XIX. *On a new Form of Calamitean Strobilus from the Lancashire Coal-measures.* By W. C. Williamson, F.R.S., Professor of Natural History in Owens College, Manchester.

Read October 19th, 1869.

In the last communication which I had the privilege of laying before this Society, I mentioned that I had found, in the collection of Mr. Butterworth, of High Crompton, portions of a fossil strobilus from the Lancashire Coal-measures, which exhibited some remarkable features, and which I believed had not improbably belonged to the *Calamopitus* that I was then describing. Since that comunication was made, Mr. Butterworth has kindly prepared for me some additional sections of the specimen; and having subjected the whole of them to a careful examination, I now beg to communicate the results to the Society. When the specimen came into the possession of Mr. Butterworth, it consisted of but three oblate joints or segments of what had once been a larger structure. In its general aspect it appears to have closely resembled, if it was not identical with, one which Mr. Binney figured* and referred to as resembling the *Aphyllostachys jugleriana* of Goeppert. Mr. Binney describes his strobilus as being about half an inch in length, and consisting of eight or nine crown-shaped masses or joints, each of which, calculating the proportions indicated by Mr. Binney's figures, must have been about the $\frac{1}{16}$ of an inch in length, and from $\frac{3}{16}$ to $\frac{1}{4}$ in transverse diameter. Mr. Butterworth's strobilus has considerably exceeded these dimensions. The specimen is somewhat compressed laterally; hence its transverse section presents an oval figure. The length of each joint, or internode, supporting one verticil of sporangia is about $\frac{1}{4}$ inch, its greater dia-

* "Observations on the Structure of Fossil Plants found in the Carboniferous strata. By E. W. Binney, Esq., F.R.S., F.G.S. Part I. Calamites and Calamodendron" (Palæontographical Society, 1868), Plate vi. fig. 1.

meter being $\frac{7}{16}$, and its lesser one $\frac{5}{16}$ of an inch. Two of the three internodes had been sliced into sections before I saw the specimen; but the third, which fortunately happened to be the lowest one of the three, was preserved intact, and is represented in figures 1 and 2, the former being its lateral aspect, and the latter that of its inferior surface. Externally, each internode of the strobilus has exhibited a series of strongly marked, rounded, longitudinal ridges and furrows, the former being apparently about 20 in number, though, owing to the fragment being somewhat injured on one side, I could not count them with exactness. These are invested by numerous closely lapping, thin, membranous, vertical bracts. Each of these bracts appears to have occupied one of the furrows between the ridges, its margins having overlapped, or been in contact with, those of its nearest neighbours along the line of each ridge; but this point also was not very clear, owing to the exceeding thinness of the bracts and the closeness with which they were in mutual contact. The upper part of the fragment having been cut off in making a transverse section, I could not decide whether these bracts terminated with the upper edge of their own internode, or whether their tips were prolonged over the joint above.

Fig. 2 represents the concave base of the specimen. I do not believe that this has been the actual base of the strobilus. In all probability there has intervened between it and the common peduncle one small joint. That if not the actual basal segment it must have been nearly so, is shown by the rapid contraction of its outline, inferiorly, when seen in its lateral aspect (fig. 1). In the centre is the medullary cavity (fig. 2 *a*), a cylinder with an internal diameter of about $\frac{1}{14}$ of an inch. This exhibits no structure, its interior being filled with infiltrated crystalline carbonate of lime. That it was hollow when entombed, and has not lost its tissues through fossilization, is shown by the presence in its interior of some of the ubiquitous rootlets of *Stigmaria* in an uncompressed condition. Extending from this medullary cavity to the periphery of the base of the strobilus is an almost unbroken disk of cellular membrane, the surface of which, under a low magnifier, exhibited myriads of very fine radiating striæ, running from the centre to the circumference. This horizontal disk was not extended in one plane, but variously inflected, presenting, when seen from below, two inner circles, each of which was slightly convex, surrounded by a larger concave one. Immediately surrounding the medulla is an unbroken ring about $\frac{1}{100}$ of an inch in breadth, perfectly flat, save at its inner border, where it is convex; but I doubt if this convexity existed in the living strobilus. From the outer margin of this ring the disk is extended in the same plane for rather more than the $\frac{1}{20}$ of an inch. In this latter portion we have a circle of symmetrically arranged pyriform figures, also filled with crystalline carbonate of lime. These figures indicate open spaces, dividing the membranous disk into ten principal inner peduncles and twenty secondary outer ones. A little beyond the outermost boundary of these spaces, the disk has bent downwards, forming on the inferior surface of the segment a convex ring, enclosing the parts just described, after which the disk reverses its direction, forming a concave space that extends to the acute inferior peripheral margin (fig. 2 *b*) of the internode. At this point the disk subdivides into a multitude of minute ovato-lanceolate bracts, which bend abruptly upwards, and which constitute, as already described, the outermost investment of the strobilus.

Fig. 3 represents a transverse section of a portion of the Strobilus, made in the plane of the flat disk surrounding the pith of fig. 2, being, in fact, a section of part of the central axis of the strobilus, where it passes through a nodal bractigerous verticil: *c c* represent two of the ten primary peduncles given off from the central axis. Each of these has an average breadth of about $\frac{1}{40}$ of an inch. It consists chiefly of cellular tissue, the cells being of various sizes. In the ring immediately investing the pith the cells are the largest, being from about $\frac{1}{400}$ to $\frac{1}{600}$ of an inch in diameter. In the centre of each peduncle they are about $\frac{1}{800}$ of an inch in diameter. At *d d* are two pores, which are sections of two canals, running the entire length of the axis of the strobilus, and which serve in an important manner to identify homologous parts in different sections. These canals have a diameter of $\frac{1}{400}$ of an inch, and the cells immediately surrounding them range from about $\frac{1}{1400}$ to $\frac{1}{1600}$ of an inch in width, these being much smaller than the rest. The dark and dense patches, *e e*, I believe mark the position of some important bundles of reticulated vessels to which I shall again have to refer. At *f f f* are three of the pyriform spaces separating the primary peduncles. The transverse section of each of these is broadly ovate at its inner extremity, and acuminate in the opposite direction. On each side of this acuminate portion, and separated from it only by a very thin film of oblong cells, is the ovate basis of a smaller, but otherwise similar, space (*g*), at the peripheral end of which is a patch of tissue (*h*) somewhat denser than the rest, and which marks the starting-point of a spore-bearing peduncle or sporangiophore, which ascends almost vertically into the substance of the strobilus. These sporangiophores are twenty in number, or double that of the primary peduncles. The remainder of this section consists chiefly of coarse cellular tissue, with the exception of the darkly shaded portions, *i i*, which are masses of spores. Owing to the peculiar inflections of the bractigerous disk given off from each node, no one continuous horizontal section can be made through its entire plane, as will readily be understood on reference to the restored vertical section of the strobilus, fig. 13, where the dotted line, *x x*, represents the direction of the horizontal section, fig. 3. From this it will be seen that, after giving off the ascending sporangiophores (*h*), the bractigerous disk continues its outward course for a very short distance, and then bends suddenly downwards, resuming its upward direction as it approaches the exterior of the strobilus. As the sporangia accommodate themselves to these curvatures, it follows that a section made in the line (fig. 13) *x x* will intersect the sporangia at its peripheral margin, as is done in the instance of fig. 3, *i i*.

Fig. 4 represents a transverse section of the entire strobilus, made at an angle somewhat inclined to the central axis *; hence, whilst in the part opposite to *x* it intersects the strobilus nearly in the same plane as fig. 3, throughout the remainder of the section (as at *y*) it has crossed the segment somewhat higher up, revealing the structure of the central axis and of the sporangiophores, *h h'*, after their detachment from the bractigerous disk and their consequent separation from the axis. In this section we see the medullary cavity at *a* surrounded by the woody axis, the innermost part of which consists of the coalesced bases of the ten primary peduncles. Each of the latter exhibits the two small pores seen in fig. 3 *d*, and which obviously indicate continuous canals, running vertically through the woody axis. The relations of the woody axis to the bractigerous disk and surrounding mass of sporangia have been somewhat disturbed by a rupture apparently due to some shrinking of the cone prior to fossilization; but, notwithstanding this, we have no difficulty in identifying the various parts of the section. Thus at *c* we have one of the primary peduncles flanked on either side by one of the large pyriform spaces, *f f*. At the peripheral extremity of this peduncle we see the rounded inner boundaries of the two smaller pyriform spaces, which, though somewhat disturbed, can

* As indicated by the line *w w* in fig. 13.

be traced up to the two well-marked sporangiophores *h″ h″*. If we proceed right and left from this starting-point, owing to the obliquity of the section, we can trace the gradual divergence of the sporangiophores from the central axis, and their isolation amidst the masses of sporangia which they have supported—also the contraction of what I have termed the primary peduncles of the bractigerous disk into mere prominent longitudinal ridges on the exterior of the central axis, like those on the stem of a Calamite, whilst the large pyriform cavities, in like manner, become deep grooves separating these ridges. In this figure little attempt has been made to delineate the complicated and interrupted outlines of the sporangia, *i i*, except at the peripheral margin, *l*, where their distinct continuity shows that we possess the outermost portion of the strobilus. In the interior of the structure, the arrangement of these sporangia has been much disturbed, apparently by inequalities in the mutual pressure to which they have been subjected, resulting from the growth of the spores.

Fig. 5 represents the central portion of a transverse section made at a higher point than the last, corresponding to the line *y y* in fig. 13. The cylindrical axis surrounding the medulla (*a*) is now more sharply defined, owing to the absence from this internodal portion of the bractigerous disk. The homologues of the bases of the ten primary peduncles of fig. 4 are identified by the two small canals in each (*c, c*), which here approach the outer surface of the axis: we thus see, as I have already suggested, that these primary peduncles are merely nodal prolongations of ten somewhat rounded, projecting ribs running longitudinally along the exterior of the central axis; these ribs, becoming increasingly prominent as they approach the node, both from above and from below, gradually converge, and at length coalesce, so as to enclose the intermediate grooves, which are thus converted into pyriform openings (*f*) perforating the bractigerous disk. The vertical section, of which one side is represented in fig. 7, seems to indicate that the disk attains its greatest development a little below the actual node of the axis which is indicated by fig. 7 *e*, since at *c* we have cellular tissue extended peripherally towards the bractigerous disk below, whilst at *c'* we have a similar expansion of the axis proceeding towards the next disk above, the next superior node (corresponding to *e*) not being contained within the section. The axis at the internodes (fig. 5) is closely invested by the mass of sporangia, the outlines of which are often more distinctly traceable here than in fig. 4; but in other respects the unfigured peripheral portion of the former section corresponds closely with the lower part of fig. 4. At this part of the internode the sporangia have obviously no connexion with the central axis, beyond that of mutual contact; but the lines of their intersected walls can be traced, in several instances, radiating from the isolated sporangiophores. The entire thickness of the wall of the axial cylinder at this point is about $\frac{1}{50}$ of an inch at the ridges (fig. 5 *c*), and $\frac{1}{80}$ of an inch at the intervening grooves.

Fig. 6 represents a vertical section made through the centre of the segment figs. 1 and 2. *a* is the medullary cavity, bounded on each side by the woody axis. At *c* we have a contribution from part of the internode immediately above the node, towards the formation of the bractigerous disk, *k*; and from the latter there ascends obliquely upwards and outwards the sporangiophore, *h*. At *k* we find the bractigerous disk continuing its outward course for a short space in the horizontal plane, then bending suddenly downwards in a sweeping curve, and resuming its upward course to support the bracts (*k'*) investing the exterior of the strobilus. All the darkly shaded portions of this figure represent sporangial masses—the rounded portion, *i*, being especially invested with the cellular wall of this sporangium, showing that the latter structure originally filled the contiguous depression in the peripheral portion of the bractigerous disk. It may be observed that, in all the vertical sections, the disk is seen to receive vascular and cellular contributions, both from above and below the node to which it belongs, though chiefly the latter—a condition not unlike what occurs in the reproductive spikes of many living Equisetaceæ, where a similar thickening of the sporangiophores takes place.

Fig. 7 exhibits the right half of a vertical section like the last; but, from its importance, it is represented as more highly magnified. *a* is part of the medullary cavity, in immediate contact with which is the prosenchymatous tissue, everywhere forming the innermost part of the solid woody axis. The cells are oblong, and of various lengths. Sometimes they have rectangular septa, but more frequently they present obliquely overlapping extremities. The structure of the outer part of the woody cylinder varies according to the line in which the vertical section has been made. We here find that the axis begins to enlarge at the centre of the internode, *e'*, and continues to do so gradually as we ascend to the node above. The enlargement is the result of additional prosenchymatous cells (*c'*) added to the exterior of the longitudinal ridges. At *f* the section has laid open a narrow segment of one of the larger pyriform canals, fig. 3 *f*, throughout a great part of its length; whilst at *c''* we have the thin film of prosenchyma which has separated that canal from one of the smaller ones, fig. 3 *g*. At the lower part of the section we have some important features exhibited. At *e* is the node, marked by a constriction of the medulla, arched over by a group of reticulated vessels. These are identical, both in their structure and arrangement at this point, with what I have described in *Calamopitus*. They spring from the medulla below the node, at an oblique angle, and arch over the node, returning to the medullary tissue at nearly the same angle as that with which they arose; but instead of terminating abruptly, they now proceed upwards (fig. 7, *e'*) parallel with the pith, forming the outermost portion of the external longitudinal ridge of the axis. Unfortunately I possess no tangential section of this part of the structure; consequently I am unable to speak with certainty respecting the superficial arrangement of these vessels; but a careful study of the various sections has led me to the conclusion that there are two of these woody bundles in each external rib of the axis. I believe that their position in the transverse section is indicated by fig. 3 *e*, or immediately external to each one of the longitudinal canals, fig. 3 *d*—which accounts for their position at the exterior of the ribs in the section fig. 5, *c*. If this explanation be correct (and I have little doubt about it), some important inferences are suggested by the fact. It indicates that these vascular bundles are the homologues of the woody wedges of Calamites, and that the small canals in like manner represent those of which, as Mr. Binney and others have pointed out, one forms the innermost angle or starting-point of each woody wedge.

From each node we find the cellular tissue *c* descending a short distance, but proceeding rapidly outwards to form the upper part of the next inferior bractigerous disk. At *h* we have the sporangiophore of the same disk, but forced inwards, away from its normal direction, to pass upwards between the two sporangia *i* and *l*. It will be observed that this upper surface of the bractigerous disk is very different from the lower one. In the latter, the gradually enlarged ribs ascend from the centres of the internodes, like ten buttresses, sustaining the disk with its sporangiophore and mass of sporangia. On the other hand, at the upper surface, the ribs, descending from the internode above, are but slightly enlarged; hence a slight concavity in the disk is adapted to receive the inferior surface of the inner sporangium *l*, which rests upon it.

Fig. 8 represents portions of two of the vessels from fig. 7, *e*, more highly magnified, and exhibiting the reticulated character which has hitherto proved so distinctive of *Calamopitus*. They have a variable diameter of from $\frac{1}{800}$ to $\frac{1}{1600}$ of an inch.

The outlines of some of the sporangia are very distinct in fig. 7, the sporangium-walls (*l*, *l'*) being more continuous and regular than usual, whilst the spores (*i*), indicated in the drawing by the dark mottled surfaces, are packed very closely round the main axis.

Fig. 9 is a transverse section of one of the sporangiophores from the unfigured part of the section of which fig. 5 is the central portion. Its dorsal surface, *h*, is rounded; but its opposite or inner margin projects as a strongly defined keel (*h'*), owing to two deep lateral excavations, which gives this part of the organism a compressed form. It chiefly consists of densely aggregated elongated cells, or prosenchyma, with vague traces of vascular tissue; but in all the longitudinal sections, its structure is so dense and black that the details are not easily made out. The greatest diameter of this sporangiophore is about $\frac{1}{100}$ of an inch, and its lesser or transverse diameter about $\frac{1}{130}$ of an inch.

The numerous spores are enclosed in sporangia, the structure of the investing membranes of which appear to be almost identical with those of the Calamitean strobili described by Mr. Binney and Mr. Carruthers. These sporangium-walls are cellular, the oblong cells being arranged vertically to the two surfaces of the membrane, which is about $\frac{1}{800}$ of an inch in thickness, whilst the individual cells have a diameter of from $\frac{1}{1200}$ to $\frac{1}{2000}$ of an inch, the latter being the more usual dimensions. Externally, the ends of the cells are generally plane (fig. 10, *l'*), whilst their inner extremities (*l*) are somewhat convex and turgid; but these differences are not constant. In some instances these membranes can be traced continuously for considerable distances round the several sporangia; but in other cases they seem to have been disturbed and broken up by the swelling of the spores. I apprehend that this derangement, combined with the regular symmetry and exquisite preservation of the vasculo-cellular portions of the cone, may be accepted as an indication that the spores had reached maturity, rather than been in a half-developed state. In all cases the undulating outlines of the sporangia indicate the same thing, the membranes having been apparently corrugated and shrivelled, their protective functions having been nearly fulfilled. The exact number of the sporangia clustered round each sporangiophore is not certain. I have not been able to trace more than three in many instances; but occasionally I find indications of a fourth. We may safely conclude from three to four to have been the normal number associated with each sporangiophore. I am unable also to make out accurately the position and extent of the surfaces attaching the sporangia to the sporangiophores. I have already pointed out the distinctness of the sporangial membranes immediately beneath the external investing bracts on the left side of fig. 4. The *spores* (figs. 11, 12) exist as a dense mass of separate cells, packed closely together within the sporangia; but occasionally detached ones are imbedded in the translucent carbonate of lime with which parts of the fossil are infiltrated, so that their structure is not difficult to determine. They consist of an outer (*i*) and an inner cell-wall (*i'*), the latter obviously representing the primordial utricle of authors and enclosing some peculiar cell-contents. In some instances, as shown in fig. 12, these cell-contents are aggregated into a dark well-defined central mass; but in others, as in fig. 11, this mass has no defined outline, being gradually merged in the inner cell-membrane (*i'*) which encloses it, whilst occasionally it is absent. I was at first inclined to believe that the dark central portions seen in fig. 12 were the spores, enclosed within a true cell; but after a very careful conjoint examination made by Mr. Carruthers and myself, we satisfied ourselves that each cell in its entirety constituted a separate spore. They have an average diameter of from $\frac{1}{250}$ to $\frac{1}{320}$ of an inch, whilst the dark central mass is from $\frac{1}{320}$ to $\frac{1}{350}$ of an inch.

As a rule, I distrust most detailed restorations of fossil plants; but in this instance the specimen is in such exquisite preservation that there can be no doubt as to the general plan of its construction. Fig. 13 may be regarded as a vertical section of its five lower segments, of which the sporangia are supplied to two of the lower ones, whilst the upper two show the relations of the axis to the bractigerous disk and its appendages. That the pith has been fistular in the fully developed cone I infer from the beautiful preservation and sharply defined outline of the cellular tissue lining the interior of the woody axis, combined with the presence, within the cavity, of perfect rootlets of *Stigmaria*, the latter especially proving that the axis was hollow when the strobilus fell into the mud which the *Stigmaria*-roots were permeating with their ubiquitous fibres.

We have next to consider the probable relations of this strobilus to other Coal-measure plants, and especially to the somewhat similar structures described by Mr. Binney* and Mr. Carruthers†, the specimens studied by the latter gentleman having been also derived from Mr. Binney's collection, and being identical in nature with those figured by him. In all essential features my plant corresponds with these, as well as with that described by M. Ludwig and referred to by Mr. Carruthers in the above memoir. Mr.

* *Loc. cit.*

† "On the Structure of the Fruit of Calamites," by Wm. Carruthers, Esq., F.L.S., Journal of Botany, Dec. 1867.

Carruthers's careful description makes a comparison of the points of agreement and difference easy. Describing Mr. Binney's specimen he says, "At regular intervals the axis gives off whorls of appendages which are *alternately* foliar and fruit-bearing." We here note the first difference. In my example *each* node gives off both these elements. "The foliar whorl consists of twelve leaves, which proceed horizontally from the axis until they reach the circumference of the strobilus, where they take an ascending direction. The leaves are united together by their margins until they reach the outside of the fruit, and form a continuous septum, dividing the strobilus into a series of chambers." This description, allowing for the inflections which I have described, identifies the structure spoken of with my bractigerous disk. Thus far we find the essential conformation of the two fruits exhibiting a close correspondence. Mr. Carruthers says, "Between each foliar whorl there is a verticil of leaves specially developed for the support of sporangia." On this point the two types differ. Instead of this alternation, in my specimen the fruit-bearing organs, or sporangiophores, are developed at each node instead of at alternate nodes; and in the place of shooting out at right angles directly from the central axis, they spring obliquely, or almost vertically, from the upper surface of the foliar verticil or bractigerous disk. In Mr. Carruthers's description, the end of each of these sporangiophores is described as being peltate. In only one instance have I been able to trace the upper part of the sporangiophore in my example; and, like the specimen described by M. Ludwig, it appears to have been a thorn-like process, unprovided with any peltate extremity. The structure of the sporangium-wall is identical in the two cases; and the arrangement of the sporangia around the sporangiophore is also similar, making allowance for the vertical position of the latter in my instance, and its horizontal one in

Mr. Binney's. "The spores are simply globular bodies, frequently exhibiting an outer and an inner wall." This description also tallies with my own; but Mr. Carruthers continues, "Sometimes, however, they appear to be composed of a single wall; and then the outer wall is represented by lines more or less separated from the spores. These I believe to be elaters, similar in structure to those of *Equisetum*." I have found spores exhibiting something of this appearance when the outer cell-membrane had been broken up, either by contraction or, more especially, during mineralization; but I am satisfied that my specimen contains no elaters. In the structure of the central axis, again, we have a difference. In Mr. Binney's specimens the centre of that axis is occupied by a bundle of scalariform tissue. Nothing of the kind exists in my plant. Its central portion presents every appearance of having been fistular, or only occupied, in its young state, by cellular tissue. The only vessels to be seen are in the woody axis, where they are reticulated and unaccompanied by any scalariform ones. At the same time, there can be no doubt that the two types are constructed upon the same general plan, the differences which they present being but generic and not ordinal ones. They resemble each other too closely in their common features to leave a doubt that if the one is Calamitean so also is the other; and since no one appears to doubt that such is the character of Mr. Binney's strobilus, I may fairly claim the same rank for my own. What, then, is the signification of the points in which they differ? It will be remembered that the Calamitean stem which I described under the name of *Calamopitus* was characterized by the possession of reticulated vessels instead of the scalariform ones common in other types of Calamite, and by a peculiar arched arrangement of those scalariform vessels wherever they crossed the node, which latter arrangement is common to *all* the types of Calamite of which I have hitherto seen the internal structure; and, in addition, *Calamopitus* has its projecting ridges composed of longitudinal wedges of vascular tissue, separated by intervening ones of prosenchyma.

Fig. 8 shows that my strobilus exhibits the first of these characteristics; figure 7 *e* displays the second; whilst, if I am correct in my interpretation, we find the third feature echoed in the longitudinal arrangement of the vascular bands (fig. 7, *e e'*), and in the relationship of those bands to the small longitudinal canals (fig. 3, *d*), as well as to the masses of cellular prosenchyma (fig. 7, *c c'*) which separate them. Bearing in remembrance the apparently obvious fact that my strobilus is an indisputable Calamitean fruit, and that *Calamopitus* is the only Calamitean stem hitherto described possessing the true reticulated vessels which it exhibits, it becomes more than probable that some close relationship exists between the two plants. If they are not actually the stem and fruit of the same species, at least the fruit must have belonged to some hitherto undiscovered stem with reticulated vessels closely allied to *Calamopitus**. It is true that, in the specimen of the latter which I described, I could not trace the small canal seen at the inner angle of the woody wedges of other Calamites; but I have already found specimens which indicate the possibility that this apparent absence may have been due to mineralization masking, by dark carbonaceous deposits, what may have existed in its minimum rather than its maximum degree.

At first there seems to be a difficulty in admitting the association of a cryptogamic fruit with an exogenous stem; but we do not escape this difficulty by refusing to accept my suggestion. No one can doubt that *Calamopitus* is merely

* Since this memoir was read I have obtained stems with reticulated vessels, but otherwise like Calamodendra, to which the strobilus may have belonged.

a highly developed Calamitean plant; neither does any one now doubt that the fruit of Calamites was cryptogamic. Besides which, we must remember that a cambium-layer and an exogenous mode of growth are still found associated with Cryptogamic inflorescence in all the living Marsileaceæ; so that the possibility of the combination which I have suggested is in strict accordance with conditions known to exist, instead of being, as some have supposed, abnormal, and contradicted by all modern experience.

The only other known Coal-measure plants in which reticulated structures abound are those for which I have proposed the name of *Dictyoxylon**. But whatever objections may suggest themselves to identifying the strobilus with *Calamopitus* militate in a tenfold degree against a similar identification with *Dictyoxylon*. The latter is not only exogenous in growth, but probably a true Exogen in the technical sense of the word, if not even an actual Conifer; hence there is the greatest improbability that it bore a Cryptogamic strobilus. But, on the other hand, admitting that *Calamopitus* and this strobilus are equally Calamitean in type, that they exhibit essential features which they possess in common, and that in both cases these features point to a higher organization than is usual amongst the more ordinary Calamites, I am justified in concluding that the subsistence of a close relationship between the two fossil plants is more than probable. Assuming this probability to be established, what light does the fact throw upon the affinities of the above fossils with recent plants? I find in my strobilus, as already stated, nothing like Equisetiform elaters. The spores are simple cells, which is also the case with recent Equisetiform spores in their young state. But, for reasons already given, I believe the fruit described to have been fully developed. Consequently, so far as it goes, it gives no support to the

* Monthly Microscopical Journal, No. viii. August, 1869.

idea that *Calamopitus* was Equisetaceous; on the other hand, whilst the stem was more complex than that of living Equisetaceæ, the fossil spores are more simple in their organization than in the recent genus. The fruit sustains the conclusion at which I arrived from a study of the stem, that *Calamopitus* possessed a higher organization than the known forms of *Calamodendron.*

The exogenous growth of the stem by the regular addition of new vascular bundles to the exterior of the woody axis, indicates the possession by these plants of a cambium-layer such as exists in the living Marsileaceæ. Unfortunately we know too little of the cortical layer of Calamites to affirm any thing respecting it; but it becomes of great importance to ascertain whether it was persistent, receiving *internal* additions from the cambium-layer (in which case we should expect to find it in some degree ruptured externally), or whether it was thrown off annually and annually reproduced as in the living *Isoëtes.* As yet we possess no facts throwing light upon either of these problems*; but when we obtain their solution, we shall doubtless find in it the explanation of the great differences observable, both in the aspect of the cortical layer of fossil Calamites and in the opinions of authors respecting its thickness and aspect.

Mr. Butterworth informs me that he found the specimen here described in a nodule from the upper foot-coal at Roe Buck, in Strinesdale, Saddleworth.

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Fig. 1. Lateral aspect of the lowest segment of the specimen, enlarged four diameters.

Fig. 2. Inferior surface of the same segment, showing the pyriform canals around the medulla, *a*; *b*, margin where the bractigerous disk divides into separate bracts.

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* This bark has now been obtained, and will shortly be described.—April 21, 1870.

Fig. 3. Transverse section of part of central portion of fig. 2, made in the line *x x*, fig. 13: *c*, *c*, primary peduncles; *d*, *d*, longitudinal canals of axis; *e*, *e*, bundles of reticulated pleurenchyma; *f*, *f*, larger pyriform apertures in the bractigerous disk; *g*, *g*, smaller apertures; *h*, *h*, bases of the sporangiophores; *i*, sporangia.

Fig. 4. Slightly oblique transverse section of one of the upper segments of the strobilus, made in the line *w w* of fig. 13, passing through the bractigerous disk opposite to *x* (fig. 4), and a little above it in the rest of the section: *a*, medulla; *c*, primary peduncles; *h*, *h'*, *h''*, sporangiophores; *i*, sporangia; *l*, cellular sporanginm-walls, seen in section.

Fig. 5. Central part of a transverse section of half of the segment figs. 1 and 2, made in the plane *y y* of fig. 13: *a*, medulla; *c*, *c*, external ridges of the central axis, identical with the primary peduncles of fig. 4; *i*, sporangia.

Fig. 6. Vertical section of segment figs. 1 and 2: *a*, medulla; *c*. central axis; *h*, sporangiophore; *i*, *i'*, sporangia; *k*, bractigerous disk; *k'*, bract.

Fig. 7. Lateral half of a vertical section of one of the upper segments: *a*, medulla; *c*, cellular tissue descending from the node *e* towards the bractigerous disk below; *c'*, prosenchyma ascending towards the next bractigerous disk above; *c''*, thin layer of prosenchyma separating the larger pyriform canal *f* from one of the smaller ones not seen in the section; *e*, arches of reticulated pleurenchyma forming the node; *e'*, the same pleurenchyma prolonged upwards, external to the prosenchyma of the axis; *h*, sporangiophore belonging to the bractigerous disk *c*; *i*, *i*, spores; *l*, inferior wall of a sporangium resting upon the bractigerous disk *c*; *l'*, external wall of the sporangium *i*.

Fig. 8. Two reticulated fibres from 7 *e*, more highly magnified.

Fig. 9. Transverse section of upper part of a sporangiophore: *h*, peripheral margin; *h'*, inner margin.

Fig. 10. Transverse section of part of a sporangium-wall: *l*, inner surface; *l'*, outer surface.

Figs. 11, 12. Detached spores: *i*, outer cell-membrane; *i'*, inner-cell membrane.

Fig. 13. Restored vertical section of five inferior segments of the strobilus: *a*, medulla; *b*, outer margin of bractigerous disk; *c*, central axis; *h*, sporangiophores; *i*, *i*, sporangia; *k*, external bracts; *l*, sporangium-walls; *w w*, plane of section, fig. 4; *x x*, plane of section, fig. 3; *y y*, plane of section, fig. 5.