XXIII.—On the Internal Structure of *Sigillaria elegans* of Brongniart's "Histoire des végétaux fossiles." By Robert Kidston, F.R.S.L. & E., F.G.S. (With Three Plates.)

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INTRODUCTION.

Before giving a description of the specimen which forms the subject of this communication, it seems desirable that a brief summary of the literature dealing with the internal structure of *Sigillaria*, and some general remarks on the classification of the genus, should be given.

More for the purpose of convenience than on scientific grounds, the genus *Sigillaria* is usually divided into four groups. These groups were originally supposed by their founders to be of generic value, but experience has shown that the characters on which they were founded are more or less common to all four divisions, and in some cases the distinctive divisional characters even occur on the same specimen.

Group I. RHYTIDOLEPIS, Sternberg, 1823.

Stem ribbed, furrows distinct, straight or slightly flexuous. Leaf scars more or less distant, as wide as, or narrower than, the rib.

Group II. FAVULARIA, Sternberg, 1823.

Stem ribbed, furrows flexuous. Leaf scars with prominent lateral angles, and occupying the whole width of the rib. The lateral angles project slightly, and, alternating with those of the neighbouring leaf scars, impart a zigzag course to the furrows.

Group III. CLATHRARIA, Brongniart, 1822.

Stem without ribs. Leaf scars placed on contiguous rhomboidal, slightly elevated cushions, which are separated by deep oblique furrows.

Group IV. LEIODERMARIA, Goldenberg, 1857.

Stem without ribs. Leaf scars distant and unprovided with cushions.

Groups I. and II. pass into each other; and though in a few cases one can refer certain species to the *Favularia* section, such as *Sigillaria elegans*, there are others which so combine the characters of groups I. and II. that in practice it is impossible to treat them as members of distinct groups.

In the same manner, groups III. and IV. run into each other; and though some species appear to possess only the characters of the *Clathrariæ*, as *Sigillaria discophora*, König, sp. (= *Ulodendron minus*, L. & H.), and others those of the *Leiodermariæ*, as *Sigillaria camptotænia*, Wood, sp., still typical specimens of the groups *Clathraria* (*Sigillaria Brardi*, Brongt.) and *Leiodermaria* (*Sigillaria spinulosa*, Rost, sp.) have been found more than once organically united on the same example.*

A transition from the *Clathraria* to the *Favularia* can also be seen in *Sigillaria semipulvinata*, Kidston.†

It is therefore evident that, although the outer surface of the stems of *Sigillaria* differs in being ribbed or smooth, and in the leaf scars being distant or approximate, all these forms are closely connected by intermediate links; and though the larger division of ribbed and non-ribbed stems is generally very distinctive, still a case is not wanting to show how closely even these two groups stand to each other.

There are, however, differences in the structure of the vascular system of those stems of *Sigillaria* whose internal organisation is known, and though these differences are only variations of a single type of structure, they may hold a definite relation to the group of which the species is a member; so it is not without interest to consider this point in connection with the group to which the species belongs. Stems of *Sigillaria* showing their internal structure and the outer surface of the bark, and thus permitting of a specific determination, are, however, very rare.

The earliest description of the internal structure of *Sigillaria* is that given by BRONGNIART in his well-known memoir, "Observations sur la structure intérieure du *Sigillaria elegans* comparée à celle des *Lepidodendron* et des *Stigmaria* et à celle du végétaux vivants."‡ It is rather remarkable, however, that the plant BRONGNIART identified as *Sigillaria elegans* in this memoir is, as ZEILLER§ has pointed out, the *Sigillaria Menardi*, Brongt.,|| and therefore a member of the *Clathrarian* section.

In 1872 WILLIAMSON described some *Sigillarian* remains which he referred to *Favularia*, but his specimens were very imperfect, and threw little additional light on the subject.¶

It was not till the publication of RENAULT and GRAND' EURY's memoir, "Étude sur

* WEISS, *Zeitsch. d. deut. geol. Gesell.*, 1888, p. 566. ZEILLER, *Bull. Soc. géol. d. France*, 3^e sér., vol. xvii. p. 603, pl. xiv., 1889. ZEILLER, *Flore fossile, Bassin houiller et permien de Briec*, p. 83, pl. xiv. fig. 1, 1892. KIDSTON, *Proc. Roy. Phys. Soc. Edin.*, vol. xiii. p. 233, pl. vii. fig. 1, 1896.

† *Trans. Roy. Soc. Edin.*, vol. xxxix. p. 57, pl. iii. figs. 1-5, especially figs. 1, 2, 1897.

‡ *Archives du Muséum*, vol. i. p. 405, pls. xxv.-xxviii., 1839, Paris. See also RENAULT, "Structure comparée de quelques tiges de la flore carbonifère," *Nouvelles Archives du Muséum*, ii., 2^e sér., 1879, p. 262, pl. xi. fig. 13. RENAULT, *Flore fossile, Deux. part, Bassin houiller et permien d'Autun et d'Épinac*, fasc. iv. p. 200, pl. xxxvi. figs. 8-11, pl. xxxvii. figs. 3-7, 1896.

§ *Ann. d. Scienc. nat.*, 6^e sér., Bot., vol. xix. p. 259, 1884. WEISS, *Sitz. Bericht. d. Gessell. naturforsch. Freunde zu Berlin*, 1886, No. 5, p. 70.

|| *Hist. d. végét. foss.*, pl. clviii. fig. 6 (? non fig. 5).

¶ "On the Organisation of the Fossil Plants of the Coal Measures." Part II. Lycopodiaceæ: *Lepidodendron* and *Sigillariæ*. *Phil. Trans.*, 1872, p. 197.

le *Sigillaria spinulosa*"* that any real advance was made in our knowledge of the structure of Sigillarian stems. This important memoir is a worthy companion to BRONGNIART'S "Observations," and is one of the most valuable contributions which have been made to the subject.

Sigillaria spinulosa, Rost, sp., is the Leiodermarian condition of *Sigillaria Brardii*, Brongt., and is the type of the section *Leiodermaria*. Probably there are species of *Sigillaria* which possess a Leiodermarian type of cortex in all stages of their growth, but unfortunately the internal structure of none of these is known.

RENAULT gives some additional details of the structure of *Sigillaria (Clathraria) Menardi*, Brongt., and *Sigillaria (Leiodermaria) spinulosa*, Rost, sp., in the *Bassin houiller et permien d'Autun et d'Épinac*† and also in the same work describes a Sigillarian axis under the name of *Sigillaria xylinea*.‡

All the Sigillarian specimens whose structure was known previous to 1899 belonged to the *non-ribbed* members of the genus, but in that year Professor BERTRAND read an account of a ribbed *Sigillaria (S. elongata*, Brongt.) before the Botanical Section of the British Association at Dover. An abstract of this communication appears in the *Annals of Botany*, vol. xiii., 1899, p. 607. This paper gives the first clear account of the structure of a *ribbed Sigillaria*, and embraces all we know of the structure of this group, with the exception of a short account given by Dr SCOTT of a transverse section of a *Sigillaria (Rhytidolepis)* type, § and a note by WILLIAMSON, || with a few explanatory remarks, where he refers the *Diploxylen* of his Memoir II. to *Sigillaria reniformis*, Brongt. ¶ This identification by WILLIAMSON is improbable, as *Sigillaria reniformis* has never, as far as I am aware, been found in so low a horizon as that from which WILLIAMSON'S specimen came—the Lower Coal Measures.

The above brief sketch contains a note of the papers and works dealing with original investigations on the structure of undoubted stems of *Sigillaria* as far as known to me,** but before passing from the literature of this subject I wish to refer to a stem which has been described by Professor F. E. WEISS as "a biseriate Halonial branch of *Lepidophloios fuliginosus*,"†† and which I think more probably belongs to the Ulodendroid group of Clathrarian *Sigillaria* than to *Lepidophloios*. I have come to

* Mém. présentés par divers savants à l'Acad. des Sciences de l'institut national de France, vol. xxii., No. 9, 1875, Paris, pls. i.-iv., pl. vi. figs. 33, 34. See also RENAULT, "Structure comparée de quelques tiges de la flore carbonifère," p. 264, pl. xi. figs. 17-21, pl. xii. figs. 1, 2, 1879. "Notice sur les travaux scientifiques de M. BERNARD RENAULT," Autun, 1896, p. 132.

† Fasc. iv. part ii., 1896, pp. 200, 208, pl. xxxvi. figs. 8-11, pl. xxxvii. figs. 3-7 and fig. 40 (*Sig. Menardi*), pl. xxxvi. figs. 2-5, pl. xli. figs. 4-11, 18-21, 23-26 (*S. spinulosa*).

‡ *L.c.*, p. 237, pl. xxxviii. figs. 1-3.

§ *Studies in Fossil Botany*, p. 207, fig. 80, 1900.

|| General, Morphological, and Histological Index to the Author's Collective Memoirs on the Fossil Plants of the Coal Measures. Part II. *Mem. and Proc. Manchester Lit. and Phil. Soc.*, Session 1892-93, p. 35, 1893.

¶ Pl. xxviii. figs. 33, 34.

** See, in addition to references already given, RENAULT, *Cours d. botan. fossile*, vol. ii., 1881. POTONIÉ, *Lehrbuch der Pflanzenpaläontologie*, 1899. ZEILLER, *Éléments de Paléobotanique*, 1900. SOLMS-LAUBACH, *Fossil Botany* (English translation), Oxford, 1891. KIDSTON, "Carboniferous Lycopods and Sphenophylls," *Trans. Nat. Hist. Soc. Glasgow*, vol. vi., new series, p. 101, 1891.

†† WEISS, *Trans. Linn. Soc. London*, 2nd ser., Bot., vol. vi. part 4, pp. 217-236, pls. xxiii.-xxvi., 1903.

this conclusion after a very careful examination of the specimen which was collected by the late Mr G. WILD, and sent to me for identification by Mr JAMES LOMAX, into whose possession it had come.

The following are my reasons for adopting the opinion that the more probable systematic position of this fossil is with the Ulodendroid Sigillariæ :—

I. The only carboniferous genera possessing biseriate cone scars, which have been definitely identified from the presence of leaf scars on their bark, are *Lepidodendron*, *Sigillaria* (Ulodendroid section), and *Bothrodendron*.

II. The specimen under discussion differs from the biserial *Lepidodendra* in the closely placed cone scars, and from *Bothrodendron* (*B. punctatum*, L. & H.) in the cone scars possessing a *central* vascular cicatrice, which in *Bothrodendron* is *eccentric*.

III. That in the position of the cone scars and their vascular cicatrices, and the distance arrangement of the leaf vascular cicatrices, it agrees entirely with specimens of *Sigillaria discophora*, König, sp.* (= *Ulodendron minus*, L. & H., sp.), when partially decorticated.

IV. That every Halonial (fruiting) branch of *Lepidophloios* which has shown the leaf scars, and so admitted of an undoubted identification, has had more than two rows of cone scars on the fully developed fruiting portion, and these are spirally arranged.

V. Dr HOYLE, Director of the Manchester Museum, has very kindly sent me for examination the specimen figured by Professor WEISS on his pl. xxiii. figs. 2, 3. In comparing these figures with fig. 1 of the same plate, it should be remembered that fig. 1 is natural size, and that figures 2, 3 are only $\frac{2}{3}$ natural size.

With the exception of a few places, the outer bark is removed from the Manchester Museum specimen (WEISS, *l.c.*, figs. 2, 3), and what remains is converted into bright coal. These coaly patches have the appearance of downward imbricating scales or cushions, but what their real structure has been cannot be clearly made out. Their lower ends are terminated by a fracture, and no leaf scars are shown.

The upper part of the fossil shows the two stumps of a bifurcation. On fruiting branches of *Lepidophloios* (*Halonina*) the fructification is frequently borne on the two forks of the stem immediately above the bifurcation. Below the fork the fructification sometimes begins as a single or double row, but when it extends to the forks the true multispiral arrangement is developed. This was pointed out many years ago by Dr (now Professor) J. M. MACFARLANE.†

The part represented by the specimen in the Manchester Museum may very probably represent a similar condition to that described and figured by Professor MACFARLANE, but as the two arms of the dichotomy are broken over on the example figured by Professor WEISS, the true spiral series which would naturally have occurred on the two arms is wanting. Had only a similar portion of Dr MACFARLANE's specimen been preserved, there would have been here a so-called "biseriate" *Halonina*, but that term cannot be applied,

* KÖNIG, *Icones fossilium sectiles.*, London, pl. xvi. fig. 194.

† *Trans. Bot. Soc. Edin.*, vol. xiv. pp. 186, 190, pl. vii.

as the "biserial" *Halonina*—in this case at least—is only the beginning of the usual and typical multiserial *Halonina*. It is quite possible that the specimen figured by Professor WEISS is a fragment of a Halonial branch of *Lepidophloios*, though the state of preservation of the specimen makes it quite impossible to affirm this positively; but though this point cannot be settled, I am perfectly satisfied that the fossil which forms the subject of Professor WEISS' figures 2, 3, pl. xxiii., does not represent the same species as that of which he describes the structure, and of which a figure is given, natural size, at fig. 1 of the same plate. The disposition of the cone scars shows this.

The specimen also figured by Professor WEISS on his plate xxiv. fig. 5, which is contained in the Williamson Collection, British Museum, No. 1945B, has very kindly been sent me for examination by Dr A. SMITH WOODWARD, F.R.S., Keeper of the Geological Department. Of this specimen Professor WEISS says, "The leaf bases are perfectly distinct over the whole surface, and their broad and fimbriating nature mark them out as belonging to *Lepidophloios*, as indeed was recognised by Williamson."* The characters here given as distinctive of *Lepidophloios* are not those which distinguish the genus, and afford no data for a generic identification. They would apply equally to most of the other genera of the Carboniferous Arborescent Lycopods if the leaves were forcibly broken over at a point above their attachment to the leaf cushion, as they appear to have been on this specimen.

This example, as I interpret it, is given in Professor WEISS' figure in inverted position. The smaller end, which he places downwards, I think is the upper end of the fossil. The outer surface bears the broken-over portions of the lower part of the leaves—not the persistent portion, which forms the leaf cushion on which the leaf scar occurs, but parts of the leaf while still attached to the cushion; hence no leaf scars are seen on the specimen. The fossil is too imperfectly preserved for a satisfactory determination, but in all the characters it shows they agree perfectly with those of *Sigillaria discophora*; and if I am correct in thinking that Professor WEISS has inverted the specimen in his figure—a view which I think his figure seems to bear out—then the "fimbriating" leaf bases point upwards. As already stated, from such imperfect material as that under discussion, it is extremely difficult, if not impossible, to arrive at any certain conclusion as to the nature of the fossil, but the fossil does not appear to me to show any of the characters of *Lepidophloios*, Sternberg.

The reference to Professor WILLIAMSON's figs. 27 and 28 of Memoir II.† throws no light on the point in question. WILLIAMSON describes his specimen as a *Ulodendron*, and at that date that was the genus into which specimens of *Sigillaria discophora* (= *Ulodendron minus*, L. & H.) would be placed; and, as far as can be learned from WILLIAMSON's figures and description, the specimen might as well belong to *Sigillaria discophora* as to *Lepidophloios fuliginosus*, Williamson.

I am further indebted to Dr A. SMITH WOODWARD for specimen No. 1949A of the Williamson Collection, and a transverse section cut from it (slide No. 1949), to which

* *Loc. cit.*, pp. 220–221.

† *Phil. Trans.*, 1872, p. 209.

Professor WEISS also makes reference. My thanks are also due to Professor BOWER for the loan of another transverse section from the same block, which he received from the late Professor WILLIAMSON.

The remaining portion of the block from which these slides were made (No. 1949A) is about $1\frac{1}{2}$ inches long, and shows a *subepidermal* surface with a single tubercle. The leaf cushions have been removed, so it thus possesses no external characters for a generic determination.

Part of a section made from this specimen is figured by WILLIAMSON in his Memoir XIX., on pl. iv. fig. 30.*

When one examines the remains of the original specimen and the slides made from it, it is difficult to interpret the relation of the parts to each other. One difficulty in explaining the relationship of the parts is, that if the two sides of the specimen represent the subepidermal surfaces of the original stem, how does the portion figured by WILLIAMSON come to hold the position that it does? Again, the pressure to which the specimen, and especially the vascular axis, has been subjected, makes a critical examination of its structure very difficult. These circumstances have prevented me from arriving at any conclusion as to the true position of this fossil.†

My thanks are due to Dr A. SMITH WOODWARD, F.R.S., Keeper of the Geological Department of the British Museum, for kindly giving me the opportunity of examining the specimens in the "Williamson Collection," and to Dr HOYLE for sending me the one contained in the Collection of the Manchester Museum.

VI. That the vascular axis of the specimen described by Professor WEISS belongs to the same *type* of structure as the vascular axis of *Lepidophloios fuliginosus* is beyond dispute. The stems of these two plants are closely related in anatomical structure, but I do not think they are *identical*. Professor WEISS in his paper points out some slight differences, but what I regard as three important differences seem to be passed over in his description as of too little value for a separation of the two plants. The first is the very prominent and continuous (except where broken by the presence of leaf traces) band of tissue described by him as *phloem*. This layer is very much more developed in the specimen under discussion than in typical *Lepidophloios fuliginosus*. The second distinguishing point is the greater number of leaf traces given off by the vascular cylinder of Professor WEISS' specimen, while the third distinctive character is the presence of a *well-defined* pericycle.

The leaf traces are generally composed of a larger number of elements than those of *Lepidophloios fuliginosus*, and therefore appear more prominent, and are frequently larger in transverse section. From these causes, and the fact of the leaf traces being more numerous, they form a much more distinct ring of leaf traces surrounding the axis than do those of what I regard as the true *Lepidophloios*

* *Phil. Trans.* vol. clxxxiv. p. 20, 1893.

† Another portion of this specimen (Williamson, 1949A) is in the Wild Collection, Manchester Museum.

fuliginosus of WILLIAMSON. If I am correct in my opinion that the specimen described by Professor WEISS belongs to *Sigillaria discophora*, the leaf traces should be more numerous than those given off by *Lepidophloios fuliginosus*, for in *Sigillaria discophora* the leaf scars are smaller, and consequently more numerous in a given space than those of *Lepidophloios*, and the close position of the leaf scars is very clearly seen in tangential sections of the specimen described by Professor WEISS, of which I possess a fine series of sections. The same character and their quadrangular arrangement are also seen on the outer surface of the specimen as figured by Professor WEISS on plate xxiii. fig. 1.

These differences are slight, and even if they did not exist within the two stems the arrangement of the cone scars is sufficient to separate the *Ulodendroid Sigillaria* from *Lepidophloios*; and in a group containing so many closely allied genera as are known to exist amongst the Carboniferous Arborescent Lycopods, one must expect to find in the internal structure of their stems a great similarity.

VII. In regard to the specimen under discussion, and which has been referred to *Lepidophloios fuliginosus* by Professor WEISS, it appears to me that the external characters of the fossil point more strongly to its belonging to *Sigillaria discophora* (= *U. minus*) than to *Lepidophloios*; and further, that its internal structure, though of the same type, is not identical with that of *Lepidophloios fuliginosus* of WILLIAMSON.

In concluding this criticism, I wish clearly to state that I do not say that a "biseriate *Halonina*"—that is, a Halonial condition of *Lepidophloios*, on which the cones are arranged in two rows, "Ulodendroid" fashion—does not exist; but what I do maintain is, that if there is a *Lepidophloios* which bears its cones in two opposite and vertical rows, and in this mode alone, proof of its existence has still to be given.

DESCRIPTION OF SPECIMEN.

Sigillaria elegans of Brongniart's *Histoire des végétaux fossiles*, vol. i. p. 438, pl. cxlvi. fig. 1, pl. clv., pl. clviii. fig. 1.

As some botanists doubt the identity of BRONGNIART'S *Sigillaria elegans* with the *Sigillaria (Favularia) elegans* of STERNBERG,* I have adopted BRONGNIART'S name as my authority for the species whose structure is about to be described, as my specimen agrees in all respects with the descriptions and figures given in the *Hist. d. végét. foss.* On the other hand, I believe that BRONGNIART was quite correct in identifying his specimen with *Favularia elegans*, Sternberg; for if STERNBERG'S figure be inverted and so brought into its natural position, and if a very slight allowance be made for the delinquencies of the artist, it is difficult to see how there can be any real difficulty in recognising the specific identity of BRONGNIART'S and STERNBERG'S specimens.†

* STERNBERG, *Essai flore monde prim.*, vol. i. fasc. 4, pp. xiv, 48, pl. lii. fig. 4, 1826.

† See also ZEILLER, *Flore foss. Bassin houil. d. Valenciennes*, p. 582, pl. lxxxvii. figs. 1-4, Atlas 1886, Text 1888.

General Description of Specimen.—The specimen was contained in one of the well-known coal balls from the Halifax Hard bed near Huddersfield, Yorkshire (Lower Coal Measures), and was found by Mr W. HEMINGWAY, by whom it was communicated to me, and to whom my thanks are due for the opportunity of describing the specimen.

Through a fortunate fracture in the stone, part of the outer surface of the specimen was exposed, showing a well-preserved row of leaf scars. This surface of the specimen is shown natural size at fig. 1, Pl. I., and enlarged two times at fig. 2.

With the exception of the row of leaf scars, the remainder of the surface of the specimen exposes the layer which lies immediately underneath that on which the leaf cushions sit. Its surface shows the leaf traces surrounded below by the parichnos,

TEXT FIG. 1.—*Sigillaria elegans*, Sternberg, sp.

- A. Transverse section of the specimen showing the vascular cylinder and portion of the cortex. The ribs are numbered I. to XIX. $\times 4$.
 B. Transverse section of the vascular cylinder. The furrows on outer margin of primary wood are numbered 1 to 28. $\times 9$. Protoxylem, *prx*. Primary xylem, *x'*. Secondary xylem, *x''*. Leaf traces are shown in the furrows marked with a *x*. Slide No. 964.

which form a semicircle, Pl. I. fig. 2. At this point the parichnos do not seem to completely surround the leaf trace. Between the narrow ridges on which the leaf trace scars are seen, the exposed surface is striated with close, slightly flexuous longitudinal ridges.

An outline sketch of a transverse section of the specimen is shown at text fig. 1, A, enlarged four times. Towards the right is seen the vascular cylinder, the two sides of which are pressed together, and only a small part of the pith-cavity is seen.

The complete zone of cortex bore twenty-eight ribs, of which nine are not seen in the section, but the figure allows one to estimate the proportional size of the vascular cylinder to that of the circumference of the stem.

The stele, which measures slightly under 13 mm. in its longest compressed diameter, consists of a perfectly continuous ring of primary wood, x' , which is surrounded by a zone of secondary wood, x'' .

The pith and the tissue which originally composed the inner portion of the cortex and all remains of the phloem elements, have been entirely destroyed. The only other remaining portion of the stem in which the structure is preserved is the outer layer of the cortex on which the leaf cushions are situated. The structure of these parts may now be considered in detail.

The Primary or Centripetal Xylem.—At fig. 3, Pl. I., is shown a transverse section of the vascular cylinder, enlarged about $4\frac{1}{2}$ times. The ring of primary xylem x' is quite continuous, and is about 0.70 mm. thick. As seen in fig. 4, Pl. I., its outer margin is deeply and regularly undulate or crenate, so as to form a number of blunt ridges alternating with as many intervening furrows. The inner margin of the xylem ring is very uneven, sending irregular toothed projections into the now empty pith-cavity (Pl. I. fig. 4, x' and *p.c.*).

The main mass of the primary xylem consists of large tracheides, more or less hexagonal in transverse section, and without any intervening parenchymatous cells. They diminish slightly and gradually in size towards without, but just underneath the ridges a decrease in size takes place somewhat abruptly, and the ridges themselves are composed of much narrower elements, that are to be regarded as constituting the protoxylem (Pl. I. fig. 4, *prx.* Text fig. 1, B, *prx.*).

At the inner margin of the primary xylem a certain amount of thin-walled parenchymatous cells are to be found between the tracheides, and a few of the latter may even be surrounded by parenchyma, and separated from the rest of the mass. Some especially narrow tracheides also occur here and there along the inner margin.

Radial longitudinal sections, Pl. II. figs. 6 and 8, show that all the elements of the primary xylem, both protoxylem (Pl. II. fig. 7, *prx.*) and metaxylem (Pl. II. fig. 9, x'), are elongated scalariform tracheides with pointed ends (fig. 7, *prx.*, fig. 9, x'), except a few of the innermost tracheides bordering on the pith, which are quite short, blunt-ended, and irregular in shape, but still scalariform. So far as observed, no spiral or annular elements at all were found at any point in the primary xylem, not even in the protoxylem.

The protoxylem elements are seen in radial section at *prx.*, figs. 6 and 8, Pl. II. They are long and narrow, and terminate in an elongated conical point (Pl. II. fig. 7, *prx.*).

Secondary or Centrifugal Xylem.—This forms a zone of varying thickness surrounding the primary xylem, and attaining at its widest part a breadth of about 0.75 mm. (Pl. I. figs. 3, 4, and 14, x''). Its inner margin follows the crenulate outline of the primary xylem. The outer margin exhibits the same crenulations, but to a slightly less degree.

The tracheides of the secondary xylem are arranged in radial rows (Pl. I. figs. 3, 4, and 14, *x.*"), interspersed at intervals by numerous medullary rays which run uninterruptedly through the whole thickness of the secondary wood.

The number of rows of tracheides at the inner margin of the secondary wood is greater than at the outer margin, so that many of the rows begun at the inner edge come to an end after running a certain distance, their loss being compensated for by the increased size of the tracheides in the rows which persist.

At figs. 6 and 8, Pl. II., are radial longitudinal sections of the stele, which show that the tracheides of the secondary xylem are elongated and scalariform, with pointed ends, similar to those of the main body of the primary xylem (metaxylem), only somewhat smaller in diameter.

The tracheides are of the same size throughout the secondary xylem, there being no difference between those opposite the ridges and those opposite the furrows.

Occasionally one or two thin-walled cells intervene between the primary xylem and the inner tracheides of the secondary xylem, but frequently the primary and secondary xylem are in direct contact.

The medullary rays (Pl. I. fig. 14, *m.r.*, Pl. III. fig 10, *m.r.*) are usually one cell wide, rarely two, and are formed of thin-walled cells, slightly elongated radially. Their walls sometimes bear delicate scalariform thickenings (Pl. I. fig. 14, *m.r.*). Similar cells have been figured by WILLIAMSON.*

In tangential section (Pl. I. fig. 28, *m.r.*) the medullary rays are seen to vary much in height, and may consist of from one to nine superposed cells. In many cases the cells have become decayed, and their position is only indicated by a larger or smaller lenticular space.

Leaf traces.—The leaf traces arise from the periphery of the primary xylem, and invariably at the base of the furrows, never from the tops or sides of a ridge (text fig. 1, B; Pl. I. fig. 4, *l.t.*; Pl. II. figs. 11, 12, 13, *l.t.*); and as the leaf traces appear to keep in the same vertical plane in their course through the cortex, the furrows on the primary xylem must correspond in position to the ribs on the surface of the stem.

In text fig. 1, B, the vascular cylinder is enlarged about nine times. This shows twenty-eight furrows, so there must have been twenty-eight vertical rows of leaves; and although text fig. 1, A, only shows nineteen, before the specimen was cut, the full number was actually present as already mentioned.

When the leaf trace is about to become free from the metaxylem at the bottom of the furrow it consists of a group of about a dozen small tracheides, arranged radially around the smallest of the group, which lies approximately in the centre (Pl. II. fig. 11, *l.t.*). Followed downwards, these small tracheides are seen to spread out over the surface of the furrow, and finally die out below (Pl. II. fig. 17, *l.t.*).

When the leaf trace becomes free from the primary xylem it first runs upwards and slightly outwards (Pl. II. figs. 12 and 13), then bending abruptly outwards, passes

* Memoir XIX., *Phil. Trans.*, vol. clxxxiv. (1893), p. 33, pl. iv. fig. 38.

out through a medullary ray in an almost horizontal direction. Once free of the secondary xylem it suddenly bends upwards again (Pl. II. fig. 15, *l.t.*).

By the time the leaf trace emerges from the secondary wood one or two additional rows have been added, mostly on the side next the axis, but a few may have been added to the opposite side, and the leaf trace now shows a distinct mesarch structure (Pl. II. fig. 15, *l.t.*). On another leaf trace, which is slightly further removed outward from the axis, a greater number of tracheides have been added, and the increase seems to have been more equally placed on all sides of the primary group (Pl. II. fig. 16, *l.t.*).

The course of the leaf traces through the xylem, and their behaviour on their emergence from it, seems to be similar to that so well represented in the figure of the radial section of *Sigillaria Menardi* given by RENAULT.*

It was impossible to discover any annular or spiral tracheides in the leaf trace, but their structure is very much effaced in their passage through the secondary xylem.

Sigillaria elegans does not show any secondary wood in connection with the leaf trace up to their entrance into the inner cortex and in the outer layer of the bark (the only portion of the cortex preserved); the leaf traces are too imperfect to permit of their structure being made out.

Cortex.—The only part of the cortex which has been preserved is that formed by the ribs, which must probably be regarded as composed of the confluent persistent leaf bases and a small portion of the underlying periderm.

Fig. 18, Pl. I., shows the outer surface of a specimen of *Sigillaria elegans*, collected by Mr W. HEMINGWAY from the Yorkshire Middle Coal Measures. In this condition the leaf cushions are usually compressed. They are arranged on the ribs in vertical rows, the leaf scars of one row alternating with those on the contiguous rows. The leaf scars are subhexagonal, with prominent lateral angles, which alternate with those of the neighbouring leaf scars, and thus impart a zigzag course to the furrows between the ribs. The cones are borne in a verticil formed of a single row, and some of the cone scars are seen in the figure at *c.s.*

In the uncompressed condition the leaf cushions slope outwards, and their lower margin becomes considerably elevated. This is shown on Pl. III. fig. 19, which is a radial section through a rib of *Sigillaria elegans*. The leaves are attached to the sloping surfaces, *s.a.* This figure is from a specimen received from Mr JAMES LOMAX, and was derived from the Halifax Hard bed.

The surface of the leaf scar is formed of a stratum of dark broken-down parenchymatous tissue. The main body of the leaf cushion below this consists of fairly thick-walled parenchyma, the cells of which are more or less oval, with their longest diameter directed outwards. Towards the upper adaxial side of the cushion these cells become smaller, and seem to contain a dark-coloured material, which causes the tissue in this region to become opaque (Pl. III. fig. 5). The lower margin is also formed by similar small opaque cells, but not developed to the same extent.

* *Flore fossile, Bassin houiller et permien d'Autun et d'Épinac*, Deux. part, Atlas, pl. xxxvii. fig. 6, 1893.

At *l.t.*, fig. 5, Pl. III., is seen the opening through which the leaf trace has passed to the leaf. The leaf cushions are attached to a continuous zone of underlying periderm (Pl. III. fig. 19, *pd.*), formed of very dense elongated fibres of small diameter, with fairly thick walls. In longitudinal section this tissue is usually very opaque, and seldom shows its structure distinctly. In transverse section (Pl. III. fig. 21) the fibres are seen to be arranged in close radial rows.

If a transverse section of cortex with several attached leaf bases be examined, it will be seen that some of the leaf bases have only a narrow band of dark dense tissue, as at Pl. I. fig. 3, *l.c.*, whereas others seem to be entirely composed of it, as at fig. 3 *l.c.'* This is explained by reference to fig. 5 and fig. 19, Pl. III. If the section passes through the lower part of the cushion the greater part of the section will show transparent parenchyma, whereas if the section passes through the upper part of the cushion it will be composed of dense opaque tissue.

A leaf cushion in transverse section is given on Pl. III. fig. 20. The dark broken-down margin is reduced here in thickness (*p.p.*), while the more transparent parenchyma occupies at this position the greater width of the cushion. At *pd.* are seen some fragments of the periderm.

The cause of the flexuous striations on the surface of the stem (Pl. I. fig. 2) where the leaf cushions have been removed is not very clear, but they seem to be formed at the point of union of cortex and periderm, and are probably caused by the projecting teeth of the latter (see Pl. III. fig. 20, *pd.*).

A section of a cushion approximately parallel with and a short distance below the outer surface is given on Pl. III. fig. 22. The two parichnos (*par.*) are seen, but the delicate tissue with which they were filled has mostly decayed. The leaf trace lying between them is too imperfectly preserved to admit of a detailed description. The parenchyma of the groundmass is here well preserved (Pl. II. fig. 24).

Cone Scars.—On the specimen showing the outer surface of the bark given on Pl. I. fig. 18 part of a verticil of cone scars is seen at *c.s.*

In one of the tangential sections of the cortex of the specimen shown on Pl. I. fig. 1 two vascular strands belonging to cones are cut through. This specimen is shown enlarged eight times at fig. 23, Pl. III., where the branches going to the cones are lettered *c.s.* and *c.s.'*

The cone axis *c.s.'*, fig. 23, Pl. III., is seen enlarged on Pl. III. fig. 25.

The peripheral zone of cortex, *b*, which has accidentally separated off from the rest, is too much disorganised to show the structure, but probably corresponds to the periderm. The space lettered *d* is a mechanically produced rupture.

The rest of the cortex consists of fairly thick-walled and apparently parenchymatous cells, which increase in diameter as they are traced inwards (Pl. III. fig. 26). This tissue, which undoubtedly belongs to the cortex, is separated from the solid axis of the cone by a clear empty zone (Pl. III. fig. 25, *g*, and Pl. I. fig. 27, *g*), which was probably occupied by some delicate tissue.

The cells of the innermost layer of cortical tissue lining this zone consist of smaller cells, roughly tabular in transverse section, and have very much the appearance of an endodermis (Pl. III. fig. 26, *c*; Pl. I. fig. 27, *e*).

Within the clear zone is a central mass of xylem (Pl. III. fig. 25, *k*; Pl. I. fig. 27, *k*), surrounded by a fairly stout zone of comparatively large thin-walled cells, separated from the xylem by a dark line of disorganised material (Pl. I. fig. 27, *h*). The xylem is too badly preserved for detailed description, but it is quite clear its development is centripetal. The smallest elements are at the periphery, and there is a gradual increase in size towards the centre. There is no trace of any secondary thickening.

The zone of thin-walled tissue surrounding the xylem possibly represents the so-called phloem of *Lepidophloios*, but the preservation is so imperfect that a definite decision as to its true nature is not permissible.

Remarks.—The structure of *Sigillaria elegans*, Brongt., is very similar to that of *Sigillaria elongata*, Brongt., the only other ribbed *Sigillaria* of which any detailed account of the structure has been given, but the short abstract of his paper given by Professor C. EG. BERTRAND scarcely enables one to make a critical comparison between the structure of the two species.* He has, however, very kindly favoured me with some photographs of his specimen, and the general agreement in structure between the two plants is very striking.

They both have a continuous circle of primary wood, with a distinct *corona*. In the Hardingen specimen the projecting teeth of the protoxylem are pointed, while in the Yorkshire example they are rounded and contain a greater number of elements. The secondary xylem seems to offer no special point of difference.

On my specimen the leaf traces rise as a single strand directly from the base of the furrows of the primary xylem, and they may differ somewhat in their mode of origin from those described by Professor BERTRAND;† but until the full description of the Hardingen specimen is published, it is undesirable to institute any critical comparison between the anatomy of *Sigillaria elongata* and *Sigillaria elegans*.

In comparing the organisation of the various species of *Sigillaria* of which the structure has been described, one might be inclined to think that in the genus there were two types of structure; this, however, is not so. If one takes the *Sigillaria Menardi* described by BRONGNIART, with its isolated strands of primary xylem, and *Sigillaria elongata* or *Sigillaria elegans*, with their continuous circle of primary wood and prominent corona, they at first sight look very distinct. But in *Sigillaria spinulosa*, which normally is supposed to possess the same type of structure as *Sigillaria Menardi*, SOLMS-LAUBACH has pointed out that the separate bundles of primary wood sometimes coalesce, and in part form a continuous ring.‡ This character of the coalescence of the primary bundles of *Sigillaria* is also well seen in the figures of *Sigillaria spinulosa* given by Dr SCOTT.§ In *Sigillaria xylina*, Renault, the same

* *Annals of Botany*, vol. xiii. p. 607, 1899. † *Loc. cit.*, p. 608. ‡ *Fossil Botany*, English ed., p. 252, fig. 29, 1891.
§ *Studies in Fossil Botany*, p. 201, figs. 77–78, 1900.

character has been observed.* It is therefore seen that the isolated strand type of primary wood, and that even in the same specimen, passes into the continuous type, and that there is between the two forms an unbroken chain which connects them together.†

If the structure of *Sigillaria elongata* or *Sigillaria elegans* be compared with the structure of the large specimen of *Lepidophloios* described by SEWARD and HILL,‡ and which they believe to be the *Lepidophloios Harcourtii*, Witham, sp., or with any of the *Lepidodendroid* stems whose primary wood is provided with a *corona*, the great similarity in structure is very apparent. The *corona* on the stems of *Lepidophloios*, though less prominent than in *Sigillaria*, is most distinctly present, and is also formed by the protoxylem elements. The leaf traces are also given off from the dividing bays, and the difference between the *corona* of many of the *Lepidodendreae* and the *Sigillariae* is only one of degree. If a series be arranged, beginning with *Lepidophloios Harcourtii*, followed by *Sigillaria elongata*, and concluding with *Sigillaria elegans*, it will be seen that by a gradual increase of the size of the teeth of the *corona* you pass insensibly from the *Lepidophloios* structure to that of the *Sigillariae* which possess the continuous ring of primary wood. The distinction at one time supposed to exist between the *Sigillariae* and the *Lepidodendreae*, of the former possessing secondary wood in connection with the leaf trace, is now found not to hold, for a considerable development of secondary wood takes place in the leaf traces of *Lepidophloios*.§ On the other hand, no development of secondary wood on the leaf traces of *Sigillaria elongata* or *Sigillaria elegans* has yet been observed.

Whether we are justified in classing all of the *Lepidodendreae* with a *corona* on the primary xylem with *Lepidophloios* may be open to question, though it is certain that some *Lepidophloios* had primary wood so formed; and though on some stems of *Lepidodendron* the primary wood has an even contour, still in other *Lepidodendra* and in *Bothrodendron* || the primary wood has a slightly undulating outline, so that in the Carboniferous *Lycopodiaceae* there is a continuous chain of structure variation in the arrangement of the protoxylem elements which binds closely together all the genera of the Carboniferous Arborescent Lycopods. Between no two genera is there any outstanding character in the structure of the vascular cylinder which sharply separates them from each other. It seems, therefore, highly probable, as suggested by ZEILLER, that the Carboniferous Arborescent Lycopods have descended from a common stock.¶ In their fructification and certain other points, however, these ancient lycopods differed from each other in several important characters.

I am inclined to regard the Arborescent Lycopods as a group which has left no

* RENAULT, *Bassin houiller et permien d'Autun et d'Épinac, Flore fossile*, Deux. part, p. 238, 1896.

† It might be mentioned that RENAULT has described a *Lepidodendron* (*L. Jutieri*) in which the vascular system is formed of a circle of separate bundles. "Structure comparée de quelques tiges de la flore carbonifère" (in *Nouv. Archives du Mus.*, ii., 2^e sér., 1879, p. 258; also RENAULT, *Cours d. bot. fos.*, vol. ii, p. 28, 1882.

‡ *Trans. Roy. Soc. Edin.*, vol. xxxix. p. 907, pls. i.-iv., 1900.

§ SEWARD and HILL, *l.c.*, p. 914.

|| From the discovery by Mr JAMES LOMAX of a specimen showing the outer surface of the bark, it has been shown that the *Lepidodendron mundum*, Williamson, is a *Bothrodendron*.

¶ ZEILLER, *Éléments paléobotanique*, p. 178, 1900.

descendants except in the case of *Sigillaria*, the structure of whose cone shows some similarity with the fructification of *Isetes*. Our other modern lycopods (*Lycopodium* and *Selaginella*) seem to have descended from the Carboniferous genus *Lycopodites*, with which they show much in common.

The geological distribution of the *Sigillaria* whose structure is known also brings out an interesting point ; and though the evidence may not be sufficient for any definite conclusions, still it indicates changes which deserve recognition.

The following table gives the age of the rocks which have yielded *Sigillaria*, showing their internal structure, and also indicates a few of the more prominent characters of the species discovered.

TABLE.

Lower Permian	<i>Sigillaria Menardi</i> , Brongt.	Stem without ribs (Clathraria section)	Primary xylem a circle of separate bundles. Secondary xylem forming a centrifugal zone.
Do.	<i>Sigillaria spinulosa</i> , Rost, sp. (= <i>Sigillaria Brardi</i> , Brongt.)	Stem without ribs (Clathraria and Leio- dermaria sections)	Primary xylem a circle of separate bundles, some of which frequently coalesce. Secondary xylem forming a centrifugal zone.
Upper Carboniferous Upper Coal Measures	No specimens show- ing structure from this horizon		
Middle Coal Measures (= "Westphalian Series")	<i>Sigillaria elongata</i> , Brongt.	Stem ribbed (Rhytidolepis section)	Primary xylem in form of a closed ring. Secondary xylem forming a centrifugal zone.
Lower Coal Measures	<i>Sigillaria elegans</i> , Brongt.	Stem ribbed (Favularia section)	Primary xylem in form of a closed ring. Secondary xylem forming a centrifugal zone.

The non-ribbed *Sigillariæ* are more characteristic of higher horizons and the ribbed *Sigillariæ* of the lower horizons, but neither group is restricted to either series.

The genus *Sigillaria* also extends into the Lower Carboniferous, where it is, however, very rare, but no specimens showing structure have yet been recognised from these rocks. In the following list I only mention the British species :—

Lower Carboniferous.

Carboniferous Limestone Series.

<i>Sigillaria Youngiana</i> , Kidston	.	Stem ribbed.
<i>Sigillaria Canobiana</i> , Kidston	.	Stem ribbed.
<i>Sigillaria Taylora</i> , Carr., sp.	.	{ Stem without ribs. (Ulodendroid Clathraria.)

Calceiferous Sandstone Series.

<i>Sigillaria Taylora</i> , Carr., sp.	.	{ Stem without ribs. (Ulodendroid Clathraria.)
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The lowest horizon from which I have seen the *typical Clathrarian Sigillariæ* is the Lower Coal Measures, but from this horizon I have only seen a single example.

The non-ribbed *Sigillariæ* of the Ulodendron-Clathrarian group (*Sigillaria discophora*, König, sp. = *Ulodendron minus*, L. & H., and *Sigillaria Taylora*, Carr., sp.) extend into both divisions of the Lower Carboniferous, but the ribbed *Sigillariæ*, although they occur in the Lower Carboniferous, do not, as far as I know, extend to the base of the Carboniferous Limestone Series.

If I am correct in believing that the stem whose structure has been described by Professor WEISS as "a Biseriate Halonial Branch of *Lepidophloios fuliginosus*" is the *Sigillaria discophora*, König, sp., with which *Sigillaria Taylora*, Carr., sp., is very closely related, then the probability is that *Sigillaria Taylora* also possessed primary wood of the continuous ring type, and the same may be presumed for the two-ribbed *Sigillariæ* from the Carboniferous Limestone Series.

If it is permissible to assume these probabilities—and the assumption is not without some support from the known structure of the Middle and Lower Coal Measure species of *Sigillaria*—then it is probable that the continuous ring of primary xylem is the older type of Sigillarian stem structure, and that the circle of isolated strands which form the primary xylem of the Clathrarian *Sigillariæ* of the higher geological horizons has originated by a splitting up of the continuous ring type of bundle; and, as already mentioned, even in the few Clathrarian *Sigillariæ* from the higher horizon of which the structure is known, the actual transition from the one type to the other can be observed.

The *Lepidodendra* form, however, an older genus than *Sigillaria*, and extend to the base of the Carboniferous Formation. In beds not far above the base and low down in the Calciferous Sandstone Series specimens of *Lepidodendron* showing structure have been found; and of two of these occurring in the same bed, one species shows the continuous ring of primary wood, while the other possesses a solid cylinder of primary wood without any trace of pith; and although there occur here the two types of primary wood, side by side, still the solid cylinder type seems to be more common in the lower than in the upper horizons of Carboniferous Rocks, and the sequence of changes in the development of the primary xylem of the palæozoic Arborescent Lycopods seems to point to the *solid* vascular cylinder as the oldest type, from which has been derived the medullate cylinder with a *continuous ring* of primary wood, and this continuous ring of primary wood has, in turn, broken up to form the *isolated strands* of primary wood found in the Clathrarian *Sigillariæ*.*

I wish to express my thanks to Mr D. T. GWYNNE-VAUGHAN, Glasgow University, for much kind criticism and advice while preparing this paper.

* See note on p. 546 (*Lepidodendron Jutieri*, Renault).

EXPLANATION OF PLATES I.-III.

Sigillaria elegans, Brongt. (Sternb., sp.).

- Pl. fig.
- I. 1. Portion of outer surface of the specimen from near Huddersfield. Halifax Hard bed, Lower Coal Measures. Natural size. To the right is seen a row of leaf scars. Specimen No. 3497.
 - I. 2. Part of the same specimen enlarged two times. To the right is seen the vertical row of leaf scars, and to the left the surface of the cortical layer which bears the leaf cushions.
 - I. 3. Transverse section of the vascular cylinder and part of the cortex $\times 4\frac{1}{2}$. Primary xylem, *x.*' Secondary xylem, *x."* Leaf cushions, *l.c.* and *l.c.'* Slide No. 964.
 - I. 4. Portion of vascular cylinder $\times 35$. Protoxylem, *prx.* Primary xylem, *x.'* Secondary xylem, *x."* Pith-cavity, *p.c.* Slide No. 964.
 - II. 5. Longitudinal (radial) section of leaf cushions $\times 20$. Spongy transparent parenchymatous tissue, *p.* Dense tissue of smaller cells, *p.p.* Leaf trace opening, *l.t.* Very dense tissue at upper left corner of figure, periderm. Slide No. 841.
 - II. 6. Radial section passing through xylem $\times 95$. Protoxylem, *prx.* Primary xylem, *x.'* Secondary xylem, *x."* Slide No. 967.
 - II. 7. Radial section passing through xylem $\times 170$. At *prx.* is shown the termination of a tracheide belonging to the protoxylem. Slide No. 967.
 - II. 8. Radial section passing through xylem $\times 95$. Protoxylem, *prx.* Primary xylem, *x.'* Secondary xylem, *x."* Slide No. 968.
 - II. 9. Radial section passing through primary xylem $\times 95$. At *x.'* is shown the termination of a tracheide. Slide No. 970.
 - III. 10. Transverse section of secondary xylem $\times 95$. Showing medullary rays, *mr.* Slide No. 964.
 - II. 11. Transverse section showing leaf trace $\times 85$. Protoxylem, *prx.* Primary xylem, *x.'* Leaf trace, *l.t.*, which is about to become free from the metaxylem. Slide No. 961.
 - II. 12. Transverse section showing leaf trace $\times 85$. Lettering as before. The leaf trace has just become free from the metaxylem. Slide No. 966.
 - II. 13. Transverse section of leaf trace $\times 85$. Lettering as before. The leaf trace has moved outwards and is becoming suddenly bent to pass out through a medullary ray. Slide No. 964.
 - I. 14. Transverse section of secondary xylem, showing cells of medullary ray with spiral thickening *m.r.* $\times 115$. Slide No. 962.
 - II. 15. Transverse section showing leaf trace at outer margin of secondary xylem $\times 85$. Medullary ray, *m.r.* Secondary xylem, *x."* Leaf trace, *l.t.* The leaf trace has bent upwards after emerging from the secondary xylem, and is cut through at approximately right angle. Slide No. 962.
 - II. 16. Transverse section of leaf trace quite free from the outer margin of the secondary xylem $\times 85$. Slide No. 962.
 - II. 17. Transverse section of xylem $\times 95$. Primary xylem, *x.'* Secondary xylem, *x."* At *l.t.* is seen the narrow spread-out base of the leaf trace shortly before it dies out. Slide No. 964.
 - I. 18. Outer surface of a specimen showing the leaf scars and portion of a circle of cone scars, *c.s.* Natural size. From Wombwell Main Colliery, near Barnsley, Yorkshire. Horizon, Barnsley Thick Coal, Middle Coal Measures. Collected by Mr W. Hemingway. Specimen No. 989.
 - III. 19. Radial (longitudinal) section passing through six leaf cushions $\times 4$. Periderm, *p.d.* Surface to which leaf was attached, *s.a.* Opening through which leaf trace passed, *l.t.* The cushion marked *l.t.* is enlarged at fig. 5. Slide No. 841.
 - III. 20. Transverse section of cushion $\times 14$. Transparent parenchymatous tissue, *p.* Broken down margin of cushion, *pp.* Periderm, *pd.*, *pd.'* The part marked *pd.'* is enlarged at fig. 21. Slide No. 962.

- Pl. fig.
- III. 21. Transverse section of periderm $\times 50$. The part enlarged is seen on fig. 20, *pd.*' Slide No. 962.
- III. 22. Section of leaf cushion approximately parallel with the surface $\times 14$. Position of leaf trace, *lt.* Parichnos, *par.* Transparent parenchymatous tissue, *p.* Slide No. 973.
- III. 23. Section approximately parallel with outer surface of stem $\times 8$. Free portions of leaf cushions, *lc.* Cone pedicels, *cs.*, *cs.*' Slide No. 972.
- II. 24. Portion of transparent parenchymatous tissue of the leaf cushion shown at fig. 22, *p.*, $\times 60$. Slide No. 973.
- III. 25. Transverse section of cone pedicel $\times 20$. Slide No. 972. See description in text, page 544.
- III. 26. Portion of the cortex shown at fig. 25, *c.*, $\times 35$. Slide No. 972.
- I. 27. Transverse section of vascular strand of cone pedicel $\times 70$. Thin-walled disorganised tissue, *h.* Vascular strand, *h.* Endodermis-like structure, *e.* Slide No. 972.
- I. 28. Tangential section through secondary xylem $\times 95$. Medullary rays, *m.r.*, cut through at right angles. Slide No. 969.

KIDSTON: STRUCTURE OF SIGILLARIA ELEGANS.—PLATE I.

1.

2.

18.

14.

28.

27.

4.

3.

KIDSTON : STRUCTURE OF SIGILLARIA ELEGANS.—PLATE II.

11.

13.

15.

17.

6.

12.

16.

24.

9.

8.

7.

KIDSTON : STRUCTURE OF SIGILLARIA ELEGANS.—PLATE III.

5.

p.p.
l.t.
p.

p.d'

19.

s.α.

l.t.

21.

26.

e.

g.

22.

par.
l.t.
p.

m.r.

m.r.

10.

par.

20.

p.p.
p.
p.d.
p.d'

23.

c.s'

l.c.

l.c.

l.c.

c.s.

25.

b. d.

c. h. k.

g.

f.

d. b.

l.c.