ON THE FOSSIL FRUCTIFICATIONS OF THE YORKSHIRE COAL MEASURES.

BY WILLIAM CASH, F.G.S.

No. 1. CALAMOSTACHYS.

The fructifications of the fossil plants of the Coal Measures are of great interest to the botanist, whether studied from an evolutionary point of view, or simply as guides to the classification of the plant-remains with which they are usually found associated; and none of them are more interesting than the small cone-like fruit spikes so well known to palæobotanists by the generic name *Calamostachys*.

The coal-measures up to the present time have yielded to geologists no remains of plants referable to the large group of true flowering plants (Angiosperms), for the Scotch fossil *Pothocites grantoni*, which is often quoted in text books of geology as an example of a fossil dicotyledonous plant nearly allied to the recent arums, had its supposed systematic position questioned so long ago as the year 1874, by Professor W. C. Williamson, F.R.S., and his views have since been abundantly justified by the researches of Mr. Robert Kidston, F.G.S., who, with fuller material at his command has, in the Annals and Magazine of Natural History for May, 1883, demonstrated that *Pothocites* is the fruit of *Bornia* (*Archæocalamites*) *radiata*, Brogn., or of a closely allied species of the same genus.

With the exception of some spores and a few examples of the mycelium of a fungus, the whole of the carboniferous flora is probably restricted to what modern botanists call the *Archegoniata*; since, in the present state of knowledge, they may all be referred to either the vascular Cryptogams, or to the Gymnosperms.

Twenty-five years ago the fructifications of the coal flora were known, almost without exception, either as casts, by the impressions of plants from iron-stone nodules or from shales, or by still more imperfect examples found in the grits and sandstones.

During the last two decades, however, the exploration and study of the calcified fossils of the Halifax Hard Bed Coal in Yorkshire, of the

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equivalent bed at Oldham and elsewhere in Lancashire, of the Scotch beds at Laggan Bay in the island of Arran, at Burntisland, in Fifeshire, of the coal measures of Westphalia, of Moravia, and of Barnat in S. Hungary, as well as of the silicified specimens from St. Autun and St. Etienne in France, have yielded rich and precious material, which has thrown a flood of light upon an exceedingly difficult department of palæobotany, for it was only when the delicate organs of fructification were discovered with their minutest structures intact that the consequent rapid advance in our knowledge of this department became possible.

In Yorkshire, through the energetic and intelligent labours of Messrs. Binns, Butterworth, and Spencer, many interesting forms have been discovered and described, and especially by the long-continued and invaluable researches of Dr. W. C. Williamson, has this department of palæobotany been again and again enriched.

The chief fossil fructifications of the Yorkshire coal measures are *Lepidostrobi* or fruit cones of *Lepidodendron* of several species, the true fructification of *Calamities*. (Williamson: *Memoirs of the Literary and Phil. Society of Manchester*, 1869-70.) *Bowmanites* (*Volkmannia*) *Dawsoni*, probably the fruit of *Asterophyllites*. (Williamson: *Memoirs of the Literary and Phil. Society of Manchester*, 1870-71.) Several sporangia of ferns, and the fruits of numerous Gymnospermous plants, (*Cardiocarpon*, *Lagenostoma*, *Trigonocarpon*, &c.) In addition to those now enumerated there are many sporecases, &c., (*Sporocarpon*, *Traquaria*, *Zygospores*, &c.), which are as yet of doubtful affinities.

The state of preservation in which these fructifications occur is very remarkable, the cells of which the organisms are built up have been infiltrated with transparent carbonate of lime, the cell-walls have been mineralised, and when the fossils are found fairly free from iron pyrites, they may be cut by the aid of the lapidary's wheel into slices, which can be attached by canada balsam to slips of glass, and then ground down sufficiently thin and transparent for microscopic examination; under a low magnifying power they display all details as perfectly as sections cut from a living plant, and under the higher powers are seen to exhibit a perfection of structure even in their

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minutest parts, which is not only highly instructive but also exceedingly beautiful to look upon; to quote the exclamation of the late Charles Darwin on his first acquaintance with these coal-plant micro-preparations, "It is marvellous to see structure so admirably preserved for so many ages."

The Yorkshire localities for these fossils with minute "structure so admirably preserved," are the pits where the "Halifax Hard Bed Coal" has been worked, these may be studied all along a line parallel with the outcrop of the lower coal-measures extending from north to south by Leeds, Yeadon, Denholme, Holmfild, Sowthowram, Halifax, Elland, Huddersfield, Hepworth, Penistone, and Hazlehead near Sheffield. A portion of the Lancashire bed known as the "Upper Foot Coal," occurs near Saddleworth, on the Lancashire border of the county.

The Hard Bed or Ganister coal may be readily recognised and traced over the whole coalfield, it lies on hard ganister underlying, which there is usually a bed of fire-clay; the roof of the bed of coal is generally composed of a dark shale containing fossil shells (*Goniatites Listeri*, *Orthoceras Stienhaueri*, *Aviculopecten papyraceus*, and other marine shells.) The coal itself and the superimposed shales often contain calcareous nodules with included fossils, the nodules in the coal known locally as coal balls, generally contain plant remains with the minute structure sometimes beautifully preserved but often, alas! spoiled by the large quantity of contained iron pyrites.

The order of superposition of the ganister group is given in "The Geology of the Yorkshire Coal Field: Memoirs of the Geological Survey." London, 1878, as follows:—

[The average thickness in feet of the various groups on the south are given in the left-hand margin and those of the north in the right-hand margin.]

S. Feet.		N. Feet.
540	{ The Elland Flagstone. Measures with irregular Sandstones and thin Coals.	{ 360

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	S. Feet.		N. Feet.
GANISTER GROUP.	150	<i>The Ganister or Hard Bed Coal.</i> Measures. <i>Clay or Middle Bed Coal.</i> Measures with middle rock. <i>Coking or Soft Bed Coal.</i>	30
	120	Crawshaw Sandstone, and Soft Bed Flags, or equivalent measures. Thin Coal and Underclay. Rough Rock.	50

My friend, Mr. James W. Davis, F.L.S., of Chevinedge, Halifax, thus tabulates the series of lower coal measure beds in the Halifax district. (See "A Monograph of the Morphology and Histology of *Stigmaria ficoides*." By Mr. W. C. Williamson, LL.D., F.R.S., Palæontographical Society. Vol. XL, p. iv. Lond. 1886):—

			Ft.	In.	Ft.	In.
Elland Flagrock—Flags	...	...	45	0		
„ Shales	...	...	35	0		
„ Flags	...	...	120	0		
					200	0
Shale	...	...	...	...	80	0
<i>Eighty Yards Band Coal, or Upper Band Coal</i>	...	...	...	...	0	6
Eighty yards Band Rock	...	...	...	...	15	0
Black Shales	...	...	...	...	80	0
<i>Hard Bed Band Coal (Forty-eight yards Coal)</i>	...	...	...	...	1	2
Shales with Ironstone	...	...	...	...	35	0
<i>Thirty-six yards Band Coal</i>	...	...	...	...	1	0
Fire Clay or Gaillard	...	...	...	...	1	6
Shale with thin Sandstones	...	...	...	...	95	0
Shale containing concretions of Carbonate of Lime with covering of Iron Pyrites. Full of Goniates, Nantili, Orthocerata, Nuculæ, Aviculopectens.					5	0
Laminated Shale with Aviculopecten	...	...	...	...	0	4
HARD BED OR GANISTER COAL, containing concre- tions of Carbonate of Lime and Iron (coated and sometimes quite charged with iron-pyrites), containing vegetable remains most admirably preserved	...	...	...	...	2	2

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					Ft.	In.
Ganister Rock	...	...	...	...	1	0
Seat Earth	...	...	...	...	5	0
Shale	...	...	...	...	25	0
<i>Middle Band Coal or Clay Coal</i>			...	...	0	6
Middle Band Rock	...	...	...	...	12	0
Shales	...	...	...	...	50	0
<i>Soft Bed Coal</i>	...	...	...	...	1	6
Seat Earth	...	...	...	...	2	0
Sandstone	...	...	...	...	20	0
Shale	...	...	...	...	80	0
<i>Thin Coal</i>	...	...	...	...	0	6
Seat Earth	...	...	...	...	5	0
Rough Rock	...	...	...	...	0	0

Fig. 1. Section in Lower Coal Measures, Beacon Hill, Halifax.

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- a. Marine Beds with "Baum Pots," containing Goniates, Nautilus, Orthoceras, Avicula-pecten, and occasionally fossil wood.
- b. Hard Bed Coal, with "Coal of Balls," containing remains of plants.
- c. Ganister Rock and Seat Earth.

Fig. 2. Enlarged section of the Hard Bed Coal.

Mr. James Spencer, of Halifax, who has devoted many years of his life to the enthusiastic study of the lower coal measures and their fossils and added several new forms to our local fossil flora, has kindly placed at my disposal for publication a diagram and description of a typical section of the measures found in Beacon Hill, near Halifax.

"The section of Beacon Hill on the East of Halifax, will give a good idea of the succession of the different beds composing this group.

Crowning the hill there is the valuable sandstone rock known as the Elland flagstone which is extensively quarried all around the outcrop of the coalfield from Leeds, by Bradford to Halifax, and thence to Elland, Huddersfield and Penistone. Underlying the flag-rock in descending order, there are 120 feet of shale and rag, then the 80 yards band coal, which is only about 6 inches in thickness, then 100 feet of shales and rag, followed by the 48 yards band coal of about 10 inches in thickness, then 36 feet of shales, followed by the 36 yards band coal, having from 3 to 4 feet of seat earth under it, which forms one of the most valuable fire-clays in the neighbourhood; then follow about 100 feet of shales gradually merging towards the base into fossiliferous marine strata, then come about 8 or 10 feet of shales highly charged with calcareous nodular concretions, locally known as baum pots, generally coated with pyrites, and containing

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a rich and varied assortment of marine fossil shells, such as *Goniatites*, *Nautili*, *Orthocerata*, *Aviculopecten* and others, along with a few fish remains. Immediately underlying these marine strata is the *Hard Bed Coal*, containing in many places (for they are not uniformly distributed), those remarkable calcareous nodules locally known as coal-balls. The coal-balls are found in the coal itself, and in some places the whole bed is occupied by them with only a little admixture of coal, but generally they seem to be scattered throughout the coal seam at irregular intervals. Some coal pits yield them more abundantly than others.

The material composing the coal-balls consists of a mixture of carbonate of lime and carbonate of iron, with iron pyrites, calcspar, and fossilised vegetable remains. They are nearly always thickly coated with pyrites, and are often very difficult to break open, an ordinary hammer being of little use for this purpose, and too frequently the whole ball is one mass of pyrites. In composition and external appearance they somewhat resemble the nodular concretions which occur in the marine strata above the coal, but there is a total difference in their fossil contents. The "Coal-balls" contain fossil plants exclusively, while the "baumpots" contain marine shells, and sometimes fish-remains, and occasionally fragments of fossil-wood (*Dadoxylon*), which have evidently drifted into the sea or estuary in which the bed was originally laid down from some neighbouring land.

The hard bed coal rests upon the very peculiar rock called ganister, which varies in thickness from 1 foot 4 inches in the neighbourhood of Halifax, to 3 feet in the neighbourhood of Penistone. Underlying the ganister there is a bed of soft earth, and both seat earth and ganister are full of *Stigmarian* roots and rootlets, while some of the best specimens of the ordinary *Stigmaria* are met with in the ganister rock. About 75 feet below the hard bed coal the soft bed coal is met with, and midway between them occurs another thin seam called the middle band coal; underlying it, there is a valuable bed of fire-clay, which is extensively worked in this district. Midway between the middle-band and the soft bed coal, there are three layers of shale, which are literally full of *Anthracosia*, separated by black shale containing *Spirorbis carbonarius*.

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The strata below the soft bed coal contains nothing very noteworthy in the Halifax district, but in the neighbourhood of Huddersfield occur what are called the soft bed flags, and under them certain layers of shale containing fossils such as *Aviculopectens*, *Goniatites*, and some fish remains. At the bottom of the series is a bed of coal about six inches thick, having under it the usual seat earth, these lie conformably upon the Rough Rock."

Among the various fossil fruits which have been found in the Coal Measures are small cones or fruit spikes, which were originally included in Sternberg's genus *Volkmannia*, the definition of this genus is not quite satisfactory, as indeed it may be used to designate fruit spikes, which are now distinctly referable to other well-defined genera. The two fruit-spikes exhibiting structure in our Yorkshire measures, and which were originally assigned to the genus *Volkmannia*, are *Volkmannia Dawsoni*, (*Bowmanites Dawsoni*), and *Volkmannia Binneyi*, (*Calamostachys Binneyana*.) These, along with *Calamostachys Casheana*, and Williamson's "True Fruit of the Calamities" are the only ones which I know from Yorkshire which contain structure which can be ascribed to Weiss' group of *Calamariæ*.

Calamostachys Binneyana was described by Professor Carruthers in Seeman's Journal of Botany, Vol. V., 1867, in a paper "On the Structure of the Fruit of Calamities," under the name of *Volkmannia Binneyi*, when, from the material then at his command, he concluded that it was a true Calamitean fruit-spike, and in comparing its organisation with that of the fruit-spike of *Equisetum*, he pointed out their apparent identity of organisation. In a lecture given by the learned Professor before the Royal Institution of Great Britain on 16th April, 1869, he said "A comparison of the fossil cone (*Volkmannia Binneyi*), with the fruit of *Equisetum*, exhibits a remarkable agreement with every point of importance. In the form of the fruit-bearing leaves, the arrangement and structure of the sporangia, the form size, and structure of the spores, even to the possession of hygrometric elaters, both fruits agree. The only difference is that in the modern plant all the leaves of the cone are fruit-bearing, while in the fossil every other whorl retains a form closely approaching that of the normal leaf of the plant. As these envelop and protect the fruit-

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bearing leaves, they may be held to give to the fossil a somewhat higher systematic position than is possessed by the living genus. This superiority is further exhibited when we contrast the complex structure of the stem, and the free leaves of *Calamites* with the fistular and sheathless stem of *Equisetum*."

Binney in his "Observations on the structure of fossil plants found in the carboniferous strata," "*Calamites* and *Calamodendron*," Palæontographical Society, London; and also in his "Note on the organs of Fructification and foliage of *Calamodendron commune*," published in 1870, in the "Transactions of the Literary and Philosophical Society of Manchester, Vol. IV., third series," describes this fruit-spike and practically accepts the conclusions arrived at by Professor Carruthers. Schimper in his classical and famous work, "Traité de Palæontologie Végétale," Vol. I., Paris, 1869, also regards *Volkmannia Binneyi* as the fruit of the Calamite, at the same time referring to his genus *Calamostachys*, in which he includes the following five species:—

Calamostachys (<i>Calamites</i>)	typica,	Sch.
do.	do.	calamitis foliosi, Sch.
do.	do.	polystachya, Stern.
do.	do.	Binneyana, Sch.
do.	do.	major (Germ.)

He thus describes: *Calamostachys* (*Calamites*), *Binneyana*, Sch. "Spicis minutis, centimetro 1 vix longioribus, amentiformibus; bracteis e disco horizontali erectis, imbricatis, internodium paululum superantibus; sporangiophoris in quoque internodio 6 tetraspermis, ita ut 24 sporangia ibidem adsint. Tab. nostra fig. 5-10."

"*Calamodendron commune* E. W. Binney, Observat. on the struct. of foss. plants found in the carbon. strata; *Calamites* and *Calamodendron*, London, Palæont. Soc., 1868, tab. IV., V., avec de nombreux détails microscopiques."

"Dans des nodules de chaux carbonatée du terrain houiller du Lancashire (Angleterre.)"

"Les epis dont il est question ici appartiennent sans aucun doute à une autre espèce que ceux que M. d'Ettingshausen rapporte à son *Calamites communis*, et que nous avons décrits sous le nom de *Calamostachys typica*."

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“J’ai déjà fait observer plus haut que le *Volkmannia sessilis*, Presl, le *Calamodendron commune*? et l’*Asterophyllites longifolia*, figurés à la pl. VI., du mémoire de M. Binney, appartiennent à l’*Annularia longifolia*.”

On the 19th June, 1873, Professor W. C. Williamson read his fifth paper “On the Organization of the Fossil Plants of the Coal Measures,” in which he discusses “the relations subsisting between certain stems described by him, and the numerous fruits that have been described and figured by various observers on previous occasions.” And he there contends “that the only British strobilus, of which the internal organization has hitherto been described, that has any claims to be regarded as the fruit of Calamites, is that which I figured in the fourth volume of the ‘Transactions of the Manchester Literary and Philosophical Society,’” this contention and the Professor’s expressed views on the structure of this strobilus have been very recently fully confirmed, and are fully expressed in his last memoir, “On the true Fructification of the Calamities.” Org. of Foss. Plants of C. Meas., Pt. XIV., Phil. Trans., London, 1888. The learned Professor’s views on the relation of the fruit spike of *Calamostachys Binneyana* to *Equisetum* and *Calamites* are thus summed up. “After balancing these various facts and arguments, I am led to the conclusion that *Calamostachys Binneyana* has much closer affinities with *Asterophyllites* than with *Calamites*. With the latter it has no one structural feature in common. There is no solitary point in which the two plants resemble each other. The resemblance of the fertile sporangia of *Calamostachys* to those of *Equisetum*, has been combined with the foregone conclusion that the *Calamites* were Equisetaceous plants, in leading to the belief that the two were parts of the same plant; but I cannot conceive of any conditions in which the stem of a *Calamite* could be prolonged into that of the *Calamostachys*. I have carefully investigated the relations which the fertile stems of *Equiseta* bear to axes of their terminal fruit spikes, and I find that their respective structures are typically identical. The transition from the stem to the fruit-axis produces no structural changes save such as are of the most trivial kind; the general type remains unaltered and continuous. But to place *Calamostachys*

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Binneyana upon the top of a Calamite, would be as abnormal as to surmount the stem of an *Equisetum* with the strobilus of a *Lycopod*."

Weiss in his "Steinkohlen Calamarien, Berlin, 1876," defines *Calamostachys*: "With paniculated shorter fruit spikes, mostly with separate tracts between which are the fertile whorls, consisting usually of six column-shaped bearers, each with four sporanzia; each sporangium is attached to a disc-shaped enlargement (shield receptaculum) of the bearer; axis of the spike solid."

He classifies the fruit spikes of his group *Calamariæ* in three sections as follows:—

1. The fruit spikes consist of fertile whorls without sterile ones—*Equisetum*.

2. The fruit spikes with whorls of sterile strongly crossed foliar-discs (Deckblattkreise), the covers always on the upper end of the internodes and the fertile whorls arranged alternately; for example, the small columns or bearers are:

(a) Exactly in the middle between two sterile whorls, or in the greater distance from each of the two next whorls in *Calamostachys*, *Stachannularia*, *Macrostachya*.

(b) At the base of the internodes or in the angle of the discs upper leaf covers (Deckblattwinkle) in *Palæostachya*

(c) Discs at the upper end of the internodes under the leaf cover whorls (Deckblattwirtel) in *Cingularia Huttonia*.

3. Finally (questionable), the sporangia are sessile in the angle of the upper leaf cover, in *Volkmannia*.

R. Zeiller (végétaux Fossiles du Terrain Houiller de la France, 1880), refers *Calamostachys* to the *Annulariæ*, under the name of *Bruckmannia*, as is evident from his description, "dans ceux de ces épis (*Bruckmannia*), dont on a pu étudier la structure, on a reconnu des sporangiophores disposés par verticilles alternant avec des verticilles de bractées stériles."

Professor Renault includes *Calamostachys* among the *Equisetaceæ* (Cours de Botanique Fossile (Deuxième Année, Paris, 1882), under the genus *Bruckmannia* as fructification of *Annularia*, "incertæ sedis," and consequently among his *Heterosporous Equisetaceæ*, in a later publication of his (Sur les fructifications des *Calamodendrons*),

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he seems to take a quite different view of these fructifications thus,—
 “Les *Calamodendrons*, les *Arthropites*, certains *Astérophylrites*, les *Annulariæ*, &c., présentent également leurs fructifications disposées d’une manière assez peu différente, *c’est à dire sous forme d’epis composés alternativement de verticilles fertiles*,” he then proceeds to discuss the fruit of *Calamodendron*, and after describing the fruit spike, sporangia and spores concludes that “the complication of organization of the sacs contained in the fruit spikes of *Calamodendrons*, and that of the reproductive bodies which they contain, bring us to the conclusion that we have here to do with pollen sacs and pollen grains, and that the *Calamodendrons* are phanerogams by their *roots*, their *stems*, and their *fructifications*.”

H. Graf zu Solms-Laubach (Einleitung in die Paläophytologie, Leipsic, 1887), p. 339, refers to these views of Professor Renault :—

“Quite recently Renault, who formerly included all these before-mentioned fruit spikes among his *Astérophylrites* and *Annulariæ*, has formed the opinion that one part of them belongs as male elements (männliche Blüthen) to the genera *Arthropitys* and *Calamodendron*, *Calamostachys Binneyana* and *C. Grand'Euryi* are especially mentioned as such, and their spores are straight-way called pollen grains. He relies partly upon the structure of the ligneous bodies of the pith; partly upon the detailed examination of the spores, in which he recognises an inner cell arrangement of the kind seen in the pollen of *Cordaite*s. He refers, by comparison, at the same time to the tetragonal arrangement of the spores to the tetradic Angiosperm pollen; then to the fact that similar tetragons have been found in the pollen cells of certain *Trigonocarpons* as well as of *Gnetopsis trigona*. It is difficult to criticise so dogmatic a description, especially as the fundamental basis (grandlagen) is very short and preliminary. However, I should like to say a few words. There is no analogy of a male blossom (männliche Blüthe) consisting of fertile and sterile leaf-whorls. It is not sufficient proof that we find solitary tetra-spores in the pollen vessel of wind fertilised Gymnosperms; every cell which is smaller than the micropyle opening will, if it gets attached to it, enter it. Tetradically connected spores are not indeed known, but are by no means impossible. The inner

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cell body equally is no proof, taking it as I do, in spite of Strasburger's recent explanation, as a rudimentary prothallium. As we know, the microspores have such a prothallium as well, its more or less strong development is not to be considered, and after all, what is Renault going to do with Williamson's fruit-spike, containing macrospores and microspores. It will have to remain, of course, amongst the Annulariæ in spite of its resemblance to *Calomostachys Binneyana*. The only criticism that remains is the secondary wood of the spike, and thus we arrive again at the so often mentioned *petitio principii* of Brogniart's school, which makes so difficult to understand the writings referred to."

Though *Calamostachys* cannot be regarded as the fruit of *Calamites*, nor as a very near ally of our *Equisetum*, yet in the present state of our knowledge of fossil botany we may at least provisionally include, as Weiss has done, the fruit-spikes we have enumerated in one group, the *Calamaricæ*. The only living genus of the group is the *Equisetum*, and the following table may serve to exhibit the chief points of resemblance and difference between that genus and *Calamostachys*:—

FRUIT-SPIKES.

(The letters given in the first column have each the same import in all the figures).

			EQUISETUM. (Plate 28.)	CALAMOSTACHYS. (Plates 22.—27.)
<i>Axis</i>	-	-	hollow or fistular	solid
<i>Sterile Bracts</i>	-	-	none	twelve or more, double the number of the fertile bracts and arranged in alternate verticils with them.
<i>Sporangiophores</i> (fertile bracts)	-	-	stalked peltate discs, arranged in verticils	stalked peltate discs, arranged in verticils, and in number 6 or more, always half as many as the sterile bracts.

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	EQUISETUM.	CALAMOSTACHYS.
<i>Sporangia</i> - - -	arranged around the inner surface of the peltate discs so that they lie nearly at right angles to the central axis of the fruit-spike	arranged around the inner surface of the peltate discs so that they lie nearly at right angles to the central axis of the fruit-spike.
<i>Spores</i> - - - (Mic=microspores, mac=macrospores)	numerous, small, nearly uniform in size (microspores) and provided with elaters	numerous small spores (microspores) having no elaters, and in <i>C. Casheana</i> , Williamson, there are also present large spores, macrospores.

There have appeared in "Nature" two communications respecting the spores of *Equisetum*, which, if they may be relied upon, will certainly tend to bring *Equisetum* and *Calamostachys* into a nearer relationship than they are now regarded as occupying by most palæobotanists. One of these states that a living species of *Equisetum* produces *macrospores*, the other one says that "The remarkable *Equisetum littorale*, differing from all other species in the absence of elaters, is recorded as British (and figured) by Mr. Beeby, on the faith of specimens from Surrey. Journal of Botany, March and April, 1887. Nature, 19th May, 1887, p. 70. I have seen neither of these species, and cannot help thinking that there is some error in observation, at any rate, until these supposed discoveries are confirmed, one must not use them in any way to modify ones views of the relationship of *Calamostachys* to *Equisetum*.

Sir J. W. Dawson evidently regards *Calamostachys* as the fruit of some species of *Calamites*, or at least of some allied Equisetaceous plant. In his work on "The Geological History of Plants," lately published (in the International Scientific Series, Vol. LXIII., Lond., 1888, p. 123-5), he thus speaks on this question: "All *Calamites* were not alike in structure. In a recent paper, Dr. Williamson describes three distinct structural types. ("Memoirs of the Philo-

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sophical Society," Manchester, 1886-87.) What he regards as typical *Calamites* has, in its woody zone, wedges of barred vessels, with thick bands of cellular tissue separating them. A second type, which he refers to *Calamopitus*, has woody bundles composed of reticulated or multiporous fibres, with their porous sides parallel to the medullary rays, which are better developed than in the previous form. The intervening cellular masses are composed of elongated cells. This is a decided advance in structure, and is of the type of those forms having the most woody and largest stems, which Brogniart named *Calamodendron*. A third form, to which Dr. Williamson seems to prefer to assign this last name, has the tissue of the woody wedges barred, as in the first, but the medullary rays are better developed than in the second. In this third form the intermediate tissue, or primary medullary rays, is truly fibrous, and with the secondary medullary rays traversing it. My own observations lead me to infer that there is a fourth type of Calamitean stem, less endowed with woody matter, and having a larger fistulous or cellular cavity than any of those described by Dr. Williamson.

There is every reason to believe that all these various and complicated stems belonged to higher and nobler types of mare's-tails than those of the modern world, and that their fructification was equisetaceous, and of the form known as *Calamostachys*.

CALAMOSTACHYS BINNEYANA. Schimp.

This fruit spike consists of verticils of bracts arranged around a central axis ; these are fertile bracts and sterile ones which succeed each other in *alternate* order.

The *sterile bracts* form a sort of circular, horizontally placed foliar disc, which, on nearly reaching the surface of the fruit spike, breaks up into verticils of leaves which bend abruptly upwards nearly at right angles, and largely overlap the next sterile whorls, giving an imbricated arrangement on the exterior of the spike, these leaves, usually twelve, are double the number of the fertile bracts or sporangiophores.

The *sporangiophores* are column-shaped organs (usually six), in number half as many as the sterile bracts, they are also arranged in verticils.

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Each sporangiophore stands out at right angles to the axis of the fruit spike, and is enlarged at its outer extremity into a considerably thickened *peltate disc*.

The *sporangia* or spore sacs are attached to the inner surface of each peltate disc, usually in fours, arranged around its pedicel.

The spores which show no trace of the presence of elaters fill the sporangia and are of small size, ranging in diameter from .04 to .05 m.m. in diameter.

The *axis* of the fruit spike is provided with a solid medulla, composed of parenchyma, the cells of which are somewhat elongated vertically, and which is enclosed in a thin cylinder of barred spiral vessels.

Professor Williamson in his memoir on the organisation of the Fossil plants of the coal-measure, read 17 June, 1880, was enabled from a specimen supplied to him from my cabinet to clear up an uncertainty as to the position of the organic union of the sporangia to the sporangiophores.

The disc in this specimen consists of a mass of parenchyma, amongst the cells of which an extension of the bundle of spiral cells that passes along the peduncle of the sporangiophore, is prolonged towards the margin of the disc; as the bundle approaches this margin its cells multiply as is the case with similar structures in the sporangiophores of recent *Equisetum*, as well as in other very different structures, *e.g.* the terminations of the hair-like emergences of the *Drosera*. The peripheral surface of the disc appears to have been composed of a layer of oblong cells, which are planted perpendicularly to it. Each sporangium is not connected with the peltate end of the sporangiophore by the entire base of the former, as is the case in the living *equiseta*, but a very narrow neck of cellular tissue attached to a point a little within the extreme overhanging margin of the sporangiophore; the remainder of the sporangium being entirely free.

I have specimens of *Calamostachys Binneyana* in my cabinet from the Halifax Hard Bed, Lower Coal Measures, of Sunny Bank and Bank Top Pits, Southowram, of Sugden Pit, near Halifax;

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from Elland, from Huddersfield, and from the Upper Foot Coal of Stronesdale, Saddleworth, Yorkshire, and also from near Oldham, Lancashire.

CALAMOSTACHYS CASHEANA. Williamson.

The only other species of *Calamostachys* which to my knowledge occurs in Yorkshire is *Calamostachys Casheana*, Williamson. This was described by Professor Williamson in his eleventh memoir on the organisation of the fossil plants of the Coal Measures from a specimen discovered in the Halifax beds by the late Captain Aitken. The importance of this specimen, which in other respects agrees in the main in all its details with *C. Binneyana*, lies in its spores. In the slightly oblique and longitudinal section of this fruit-spike all the sporangia of the uppermost of the three fertile verticils, as well as those to the right of the middle one are filled with microspores. The three to the left of the middle verticil, and all the four of the lowermost ones contain macrospores. The microspores are about '0031 in. and the macrospores occur as large as '01, most of them equally '0093 in. The latter exhibit an outer sporangial wall, as well as an inner one, whilst a dark coloured mass exists in the centre of most of the examples.

Since the publication of the paper here alluded to I have secured specimens from the Upper Foot Bed, Strinesdale, Saddleworth, in Yorkshire but close on the Lancashire Border. Figures from photographs of these are given in Plate

In our report on recent Researches amongst the Carboniferous Plants of Halifax" at 56th Meeting of the British Association, held at Birmingham in September, 1886, Dr. Williamson refers to those specimens, and to some still better preserved examples which I handed over to him for study.

"We have also obtained a fresh example of the remarkable heterosporous form of *Calamostachys*, described in Part XII. of the "Organisation of the Fossil Plants of the Coal Measures," and which latter example previously constituted the only known specimen of a Calamitean plant with bisexual fructification. This second example seems to establish clearly the distinctness of this fructification from that of the allied *Calamostachys Binneyana*; and I now propose that it should be known as *Calamostachy Casheana*."

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What is the plant to which these *Calamostachys* fruit spikes should be referred, is a question which, I fear, we are not yet in a position to answer very definitely. That it belong to Weiss' group of *Calamariæ*, I have no doubt, further than that I am not at present prepared to go, except to express my opinion that it is not a true *Calamites*, and I think a comparison of the transverse section of the fruit-spike axis of *Calamostachys* with the stem of *Calamites* will substantiate this view. On the latter (plate XXIX.) we have a hollow stem with a pith of ordinary looking parenchyma, whose elements are rounded or polygonal in shape, and are larger and have thinner walls towards the centre than at the periphery, surrounding this is a ring of wedge-shaped masses of vascular tissue, each of which carries at its apex a well-marked internodal canal, these are enclosed by a very thin Cambium zone, outside of which is a cortex composed of three portions, the inner, middle, and outer cortical layers. This arrangement is in marked contrast to that of the axis of the *Calamostachys* fruit spikes, instead of corresponding with it in its elements as we should expect if they were both referable to the same plate. Besides all this we have Williamson's latest discovery of further examples of what he considers to be the true fruit of the *Calamites* (published in his 14th Memoir on the Organization of the Fossil Plants of the Coal Measures) in which he maintains that they are truly Calamitean, since "The most absolute of these proofs is seen in the fact that each of three of these newly discovered strobili had its basal peduncle attached to it; and that these peduncles are ordinary Calamitean twigs of the type, to which our French friends have long assigned the generic name of *Arthropitus*, and which they have, until recently, regarded as a Gymnospermous genus.

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CALAMOSTACHYS BINNEYANA, Schimp.
Vertical Section of Fruit-Spike (x 10).
Hard Bed Coal, Halifax. *Ex. coll.* W. Cash.

Proc. Yorksh. Geol. & Poigt. Soc, Vol. IX., Pl. 23.

CALAMOSTACHYS BINNEYANA. Schimp.
Transverse Section through the Fruit-Spike (x 50).
Halifax Hard Bed Coal. Ex. coll. V. Cash.

Proc Yorksh. Geot. & Polyt. Soc. Vol. IX., Pl. 24.

CALAMOSTACHYS CASHEANA. Williamson.
Vertical Section of Fruit-Spike (x 35).
Strinesdale, Yorkshire. Ex. coll. W. Cash.

Proc. Yorksh Geol & Polyt. Soc, Vol IX., Pl. 25.

CALAMOSTACHYS CASHEANA. Williamson.
Transverse Section of Fruit-Spike (x 64).
Strinesdale, Yorkshire. *Ex. coll.* W. Cash.

Proc. Yorksh. Geol. & Polyt. Soc, Vol. IX., Pl. 26.

CALAMOSTACHYS BINNEYANA. Schimp.
Section of Sporangium containing Microspores (x 108).
Hard Bed Coal, Halifax. Ex. coll. W. Cash.

Proc. Yorksh Geo! & Polyt. Soc, Vol IX., Pl. 27.

CALAMOSTACYS CASHEANA. Williamson.
Section of Sporangium containing Microspores (x 85).
Strinesdale, Yorkshire. *Ex coll.* W. Cash.

Proc. Yorksh. Geol. & Polyt. Soc., Vol. IX., Pl. 28.

EQUISETUM MAXIMUM.
Vertical Section ($\times 11$).
Ex. coll. Thos. Hick.

Proc. Yorksh. Geol. & Polyt. Soc, Vol. IX., Pl. 29.

Transverse Section of Stem of CALAMITES with Bark (x 30).
Hard Bed Coal, Halifax. *Ex. coll. W. Cash.*