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TRANSACTIONS OF THE SOCIETY.

VIII.—*Additions to the Knowledge of the Carboniferous Foraminifera.*

By the Rev. WALTER HOWCHIN, F.G.S.

(*Read* 13*th June*, 1888.)

PLATES VIII. AND IX.

RESEARCHES in relation to the Carboniferous Foraminifera of the North of England were begun by the author in 1873, and some of the earlier

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EXPLANATION OF PLATES.

PLATE VIII.

Figs. 1, 2.—*Hyperammina elongata*, var. *clavatula*, nov. .. .. × 60 diam.
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„ 4.—*Placopsilina cenomana*, d'Orbigny .. .. × 35 diam.
„ 5.—*Lituola rotundata*, sp. nov. .. .. × 50 diam.
„ 6.— ——— ———, transverse section .. .. .. × 50 diam.
„ 7.—*Lituola Bennieana*, Brady .. .. × 55 diam.
Vertical section showing the coarse perforation of the test.
„ 8, 9.—*Webbina fimbriata*, sp. nov... .. .. ×100 diam.
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PLATE IX.

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Lateral aspect of a tall specimen.
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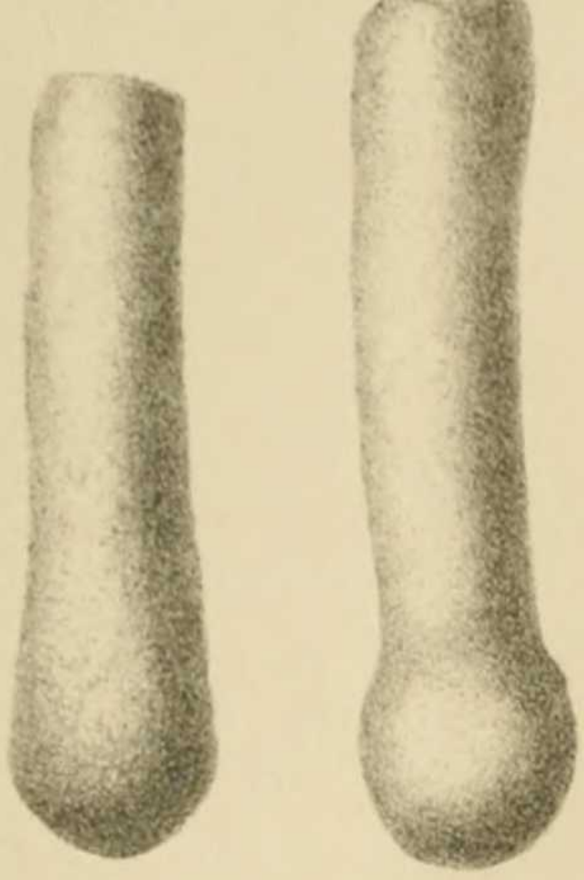
b, inferior face of another shell .. .. × 65 diam.
„ 24.— ——— ———, transverse section .. .. .. × 55 diam.
„ 25.— ——— ———, longitudinal section .. .. .. × 55 diam.



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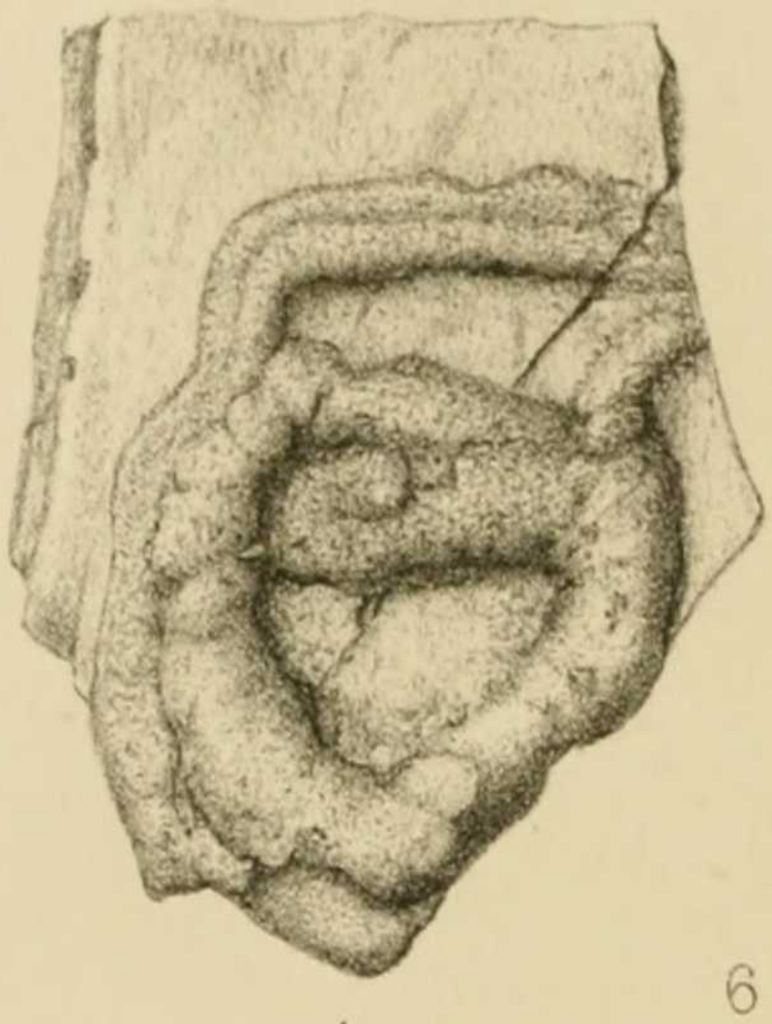

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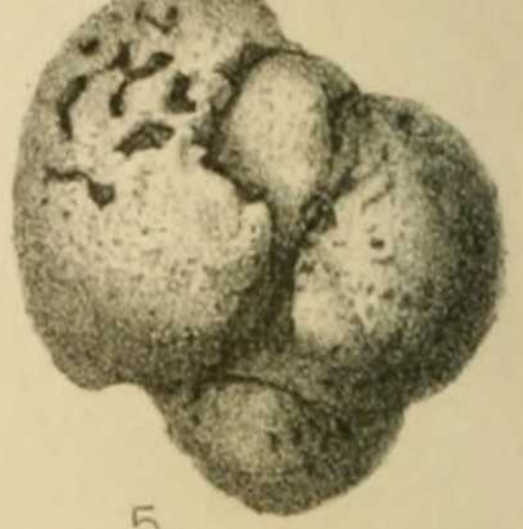

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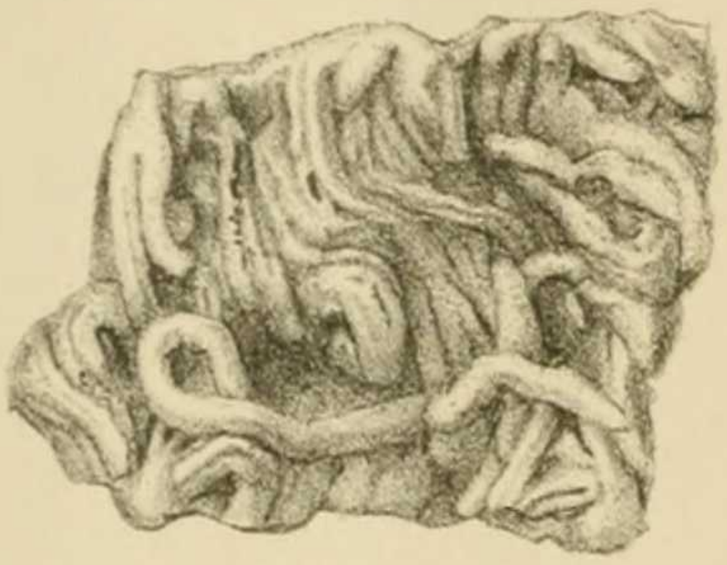

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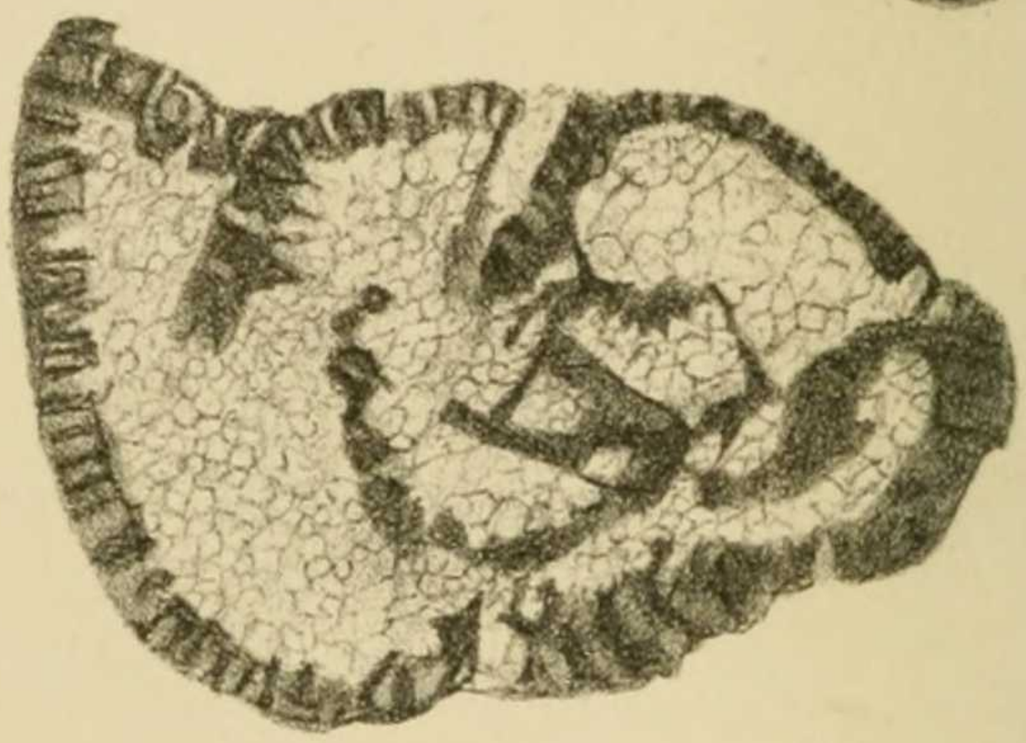

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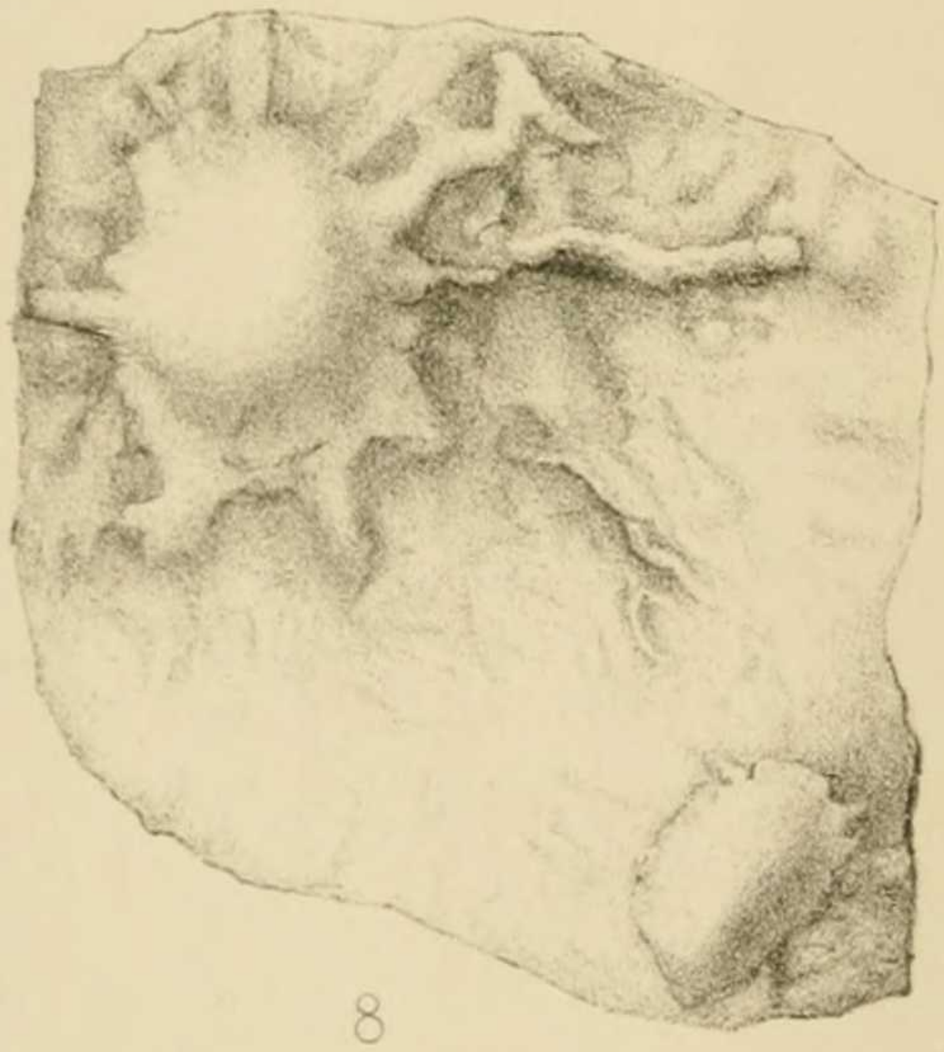

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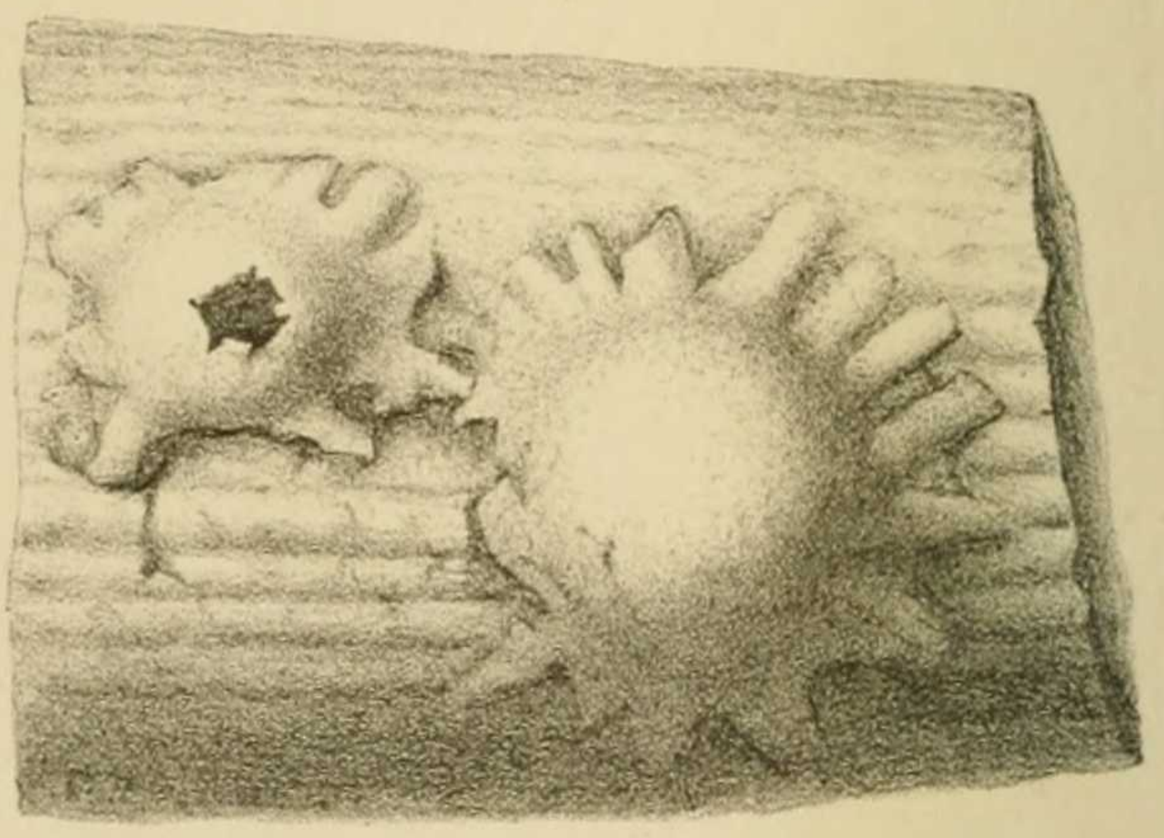

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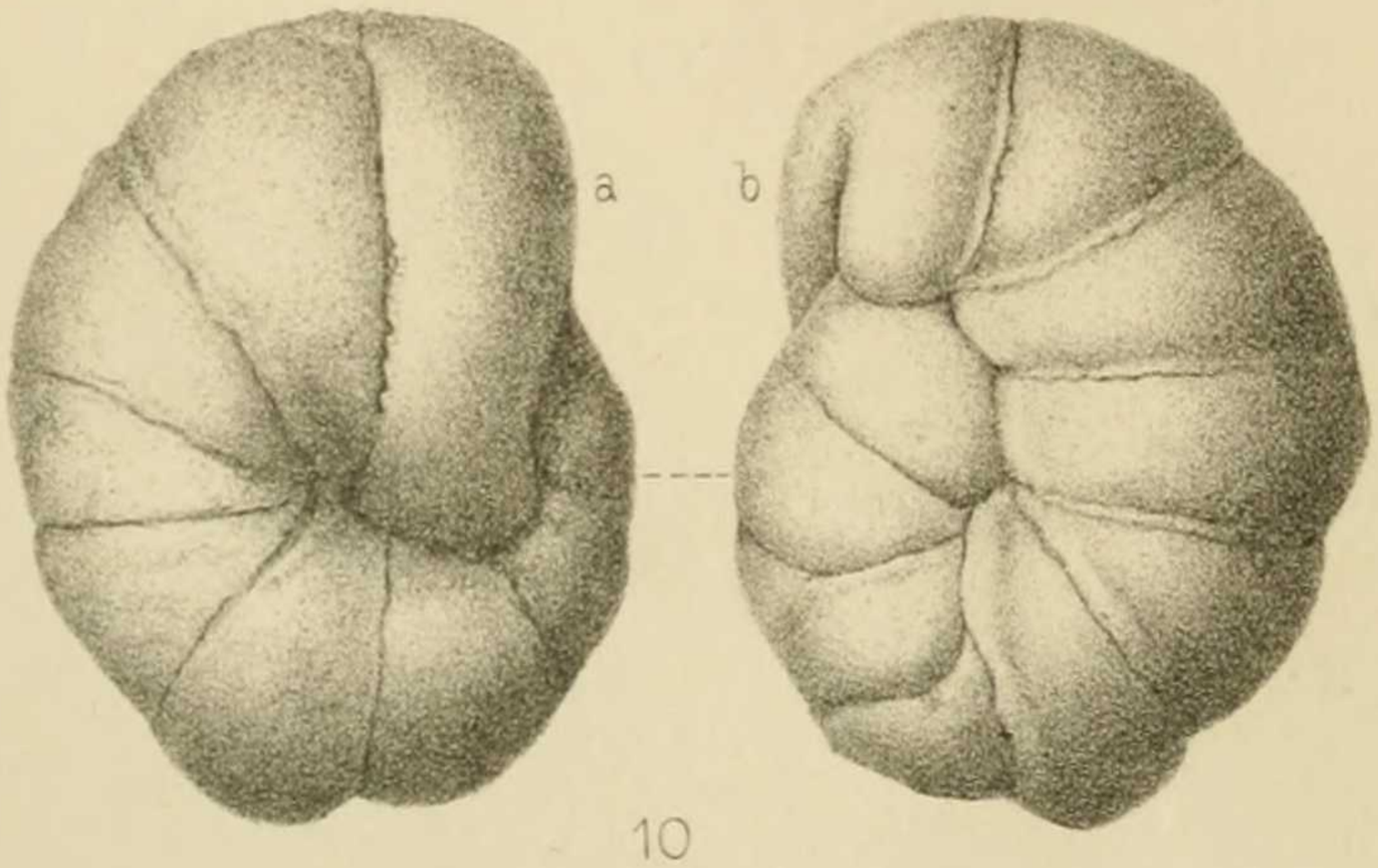

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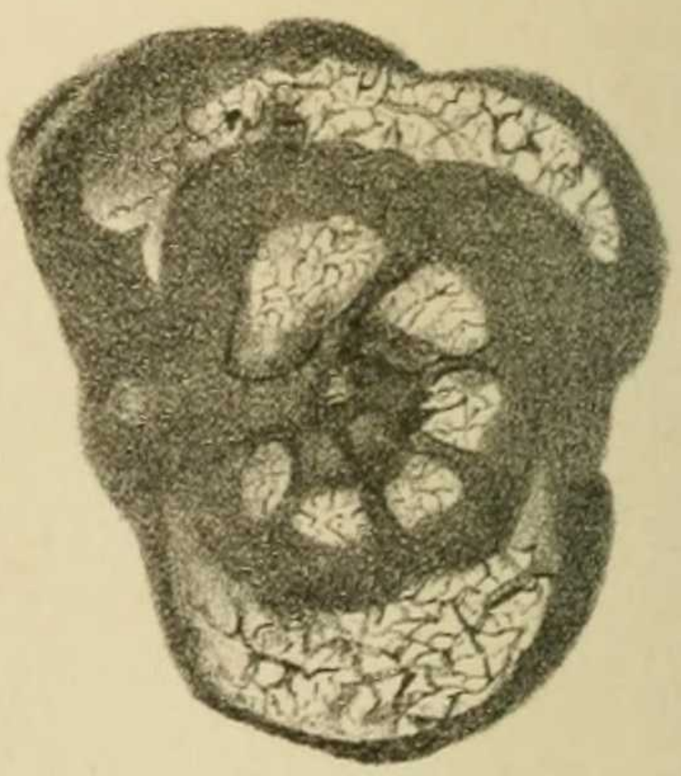

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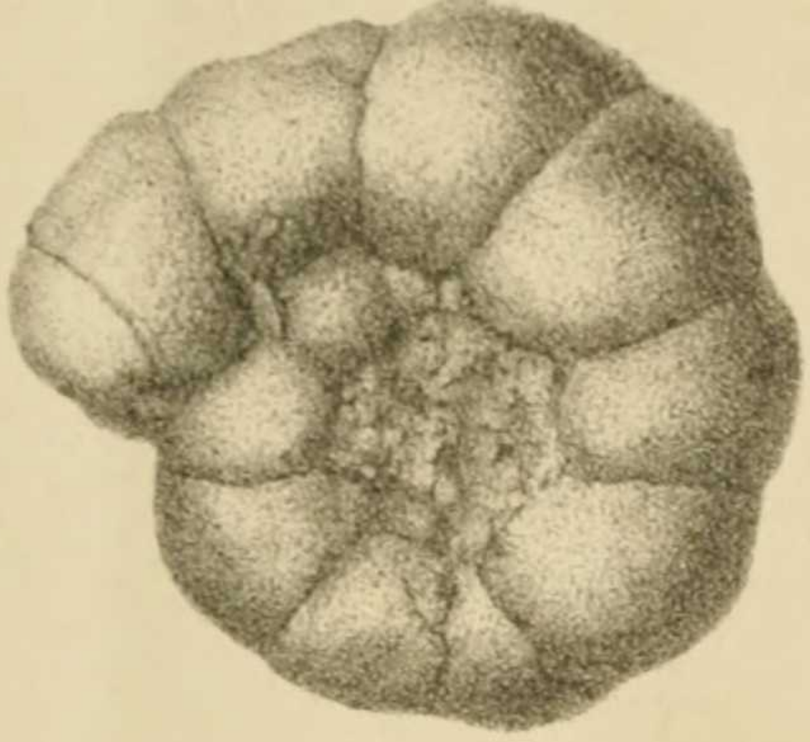

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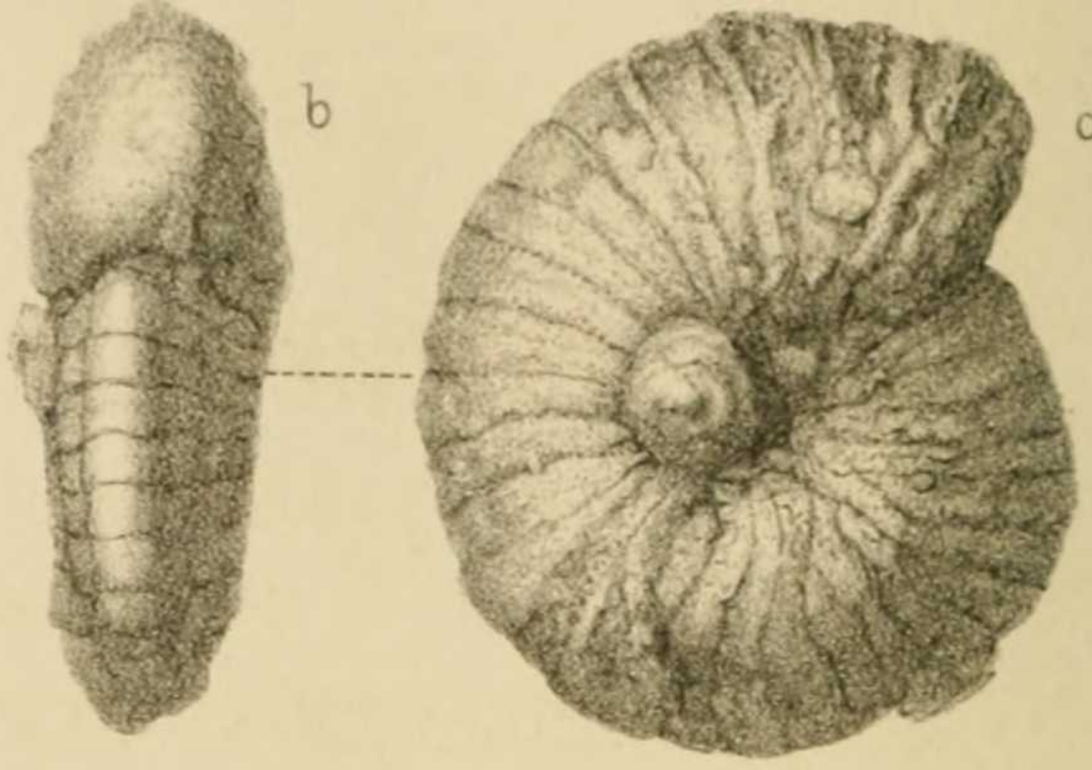

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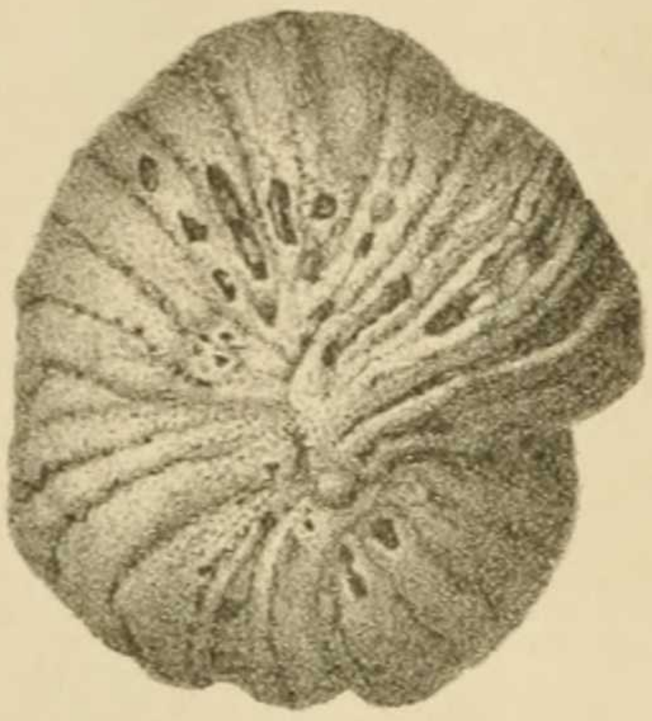

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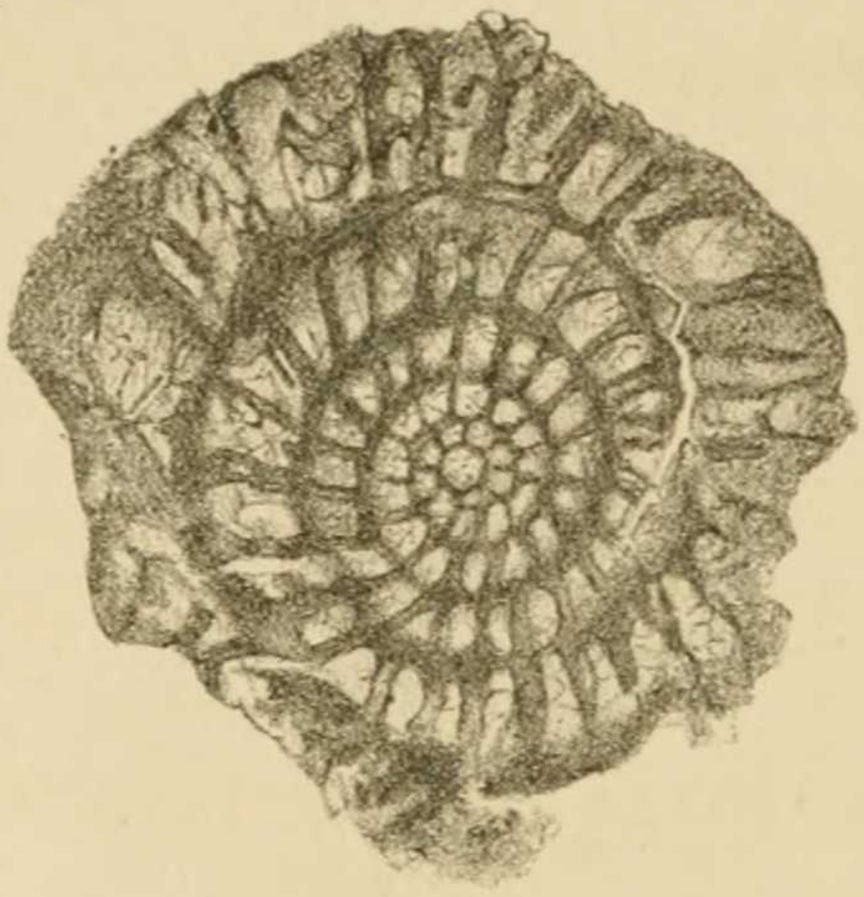

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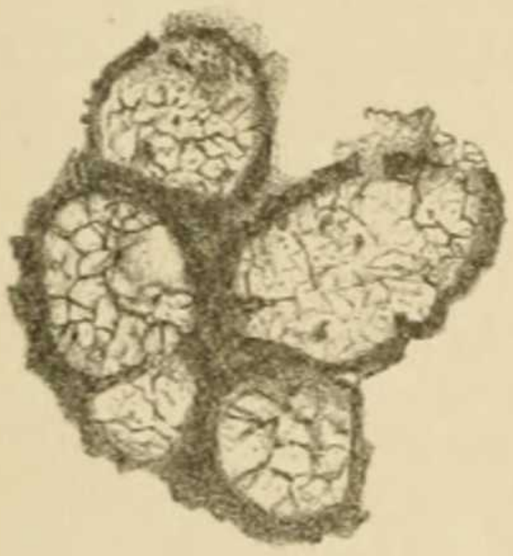

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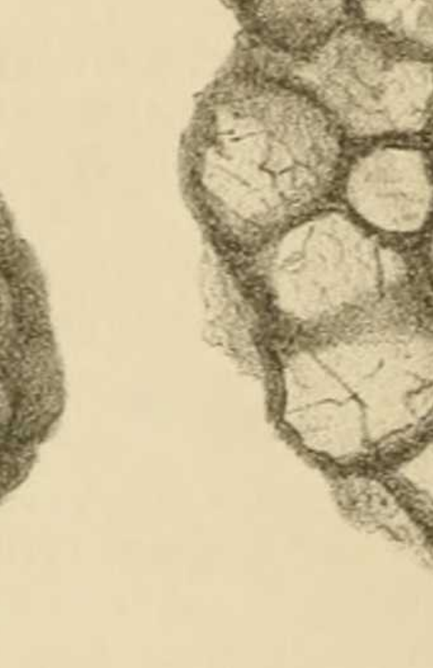

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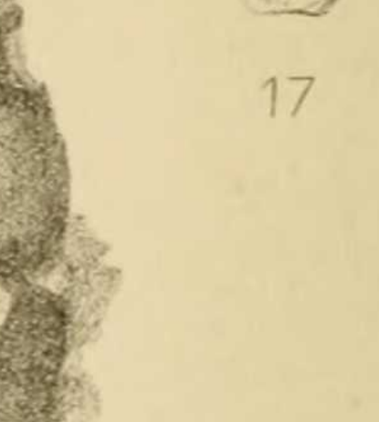

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Carboniferous Foraminifera.

results were included and acknowledged by Mr. H. B. Brady, F.R.S., in his 'Monograph of the Carboniferous and Permian Foraminifera,' published in the Palæontographical Society's volume for 1876. The publication of a general treatise on the subject, by so competent an authority, offered great facilities for workers in this interesting although somewhat difficult palæontological study. In 1876 the author of the present paper began a systematic investigation of the microzoic beds of Carboniferous age over an extended area of the North of England. The country thus geologically examined may be roughly stated as extending from the Wansbeck to the Wear, in a north and south direction, and from a line a little east of Corbridge, on the east, to Greenhead, on the west. The vertical range of the geological section concerned extends from the highest calcareous bed of the district down to the "P" Limestone of the Ordnance Geological Survey map. Within the limits of the vertical section, 30 distinct calcareous beds are included and separately denominated, and in their examination for Foraminifera, results have been tabulated from 83 localities and 242 separate washings. Although every available argillo-calcareous horizon in this series was placed under examination, only five samples throughout the entire vertical range were found to yield no trace of Foraminifera. The district, as defined above, is generally rich in microzoa, whilst some geological horizons are extraordinarily so. The labour of gathering, preparing, and examining so much material, together with manipulating many hundreds of transparent sections necessary to determine doubtful forms, can only be appreciated by those who have had experience in working out these or similar minute palæozoic organisms.

The object of the present communication is to place on record some of the more interesting forms, either new to science or previously unobserved in rocks of palæozoic age, met with during my investigations. I may add that in addition to the species enumerated in the following pages, there are a number of other organisms, which I have some ground for believing to be foraminiferal; but as the evidence of their affinity is scarcely sufficient to carry conviction to those less accustomed to handle the obscure and often much altered fossil microzoa of these palæozoic limestones, it appears safest for the present to leave them undescribed.

I must express my great indebtedness to Mr. H. B. Brady, not only for many valuable hints and the trouble he has taken in the preliminaries of publication, but also in seeing this paper through the press, a service all the more valuable in that it was cheerfully rendered and that without it the difficulties of publishing these notes at so great a distance, I fear, would have been insuperable. Mr. Rogers, of Adelaide, has also placed me under great obligation in drawing the objects, in the first instance, from nature, a work in which he has shown great patience and accuracy.

Family ASTRORHIZIDÆ.

Sub-family **Rhabdammininæ.**

Genus HYPERAMMINA, Brady.

Hyperammina elongata, var. *clavatula*, nov. Plate VIII. figs. 1, 2.

Test free, clavate in form; primordial end inflated, rounded and closed; tubular extension straight or only slightly curved, of uniform diameter throughout, and short; sometimes marked externally by slightly depressed transverse lines. Texture finely arenaceous. Walls thin, smooth on both exterior and interior surfaces. Aperture, the open end of tubular extension. Short diameter of tube 1/130 in. Length 1/30 in.

The discovery of *Hyperammina* in the Jurassic rocks of Switzerland, by Dr. Haeusler, and, almost concurrently, that of a vermiculate fossil in the Silurian of Scotland (*Girvanella*) by Messrs. Nicholson and Etheridge, which Mr. H. B. Brady thinks more than probable may belong to the same genus, indicate a high probability that some representatives of this very simple form might occur in the rich microzoic beds of the Carboniferous Limestone. The organism now described seems, in all respects, very characteristic, and comes so near the smooth examples of *H. elongata*, Br., that it can hardly be specifically distinguished from that form. It differs, however, in its minute dimensions, the proportionately larger size of its primordial chamber, and its shorter contour. With regard to the last mentioned feature it is just possible that the Carboniferous examples fail to show the entire length of the tube. Its minute size and delicate proportions render it very liable to breakage in the mechanical operations of cleaning the material; but, on the other hand, I have not detected a single fragment in the material searched that would be recognized as a fractured portion of the organism.

Distribution.—It was noted in seven samples of material, embracing the Great Limestone and the "D," "H," "I," and "J" Limestones of the Cowburn and Tipalt districts. It is more or less scarce except in the overlying shale of the Great Limestone at Clowes Gill. It maintains a remarkable uniformity of character throughout the geological section, and cannot well be mistaken for any other form.

Hyperammina vagans, Brady. Plate VIII. fig. 3.

An adherent vermiform test of arenaceous texture; consisting of a primordial chamber (not clearly defined in the Carboniferous specimens) and a tubular extension, the latter disposed either in more or less closely set parallel lines or growing wildly and irregularly; always either attached to the surface of some foreign body or forming of itself acervuline masses, the diameter of the tube being about 1/800 in.

It has not been an easy matter to assign a place to this minute and very irregular organism. It occurs in confused masses, and it is

rarely that a specimen can be found showing the primordial cell, the latter having been generally obscured by the subsequent growth of the tubular portion.

Prof. Nicholson and Mr. R. Etheridge, jun., in their monograph of "The Silurian Fossils of the Girvan District," have described a minute vermiform object [*Girvanella problematica*] which appears closely to resemble the above. With the hope that Mr. Etheridge would be able to determine their identity, or otherwise, I sent him some examples of the Carboniferous form. Mr. Etheridge was much struck with their apparent resemblance, but as he only knew the Silurian object from polished sections, his determination could go no further.

In assigning this little fossil to *Hyperammina vagans*, it is needful to state that though its zoological characters and general habit correspond with those of the recent species the diameter of the tube is much smaller than that of any living specimen hitherto described. Further, that in some instances the transverse fracture of the tube, and the apparent absence of proper investment on the attached side, suggests an affinity with the genus *Webbina*, though in other cases this is not apparent.

Distribution.—Only known from the "D" Limestone of the Tipalt in which it is by no means a rare form.

Family LITUOLIDÆ.

Sub-family Lituolinæ.

Genus Placopsilina, d'Orbigny.

Placopsilina cenomana, d'Orbigny. Plate VIII. fig. 4.

The "D" Limestone, which has added so much to our knowledge of the Palæozoic Foraminifera, is especially rich in adherent forms. Amongst these there occur some few which exhibit a close resemblance in texture and habit of growth to the above species. The test is somewhat coarsely arenaceous, imperfect on the side of attachment, generally more or less spiral in manner of growth (though often a very open spiral), and exhibits at irregular intervals constrictions of the testaceous tube, suggestive of septal divisions. The tube varies considerably in size in different individuals, varying from 1/200 in., or less, to 1/75 in. in diameter. The drawing given in Plate VIII. fig. 13 may be taken as an average specimen.

Distribution.—Only known in connection with the "D" Limestone, Tipalt, growing adherent to small fragments of shell and other objects.

Genus Lituola, Lamarck.

Lituola rotundata, sp. nov. Plate VIII. figs. 5, 6.

Test free, globular, subglobular, or, more rarely, subcylindrical; spiral, nautiloid, more or less asymmetrical, consisting of about five or

six chambers, four of which are commonly visible externally; chambers globose, increasing rapidly in size, the final segment very large, slightly overlapping and generally equal in size to the rest of the shell, giving a ventricose appearance to the oral extremity. Septal divisions often confused and labyrinthic. External surface rough. Aperture compound or cribriform, very distinct, and situated on the convex surface of final segment. Diameter of globose example 1/50 in.; subcylindrical, 1/30 in., long diameter.

This form is easily distinguished from *Lituola Bennieana*, Br. by its much smaller size, more rounded form, the fewness of its chambers, their greater inflation, and the position of its compound aperture. The aperture, which generally is very clearly visible, occurs, not on an incurved septal face, but on the convex part of the final segment, suggestive of a rectilinear growth. Fig. 5, whilst a fairly typical example in other respects, exhibits this feature in a less degree than the average number of specimens. The tendency to variation in this species is in the direction of a partial uncoiling of the spire, and some individuals even exhibit intermediate gradations with the crozier-shaped members of the genus. A comparison of the transparent vertical section given of *L. Bennieana*, Plate VIII. fig. 7, with a similar section given of the present species, Plate VIII. fig. 6, will give a fair idea of the distinctive features of their internal structure. The only form with which *L. rotundata* is likely to be confounded in the Carboniferous shales, is *Valvulina bulloides*, Br. I have not had the good fortune to obtain this latter form from the district concerned in the present investigations; but, judging from Mr. Brady's excellent drawings, the concave surface of the oral extremity of *Valvulina bulloides*, as well as the very distinctive apertures, in each case, would be easy guides to their identification.

Distribution.—It is not a very frequent form. It is rare in the Great Limestone of Curry Hill, Allendale; moderately common in the "D" Limestone of the Tipalt, and was recognized in transparent sections of the "K" Limestone, Cowburn.

Lituola Bennieana, Brady. Plate VIII. fig. 7.

In the schemes of classification where the perforate or imperforate character of the test was made a ground of primary division among the Foraminifera, the genus *Lituola* was placed among the "Imperforata." Mr. Brady's reasons for rejecting this principle of classification receive from time to time additional justification. The artificial nature of this method of division has received conspicuous illustration in that, whilst the Lituolidæ are normally imperforate, the large Carboniferous species, *L. Bennieana*, is frequently coarsely perforate. This has been demonstrated by several sections made both in horizontal and vertical directions, in which the perforate character of the test is equally manifest. Plate VIII. fig. 7 is one such section, taken vertically, which also shows, in this individual, an aperture at the inner margin of the terminal segment.

The chambers are much more numerous than in *L. rotundata* (nearly double) and less globose. Long diameter 1/28 in.

Distribution.—I have notes of the occurrence of this fine species in twelve samples of material, viz. the Felltop Limestone, at Wolf Hills, near Haltwhistle; First Lower Felltop, Thornbrough; Great Limestone, of Allendale; Small Limestone, of Nenthead; "D" Limestone, of Tipalt and Cowburn valleys; and the "J" Limestone, in Tipalt. In the Thornbrough quarry I obtained it from five horizons, and in the majority of these it was a common form.

Sub-family **Trochammininæ.**

Genus WEBBINA, d'Orbigny.

Webbina hemisphærica, Jones, Parker, and Brady.

In the rich material of the "D" Limestone there are frequent examples of a monothalamous and adherent Foraminifer which appear to me to belong to this species. The test is convex and imperfect on the side of its attachment. The degree of convexity varies from a somewhat low relief to almost subglobular. The margin is at times slightly spreading, and not unfrequently exhibits a clear space between some parts of the edge of the test and the object to which it is attached. It is a minute form, not exceeding 1/50 in. in diameter. It is an interesting feature to find this rare form, which has hitherto only been known in the living state as dredged off the coast of Durham, and as a fossil by a single specimen from the Suffolk Crag, with so high an antiquity as these Palæozoic examples confer upon the species.

Distribution.—Only known in the Carboniferous rocks in connection with the "D" Limestone, Tipalt.

Webbina fimbriata, sp. nov. Plate VIII. figs. 8, 9.

Test thin, adherent; in shape, convex or subconical; normally monothalamous, sometimes two or three grouped together and connected by minute stoloniferous tubes; margin attenuated, spreading, and deeply notched, giving the test a fringed or stellate appearance. Stellate projections numerous, short, raised, and tubular, sometimes open at their extremities. Diameter of test 1/100 in.

This is a very pretty little shell, and makes a conspicuous object by its white colour shown on a dark background. The test is to all appearance finely arenaceous and very thin, and owing to this latter fact most of the examples have the test broken at the apex, as shown in one of the figures. Some of the fractures probably date from a period prior to the fossilization of the specimens. Its habit of growth, in throwing out tubular extensions from a primordial chamber, gives it a likeness to *Webbina clavata*, and it is more closely isomorphic with *Placopsilina vesicularis*, Brady; but it differs from the former species in the number and stellate form which these tubular processes assume, as well as in their very short length, seldom exceeding a length greater than the diameter of the chamber from which they emanate; whilst the finely

arenaceous texture of the test at once distinguishes it from the coarser Placopsiline species. The radiating tubuli undoubtedly formed the general apertures of the test, they sometimes bifurcate, and there is commonly a thin film or weblike extension of the testaceous envelope partly covering the spaces separating the tubuli.

Distribution.—It is rather a common form in the "D" Limestone, where it is found attached to a great variety of objects, but I have not found it at any other horizon in the district.

Webbina irregularis d'Orbigny. Plate IX. figs. 16, 17.

There can be little doubt, I think, that figs. 16 and 17 represent examples of this species. Although differing in some respects from the recent form, they carry clearly marked *Trochamminina* characteristics. The test is typically, although not constantly, oval in shape; finely arenaceous in structure, smooth externally, and imperfect on the side of attachment. The segments are arranged in a moniliform order, and sometimes in several parallel and adjoining series of such an order of arrangement. The features of divergence from the modern examples of the species, exhibited by the Carboniferous specimens, are in the direction of a greater thickness of test, the stoloniferous connection between the chambers is often imperfectly developed, the division of segments being at times marked by a simple constriction of the test rather than by stoloniferous tubes; whilst in many examples there is an approach to the cylindrical form by the margin of the chambers almost coalescing on their under sides when the object on which they have grown has been a column of small diameter.

These divergences may be regarded as features of minor consequence where the general agreement to the type is so close. Average size of segments, long diameter 1/75 in.; short diameter 1/125 in.

Distribution.—Very rare in Great Limestone of Blagill, Allendale, but common in the "D" Limestone of the Cowburn and Tipalt outcrops.

Sub-family **Endothyrinæ.**

Genus Archælagena, nov.

Syn. *Lagena* (in part), Brady.

Shell parasitic or free; either monothalamous or polythalamous. Chambers inflated; ovate, subglobular, or irregular in shape. Polythalamous examples confused in arrangement. Test thicker than in the typical *Lagenidæ;* finely perforated. Texture either entirely calcareous or with only a small proportion of included arenaceous particles. Aperture at the termination of a short neck; in parasitic examples the orifice may be defective on the side of attachment, and is then a semicircular, slightly produced lip.

The genus now described may be regarded as bearing a similar relation to *Lagena* that *Nodosinella* bears to *Nodosaria.* In both cases we probably possess ancestral, generalized types, from which have diverged distinct lines of modification leading up to more specialized

forms of recent times. The not unfrequent duplication, seen in aberrant examples among recent *Lagenæ*, may, perhaps, be instances of reversion to type, as seen in the polythalamous examples of Carboniferous times, and included in the present genus.

Archælagena Howchiniana, Brady, sp. Plate IX. fig. 18.

Mr. Brady's description of the monothalamous examples of this species is a very accurate one, and needs no adjustment. A more extended acquaintance with this form has, however, shown that it is much more commonly polythalamous than monothalamous in its habit of growth. The chambers usually number from two to twelve, and, in rare cases, even up to nearly twenty, and are irregularly grouped around the axis of growth. The method of growth is apparently by budding. The chambers differ greatly in relative size, and many show more or less distortion in shape by compression through the concurrent growth of adjoining segments. There may be one or more general orifice to each group of united segments, the latter communicating by interseptal apertures.

Possessing the morphological and structural characteristics now described, *Archælagena Howchiniana* can no longer be consistently regarded as belonging to a genus which is essentially monothalamous. On the other hand, *Lagena Parkeriana*, and *L. Lebouriana*, although exhibiting in test structure some points of resemblance to the forms classed under the present species, have never been met with except as single-chambered and free examples, and may therefore be left, at least for the present, in the position assigned them by Mr. Brady.

Distribution.—Not very common; recorded in connection with twelve washings from the following:—First Lower Felltop, at Penpeugh; at various localities and horizons of Great Limestone; and from the "D" Limestone of Tipalt and Cowburn, the last-named limestone being the best bed for the form.

Genus ENDOTHYRA, Phillips.

Endothyra conspicua, sp. nov. Plate IX. fig. 12.

Test nearly circular in lateral outline, compressed, slightly asymmetrical bi-laterally, composed of about three convolutions, all of which are more or less visible exteriorly. Segments inflated, sub-globular, from ten to twelve in the outer whorl. Diameter of large specimens 1/20 to 1/16 in.

This is an interesting variety in which the usually embracing character of the genus is but feebly developed. It has probably its closest relationship with *E. Bowmani*, some examples of which exhibit a considerable umbilical depression not embraced in the fold of the outer convolution. It is, however, easily distinguished from the latter species, by its more circular outline, its more numerous and globular-shaped segments, and, more particularly, in the exposure of the inner whorls which are often visible throughout their entire convolutions. In

E. ammonoides there is the same exposure of the inner whorls by the only slightly embracing character of the test, but its minute size and the number of its convolutions and septal divisions at once distinguish it from the present species. This departure from the normal character of the genus, shown by *E. conspicua*, is not likely to have arisen from starved conditions as some of the individuals attain a larger size, exceeding those of *E. Bowmani*, whilst the beds in which they occur are somewhat rich in Foraminifera.

Distribution.—Rare in the "J" Limestone of the Tipalt, and in a limestone, low in the series, situated in a burn between The Banks and Lannercost, occurring at three horizons in the limestone, in one of which it is moderately common.

Endothyra circumplicata, sp. nov. Plate VIII. figs. 10, 11.

Test free, subglobular, irregularly spiral, embracing; composed of three or more convolutions, which, instead of following the same plane of growth throughout, become twisted, so that the later convolutions are formed more or less at right angles to the plane of the earlier segments. Segments numerous, and in their later growths enlarging rapidly and becoming ventricose. Later chambers subdivided near their umbilical margins by transverse septa. Septal divisions marked externally either by depressed lines or slight limbation. Test plicate. Exterior surface smooth; white or reddish-white. Texture finely arenaceous, and in some cases (?) perforate. The final segment has a protruding lip forming its convex or outer margin, with a corresponding lip or ridge transverse to the peripheral margin and parallel to the inner margin of the septal plane. Aperture distinct, oval. Diameter 1/25 in.

This striking variety exhibits an extreme of inequilateral growth. In its large size and globose form it somewhat resembles *Endothyra crassa*. The latter includes the "nearly symmetrical," large, globose *Endothyræ* of the Carboniferous rocks, whilst *E. circumplicata* is extremely unsymmetrical, and from this cause exhibits considerable divergence in internal structure from its more equilateral congeners. The umbilical axis is not unfrequently shifted in position by the inequilateral plan of growth to the peripheral margin. Transparent sections show in many instances a remarkable confusion in the arrangement of the earlier chambers with successive foldings, amounting in some cases to two, three, or four plications of the shell substance; and in the expanded chambers of the final whorl, transverse septa, giving rise to small chamberlets, near the umbilical margins of the terminal segments. The last segment is sometimes much contracted by vertical compression towards the aperture, taking the form of a slit which, with its pouting margins and great obliquity of the septal plane, gives the shell a very grotesque appearance. The shelly investment, consequent upon the laminated construction of the test, is very stout in comparison with the other *Endothyræ*, especially in its earlier convolutions, and has a clear, smooth, and sometimes

glossy surface. The test, whilst finely arenaceous, exhibits great uniformity of structure, and when viewed in section by transmitted light exhibits a peculiar white opacity of texture not commonly seen in members of this genus.

Distribution. — It is a form apparently much limited in distribution. Recorded in four samples, three of these belonging to the "D" limestone of the Cowburn and Tipalt districts, and the other in "K" limestone, near West Stone Folds, Cowburn. In the "D" limestone it is common.

Endothyra radiata, var. *Tateana*, nov. Plate IX. figs. 13–15.

Test free, nautiloid, nearly circular in peripheral outline, compressed laterally, embracing, umbilicus sunken, slightly inequilateral, peripheral margin thin or subcarinate; convolutions numerous, five to six in fully grown examples; chambers very narrow and numerous, from 25 to 40 in last convolution; septal walls double; sutural lines slightly excavated; septation sometimes indistinct and often showing considerable irregularity in arrangement on exterior surface. Texture finely arenaceous with large proportion of calcareous cement. Diameter of fully grown specimen 1/25 in.

A fine variety of *Endothyra*, differing in some minor particulars from *E. radiata*. The shell attains about twice the diameter of typical specimens of the latter species; it is more symmetrical and compressed, and the segments are more numerous and less regular, often showing crenulations, meeting at various angles on the surface of the test. The duplication of the septal walls is also an important feature, and one that has not been observed in connection with any other members of the genus. It is well seen, not only in transparent sections of this form (Plate IX. fig. 15), but in those examples which have been subjected to a degree of weathering, as shown in fig. 14 of the same plate. The double septation gives a higher character to the genus than was at first indicated, and is another feature confirmatory of Mr. Brady's opinion, expressed when working out this interesting palæozoic type, of the close analogy which the genus bears to the more recent and distinctly calcareous Rotaline series, with which *Endothyra* in its various modifications is closely isomorphic.

I have great pleasure in associating this variety with the name of the late Mr. George Tate, F.G.S., of Alnwick, who was one of the earliest and most enthusiastic students of the palæontology of Northumberland.

Distribution.—*Endothyra radiata*, var. *Tateana* is not uncommon in the lower Carboniferous beds of south-west Northumberland. It was noted in the upper beds of the Great Limestone at Blagill, Alston; but all of the twenty-four localities in which it has been observed, with the exception just noted, are at horizons included between the "B" and "N" limestones of the Cowburn and Tipalt valleys.

Genus STACHEIA, Brady.

Stacheia moriformis, sp. nov. Plate IX. figs. 19, 20.

Test parasitic (or free?); globular, subglobular, or, more rarely, elongate or complanate in shape. Chambers larger than those of allied species, more or less rounded in outline, and often showing a roughly concentric or spiral arrangement of segments around the axis of growth. Chambers of the superficial layer inflated and tumid, raised in hemispherical bosses upon the surface of the test; walls very thin, often abraded on their convex surfaces so as to expose the darker material filling the interior of the chambers. Diameter of globose examples, from 1/30 in. to 1/25 in.

This species is pretty constant in character, and cannot well be confounded with any other of the Carboniferous Foraminifera. Its globular form and conspicuously inflated chambers are ready means of identification, It is often impossible in the other members of this genus to mark any superficial indications of the septal divisions, and when distinguished they are made apparent only by a faint areolation or mottled appearance of the exterior surface: but in *Stacheia moriformis* the superficial chambers are not unfrequently elevated to the extent of half their diameter. The test is not nearly so compact as in the allied species, and the chambers are relatively larger, whilst the shelly investment is remarkably thin. In this respect, and from a greater or less tendency to a spiral arrangement in building up the test, there is some morphological analogy to the acervuline modifications of *Planorbulina*, especially when *S. moriformis* has grown parasitically on a flat surface; but the subarenaceous and imperforate characters of the test show its affinity to be with the *Endothyrinæ* rather than the recent perforate and hyaline forms.

Distribution.—*Stacheia moriformis* is not very common in point of number of specimens, but is widely distributed through the Carboniferous Limestones of the North of England. It occurs in fifty-two washings gathered from the following horizons:—First Lower Felltop, Second Lower Felltop, Great Limestone, Four-fathom Limestone, and the "D," "E," "G," "J," "N," and "O" Limestones.

Family LAGENIDÆ.

Sub-Family **Nodosarinæ.**

Genus NODOSARIA, Lamarck.

Nodosaria (*Dentalina*) *farcimen*, Soldani. Plate IX. fig. 21, *a*, *b*.

Amongst the many interesting forms which the "D" limestone has revealed must be included the above species. Its lowest stratigraphical record hitherto known has been the Upper Permian, where it is found associated with several other cognate forms. No unquestionable Nodosarian had been found in rocks older than the Permian. It is, therefore, of some interest to secure examples of this common recent species so far back as the Carboniferous Limestone. In

the Permian seas it was scarce, and apparently was still more rare in Carboniferous times, when the arenaceous types were in the ascendant. Only one undoubted example of this species was obtained from the material searched, but with the exception of exhibiting a mineralization corresponding to the much older formation from which it was obtained, it does not materially differ from the examples of later age. It is a minute shell with a clear calcareous appearance. Test slightly compressed laterally. The chambers, which are elliptical in shape, number six, in a curved linear series, and increase somewhat rapidly in size in the direction of growth. Septal lines marked by oblique and rather deep constrictions. Primordial end apiculate. Length 1/28 in.

Distribution.—Only known from the "D" Limestone, Tipalt; rare.

Family ROTALIDÆ.

Sub-family Rotalinæ.

Genus PATELLINA, Williamson.

Patellina Bradyana, sp. nov. Plate IX. figs. 22–25.

Test free; conical; trochoid; primordial end obtusely pointed; transverse section circular; length equal to two or three times the diameter of the test; inferior side slightly concave; external surface limbate, exhibiting numerous annular, semi-annular, or spiral whorls of raised shell-substance alternating with lines of depression; depressed areas bridged by minute crenulations of the test, which, as raised transverse lines, connect the limbate septal ridges. Internal structure a simple, undivided and continuous spiral chamber (or alternating semi-annular chambers?). Chamber cavity compressed. Umbilical region extending almost the entire length of the shell and of nearly equal diameter throughout, filled with uniform shell-substance. Convolutions of spire varying from five to twelve; average number ten. Aperture a narrow slit, extending from the periphery to the umbilical margin. Umbilicus depressed; or, frequently, marked by a raised lip extending from the umbilical termination of the orifice, forming a low, semicircular wall defining the central portions of the test. Length about 1/38 in.; diameter, at base, 1/100 in.

This is, perhaps, the most interesting find in the present group of new forms. The oldest record of *Patellina* has not, hitherto, extended beyond the Cretaceous formations, in which, as well as in rocks of early Tertiary age, the genus was represented by shells of relatively large size and complicated structure. The common recent species, *P. corrugata*, exhibits to some extent the subdivision of chambers by secondary septa, so remarkably developed in some of the earlier forms. The Carboniferous examples are of a simpler type, and do not possess any subdivision of the chamber cavities. Mr. H. B. Brady, in the "Challenger Foraminifera," describes a new recent species, *Patellina campanæformis*, which shows the same simple and undivided chamber

(or chambers) as in *P. Bradyana*, and it seems probable that the palæozoic form has its nearest relationship with this interesting but extremely rare species of the present day. The recent species combines the twofold plan of growth, of semi-annular, crescentic segments in the early whorls, with a true spiral form of chamber in the later whorls. From a careful examination of several transparent sections of the test of *P. Bradyana* I cannot satisfy myself that it conforms to the normal type, with respect to an alternating series of semi-annular segments, but appears to exhibit the generic characters under the simplest possible form, that of a non-segmented spiral chamber with the spire drawn out from the primordial plane to that of an elongated cone. Its spiral growth gives it a likeness to *P. Cooki*, although wanting the subdivision of chambers seen in that species. The bridging of the lines of depression by shelly matter, between the raised sutures on the external surface, may have been the foreshadowing of that modification of the type which, in later ages, became more definite in the subdivision of the chamber cavities. The chief variations to which the Carboniferous form is subject are in the height of the spire, the occasional irregularities of the limbate outlines of the chamber walls—the latter, at times, being subject to interruption or coalescence—or an abnormal constriction or inflation of the test at some stage of its growth, producing more or less distortion of outline. The umbilical region is filled with calcareous shell-substance which in section has a mottled appearance, but is unsegmented. The only species with which *Patellina Bradyana* is likely to be confounded in Carboniferous material are *Valvulina palæotrochus* or *V. Youngi*, but *P. Bradyana* has a shorter transverse diameter in comparison with its length than either of these forms, its numerous limbate sutures are also distinctive, whilst the respective apertures and internal structures are widely different.

As the most striking addition to our knowledge of Carboniferous Foraminifera, I have much gratification in associating with the species the name of Mr. H. B. Brady, to whose researches we are indebted for the first systematic treatment of this group of palæozoic fossils.

Distribution.—Only known from the "D" Limestone of the Tipalt and Cowburn outcrops.

With this species I may fitly conclude my notes. In the present series details have been given of four genera and of thirteen species and varieties not previously known as Carboniferous fossils, some of them of peculiar interest. As has already been stated I have still a number of specimens which appear to me to belong to the Foraminifera, and if so to types hitherto undescribed, but these I withhold for the moment in the hope of obtaining further evidence respecting them.

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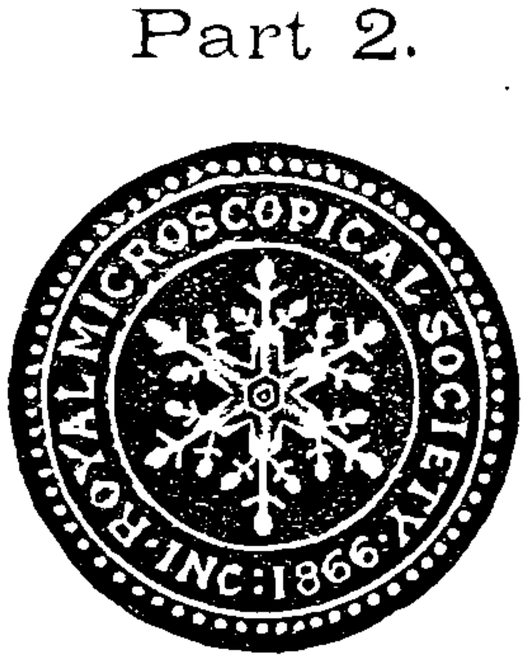

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