjective ποδαγρικος ("gouty"), and refers to the fancied resemblance of the expanded *LPost* and *RPost* (text-fig. 2; pl. 133, fig. 4) to afflicted legs.

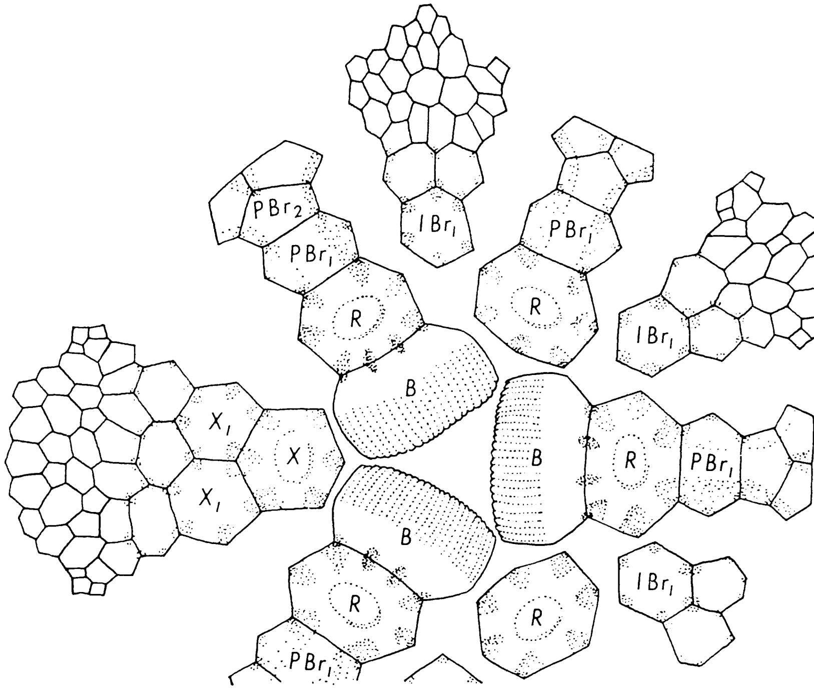
Locality.—Slope exposure about ¼ mile from the mouth of Forbush Creek, in Wayne County, Kentucky (see text-fig. 1), approximately 4¼ miles northwest of Mill Springs and 9½ miles north of Monticello; about 500 feet south of Forbush Creek and 1000 feet east of Cumberland River, at an elevation of about 657 feet MSL (in 1926 about 76 feet above the Cumberland River, now about 66 feet below the surface of Lake Cumberland).

Holotype.—UMMP No. 44456.

Explanation of Plate 134

All figures ×2

Figs. *1–6*—*Actinocrinites tripus*, n. sp. Stereograms of holotype, UMMP No. 44457, in tegminal, *Post*, basal, *PostL*, *Ant*, and *LAnt* views.



TEXT-FIG. 3—*Actinocrinites tripus*, n. sp. Expanded diagram of plates of dorsal cup labeled with conventional symbols. *BB* are shown in lateral view. Boundary of *IBrBr* and *IAmbAmb* areas indistinguishable. Nodose plates of tegmen not shown. Based on holotype.

Family ACTINOCRINITIDAE Bassler 1938
ACTINOCRINITES TRIPUS, n. sp.
Pl. 134, figs. 1–6; text-fig. 3

Description.—As viewed basally, calyx pentalobate with quadrate extensions of the rays and deep *IBrBr* indentations between arm bases; as viewed laterally, truncated obpyramidal except for flaring base, sides relatively flat above *RR* and *X*, tegmen convex and covered with subspherical nodes.

BB equal, by far the largest plates of the calyx, broad, thick, flaring out and down, forming a substantial base on which the calyx rests when placed upright (pl. 134, figs. 4–6). As viewed basally, *BB* forming a subcircular trifoliate ring (pl. 134, fig. 3). As viewed laterally, each *B* subquadrate, except for the somewhat tapering upper (ventral) third, with rounded distal corners (text-fig. 3; pl. 134, fig. 5). Each *B* with striae perpendicular to the distal edge and curving around edge from lateral onto basal side, there becoming radial (pl. 134, figs. 3,5). *BB* located more or less in *RPost, LPost,* and *Ant* positions. *LPost* and *RPost BB* with small, deep, round pits at corner junctions with *LAnt R*, *X*, and *RAnt R;* shallower pits at the *LAnt R-LPost R-B*, *LPost R-X-B*, *RPost R-X-B*, and *RAnt R-RPost R-B* junctions; and small indentations, one on each half of the *LPost R/B* and *RPost R/B* sutures. *Ant B* with small, deep, round pits at corner junctions with *LAnt R* and *RAnt R;* shallower pits at the *LAnt R-Ant R-B* and *RAnt R-Ant R-B* junctions; and two smaller deep pits, one on each half of the *Ant R/B* suture. Impression of column circular, less than half the diameter of the *BB*.

RR equal, each slightly more than half the size of a *B*, distinctly broader than high. Each *R* with a large, laterally expanded, central spine; as seen basally, spines of *RR* projecting beyond edges of *BB* (pl. 134, fig. 3). *LPost* and *RPost RR* each hexagonal, bounded by *B* below, *X* and *R* at the sides, PBr_1 above, and by IBr_1 and X_1 at the upper corners; each with fairly strong ridges sloping from the large spine to the centers of the sutures with *B*, *R*, *X*, and PBr_1, lower ridges to the centers of the sutures with X_1 and IBr_1, and two small, narrow ridges slanting down to the suture with *B*, one near each corner (along the sides of the shallow pits at the *R-R-B* and *R-X-B* junctions); hence, each *R* ornamented by eight ridges radiating from the very prominent central spine, with the vertical and horizontal ridges larger than the others. *Ant R* also hexagonal, bounded by *B* below, two *RR* at the sides, PBr_1 above, and two IBr_1 at the upper corners; radiating ridges similar in size and arrangement to those in *LPost* and *RPost RR* (pl. 134, fig. 5). *LAnt* and *RAnt RR* each septagonal, bounded by two *BB* below, two *RR* at the sides, PBr_1 above, and two $IBrBr_1$ at the upper corners; each *R* with seven ridges sloping out from the central spine, those to the centers of the sutures with the two *BB*, two adjacent *RR*, and PBr_1 larger and more clearly defined than those to the sutures with the two $IBrBr_1$ (pl. 134, fig. 6); the two ridges to the *BB* set astride the circular pit at the *B-R-B* junction.

$PBrBr_1$ equal, each slightly more than half the size of the adjacent *R*, its width more than $1\frac{1}{2}$ times its height. Each PBr_1 bearing a strong vertical ridge continuous with ridges on the *R* below and PBr_2 above. Subtriangular pits at each corner, producing a subordinate radial ornamentation of low ridges. *LPost* and *RPost* $PBrBr_1$ bounded by *R* below, X_1, X_2, IBr_1, and IBr_2 at the sides, and PBr_2 above; other $PBrBr_1$ each bounded by *R*, two $IBrBr_1$, two $IBrBr_2$, and PBr_2.

$PBrBr_2$ nearly equal but more variable than $PBrBr_1$, each about $\frac{3}{4}$ the size of the adjacent PBr_1, distinctly wider than high. Each PBr_2 pentagonal, axillary, bearing a Y-shaped ridge with branches to the centers of the sutures with PBr_1 and the two $SBrBr_1$, the sides of the PBr_2 sloping rather steeply away from the ridge to give the plate a modified-wedge shape. *LPost* and *RPost* $PBrBr_2$ each bounded laterally by X_2 and IBr_2, other $PBrBr_2$ each bounded laterally by two $IBrBr_2$.

$SBrBr_1$ varying in size, each approximately $\frac{2}{3}$ the size of the PBr_2 on which it rests, pentagonal, wider than high. Each SBr_1 with a central ridge from which the sides slope steeply away, making the plate wedge-shaped. Each SBr_1 adjacent to the SBr_1 in the other half of the ray, with the sloping inner sides of the two $SBrBr_1$ forming a *V*-shaped trough along the middle of the ray.

X a little smaller than one of the *RR*, hexagonal, bounded by two *BB* below, two *RR* at the sides, and two XX_1 above. Plate ornamented with a large, laterally expanded, central spine, much like those on the *RR*, from which prominent ridges slope to the centers of the sutures with each of the bordering plates. Each corner of *X* depressed: at the lower (dorsal) corner, a small, deep, circular pit at the *B-X-B* junction; at each lower lateral corner, a shallower, subtriangular pit at the *B-X-R* junction; and at each of the three upper (ventral) corners, a slightly larger, shallow, subtriangular pit or depression at the X_1-*X*-X_1 and the two PBr_1-*X*-X_1 junctions (pl. 134, fig. 2). As viewed basally, *X* and the five *RR* outlining a hexagon by their lateral ridges, with the central spines forming protuberant, rounded apices (pl. 135, fig. 3).

XX_1 two equal plates, each hexagonal, about $\frac{2}{3}$ as large as *X*. Each X_1 with a shallow, subtriangular depression or pit at each corner, giving it a stellate pattern of ridges; ridges confined to the marginal area, proximally confluent with central flat area of the plate, distally aligned with ridges of adjacent plates. Each X_1 bounded by the other X_1, *X*, *R*, PBr_1, and two XX_2 (text-fig. 3; pl. 134, fig. 2).

XX_2 three subequal plates, hexagonal or septagonal. Shallow, subtriangular depressions at the lower corners and very shallow, less distinct depressions at the upper corners producing a fluted or scalloped appearance around the margin of each X_2. XX_3 and succeeding rows of plates in the anal series more numerous and irregular in size and shape. No expressed boundary between plates of the dorsal cup and those of the tegmen in the *Post* interradius (pl. 134, fig. 2).

$IBrBr_1$ nearly equal, one in each interradius except *Post*, each hexagonal, approximately equilateral, about half the size of an *R* and about $\frac{2}{3}$ the size of a PBr_1. Each IBr_1 with a shallow, subtriangular depression or pit at each corner, giving it a stellate appearance, much like that in the XX_1. IBr_1 bounded by two *RR* below, two $PBrBr_1$ at the sides, and two $IBrBr_2$ above (pl. 134, figs. 4–6).

$IBrBr_2$ subequal, two in each interradius except *Post*, each hexagonal or septagonal, about the same size as an X_2. Shallow, subtriangular depressions at the lower corners. About four $IBrBr_3$ in each interradius, irregular. Succeeding *IBrBr* plates small and irregular. No expressed boundary between dorsal cup and tegmen in any interradius (pl. 134, figs. 4–6).

Tegmen convex as viewed laterally (pl. 134, figs. 2,4–6). *IAmbAmb* deep troughs floored with small, irregular, smooth plates. Anal extension round, offset toward *Post*, about seven plates in the circlet at the base; base about as wide as *X*; length of extension unknown (pl. 134, fig. 1). *AmbAmb* areas overlain by plates with large, contiguous or nearly contiguous, finely papillose, subspherical nodes arranged in five radiating bands, one in each *Amb*, each band two to three nodes in width.

Arms unknown. Insofar as can be judged from the axillary $SBrBr_1$, each ray with four arms. Surfaces for attachment of arms vertically elongate, narrow, nearly vertical on the ends of the rays. No *ISBrBr* plates; hence the four arms of each ray set side-by-side.

In addition to striae on *BB* and papillae on tegminal nodes, plates of the calyx ornamented with very fine, rather indistinct, raised elements somewhat irregularly disposed, some apparently discrete and others in short anastomosing or vermiform crests. Ornamentation may be in part obscured by weathering.

Dimensions of holotype: height of calyx, $21\frac{1}{2}$ mm.; *PostL-PostR* interradial width, $12\frac{1}{2}$ mm.; maximum diameter of *BB* circlet, 10 mm.

Remarks.—Actinocrinites tripus, n. sp., differs from many species of its genus in having large, flaring basals, much like those found in species of *Dorycrinus*. There is no need for further comparison with those species of *Actinocrinites* in which the *BB* are small or crossed by ridges.

Four species described by Miller & Gurley have certain characteristics like those in the new species, and are presumed to be closely related to it. The first, which bears perhaps the closest resemblance, was described and figured in 1896 (p. 29–30, pl. 2, figs. 4–7) as *Steganocrinus spergenensis*. Bassler & Moodey (1943, p. 274) correctly transferred it to *Actinocrinites* and gave the occurrence as "probably Burlington ls." *A. spergenensis* (M. & G.) agrees very well with *A. tripus* in the following characteristics: large, flaring *BB;* large, laterally expanded, central spines and radiating ridges on *RR* and *X; X* somewhat smaller than an *R;* sides of cup relatively flat; at the level of the arms, the *IBrBr* and *IAmbAmb* areas deep and troughlike; and the nodose plates of the tegmen restricted more or less to areas overlying the *AmbAmb*. Furthermore, Miller & Gurley described the plates of the cup (p. 29) as "sculptured so as to depress the angles of the plates," although they failed to show such features in their figures; we suppose they were describing pits or depressions at the plate corners, such as those reported above in the *BB*, *RR*, *X*, $PBrBr_1$, XX_1, $IBrBr_1$, and other plates of *A. tripus*. Despite these numerous similarities, *A. spergenensis* differs from *A. tripus* and can be readily distinguished by the following: as seen basally, the *BB* circlet is only slightly more than half the diameter of the *RR* circlet; central nodes and radiating ridges are present on $PBrBr_1$*;* small central spines are indicated on XX_1, XX_2, and *IBrBr* plates; the nodose plates of the tegmen are more irregular in size, lower, and less subspherical than those in *A. tripus;* and the impression of the column is relatively much larger as compared to the diameter of the *BB*. In particular, we regard the presence of central spines on $PBrBr_1$ in *A. spergenensis* and their absence in *A. tripus* as significant and specific differences.

The second species was named *Steganocrinus sharonensis* by Miller & Gurley (1897, p. 32–33, pl. 2, figs. 10–12) and placed in *Actinocrinites* by Bassler & Moodey (1943, p. 274). It is based on a crinoid found in the Burlington limestone near Sharon, in southwestern Missouri. It resembles *A. tripus* in the shape and relative size of *BB* and *RR*, the flat sides of the cup, presence of nodes on *RR* and *X* and ridges on $PBrBr_1$ and $PBrBr_2$, the shape of the tegmen in lateral view, and the presence of large nodes in the tegmen. *A. sharonensis* can be easily separated from *A. tripus;* it has *BB* nearly vertical instead of flaring, at the level of the arms the *IBrBr* areas are only shallowly indented, the plates in the lower (dorsal) part of the cup lack pits or indentations at the corners, and the tegmen is all covered with nodose plates with no distinct *IAmbAmb* areas having small, smooth plates. The differences between the *BB* and *IBrBr* areas of the two species are best seen in basal view.

The third species bearing certain resemblances to *A. tripus* was named *Actinocrinus botruosus* by Miller & Gurley (1895, p. 22–24, pl. 2, figs. 1,2), who reported it from the Keokuk formation in Tennessee. It is like *A. tripus* in having large flaring *BB*, central spines and radiating ridges on *RR* and *X*, and nodose plates in the tegmen. In fact, the dorsal cup of *A. botruosus* as high as the *RR* and *X* can scarcely be distinguished from that of *A. tripus*. Above this level, however, the resemblance sharply decreases. *A. botruosus* has central spines and radiating ridges on $PBrBr_1$, $PBrBr_2$, XX_1, XX_2, $IBrBr_1$, $IBrBr_2$, and higher anal and *IBrBr* plates. In addition, the arm bases of *A. botruosus* are not widely separated, and its *IAmbAmb* areas contain very few if any small, flat plates.

The fourth species was named *Actinocrinus gibsoni* (Miller & Gurley, 1893, p. 10–11, pl. 2, fig. 1). It is from Keokuk strata (probably Edwardsville formation) on Indian Creek, near Crawfordsville, Indiana. The holotype and only known specimen does not have the *Post* region exposed and its tegmen is covered by the arms. It resembles *A. tripus* in the shape of the *BB* and the spines and ridges on the *RR*. Like *A. botruosus*, it differs from our species in having central spines and radiating ridges on $PBrBr_1$, $PBrBr_2$, $IBrBr_1$, $IBrBr_2$, and other plates of the cup. *A. gibsoni* and *A. botruosus* are very similar; the only difference seems to be that the ornamentation of the latter is more strongly developed, particularly on the *PBrBr* and *IBrBr* plates.

Inasmuch as the species described by Miller & Gurley are not well represented, it is impossible to judge whether the specimens are mature. Nevertheless, *A. spergenensis* is considerably larger than *A. tripus*, with a height of $30\frac{1}{2}$ mm., *PostL-PostR* interradial width of $20\frac{1}{2}$ mm., and *BB* diameter of $13\frac{1}{2}$ mm. *A. sharonensis* is appreciably smaller, with height of 15 mm. and *BB* diameter of 6½ mm. *A. botruosus* is much larger than *A. tripus*, with height of 36 mm. and *BB* diameter of 13 mm. *A. gibsoni* is also very large, with *BB* diameter of 19½ mm. We do not believe the differences noted above are ontogenetic, especially since shallow *IBrBr* indentations and nodose *IAmbAmb* tegminal plates are known both in smaller (*A. sharonensis*) and larger (*A. botruosus*) species but not in *A. tripus*.

Actinocrinites scitulus (Meek & Worthen) also has large *BB* and spines on *RR* and *X*. As clearly shown by Wachsmuth & Springer (1897, pl. 55, figs. 5,6a–b), however, its XX_1 and $IBrBr_1$ bear central spines and its tegminal plates are convex but not subspherical.

The name of our species is derived from the Greek work τριπους ("three-footed, as an urn") and refers to the flaring *BB*, which are exceptionally well developed.

Locality.—Exposure on the bank of the Cumberland River near the mouth of Wolf Creek, in Russell County, Kentucky, about 4½ miles southeast of Jamestown and 14 miles east of north-northwest of Monticello; about 250 to 500 feet southeast of Wolf Creek and 50 to 75 feet from the Cumberland River (at Wolf Creek Shoals) at an elevation of about 578 feet MSL (in 1926 about 18 feet above the river, now about 145 feet below the surface of Lake Cumberland).

Holotype.—UMMP No. 44457.

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Manuscript received April 23, 1962