

CUTICULAR STUDIES OF THE REPRODUCTIVE ORGANS OF
GLOSSOPTERIS PART II—CISTELLA TYPE FRUCTIFICATION—
PLUMSTEADIOSTROBUS ELLIPTICUS GEN. ET SP. NOV.
ATTACHED ON *GLOSSOPTERIS TAENIOIDES* FEISTMANTEL

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ABSTRACT

A Cistella type female fructification is described under a new generic name, *Plumsteadiostrobos*. It is attached on *Glossopteris taenioides* Feist. The leaf has similar cuticular characters as described by Srivastava for *G. taenioides* and by Pant and Nautiyal for an identical leaf but described under a new specific name. We prefer to retain Feistmantel's specific name. The female reproductive organ consists of a receptacle bearing a large number of small seeds arranged in close spiral all round it. The seed bearing receptacle is borne in the axil of a protective bract which closely covers the receptacle like a spathe. The bract and the receptacle is borne on a short common pedicel which is attached to the midrib of *Glossopteris taenioides* at a distance from the base of the leaf. The reproductive organ is thus adnate to the leaf, which means that the fructification is borne in the axil of the vegetative leaf. The female reproductive organ yields three types of cuticles, two belong to the protective bract and the third belongs to the receptacle. The receptacle cuticle possesses lens-shaped openings on which ovules sit. The ovule must be drawing through this hole in the cuticle its vascular supply from the receptacle. The seeds are small, winged, orthotropous, platispermic and were described by Pant and Nautiyal as *Pterygospermum raniganjense* in dispersed condition. The cells of the integument contain characteristic crystalline imprints. The nucellus is thickly cutinized and show excavated pollen chamber. Two winged pollen grains are very often found trapped in the pollen chamber. This Cistella type of fructification is distinct from *Dictyopteridium* and *Scutum*. One species, *Plumsteadiostrobos ellipticus*, is described here from the Raniganj Stage of the Raniganj Coalfield, India.

INTRODUCTION

IN 1952, Plumstead described two genera of reproductive organs, *Scutum* and *Lanceolatus*, associated with species of *Glossopteris*. Prior to this, fructifications of *Glossopteris* were unknown. In 1956, Plumstead pointed out that pollen organs of one species of *Scutum* differed so much from the others, that it should be separated from this genus, although at that time no new name was suggested. In the same

year she (Plumstead, 1956) described the earlier known genus *Ottokaria* in association with *Gangamopteris*. Plumstead (1958) added two new types of fructifications and in all made six main sub-divisions or groups under the class Glossopteridae. She stated (Plumstead, 1958, p. 53), "Because these six groups varies so considerably in numerical importance, and because our knowledge of Glossopteridae is still so imperfect, the author (Plumstead) considers it unwise at this stage to attempt to evaluate them and would prefer to regard them as six fructification types to which descriptive names will be given, rather than designating them as true genera, groups which time may show to be of greater or lesser importance". Plumstead's types are: Shield or Scutum type, Hair or Hirsutum type, Spear or Lanceolatus type, Long stalk or *Ottokaria* type, Casket or Cistella type and Ostrich feather of Pluma type.

The fructification described in this paper belongs to Cistella type. Plumstead described this type as wingless, possessing two halves, the female half with well developed oval sacs and the other concave, protective half. Both halves were free and adnate only at the pedicel. Plumstead (1958) described two species from South Africa, *Cistella stricta* attached to *Glossopteris stricta* and *Cistella waltonii* which was found detached. H. K. Maheshwari (1965) described a new species of *Cistella*, *C. indica*, from the Raniganj Stage, India attached to a leaf of *Glossopteris* sp. Three species of *Cistella* have been reported from Australia. White (1963) described *Cistella bowensis* attached on *Glossopteris communis* and *Cistella ampla* on *Glossopteris ampla*. Rigby's (1963) *Plumsteadia microsacca*, which White (1963) considered synonymous with *Cistella*, was borne on a leaf described as *Glossopteris* cf. *communis*. White (1963) considered the

name *Plumsteadia*, proposed by Rigby for a glossopterid fructification, as synonymous with *Cistella*, to which Rigby (1968) later agreed. In the same paper, however, he proposed conservation of *Plumsteadia* Rigby over *Cistella* Plumstead and suggested the following change in nomenclature: *Plumsteadia waltonii* (Plumstead) Rigby, *Plumsteadia microsacca* Rigby, *Plumsteadia bowensis* (White) Rigby, *Plumsteadia ampla* (White) Rigby, *Plumsteadia indica* (Maheshwari) Rigby. In 1971, Rigby published a diagnosis, which is quite distinct from *Plumsteadia* which is being described in this paper. He also put *Dictyopteridium sporiferum* as a synonym of *Plumsteadia microsacca*, which is wrong. *Dictyopteridium* is quite distinct in all respects (Shaila Chandra & K. R. Surange (1976) from *Cistella*-like fructifications. They are also not microsporangiate organs as we have found attached seeds on them.

In the same year (1968) in the April issue of *Taxon*, J. K. Maheshwari pointed out that the multiple use of the name *Cistella* brings to attention a case of homonymy involving three unrelated extant and fossil plants. He, therefore, proposed the name *Gonophylloides* for the fossil genus *Cistella*.

Thus there are two names, viz., *Plumsteadia* Rigby and *Gonophylloides* Maheshwari which have been proposed for the replacement of the genus *Cistella* Plumstead in the same year.

We are inclined to agree that the descriptive names such as *Scutum*, *Cistella*, *Lanceolatus* etc. should not be taken as natural genera as Plumstead herself intended (1958). They can at best be regarded as artificial genera or group names. When a reproductive organ is known in sufficient details, it should be separated from the group and placed under a new generic name. This practice we have followed in this paper.

The female fructification described below belongs to *Cistella* type which is borne on the leaf *Glossopteris taenioides* Feist-

mantel. The fossils are preserved in the form of coaly compressions and have revealed the detailed structure of the protective bract, the receptacle and the seeds borne on them. We have, therefore, separated it from the group name *Cistella* and placed it under a new generic name *Plumsteadia* after Dr. Edna P. Plumstead.

The material was collected from the Raniganj Stage, Raniganj Coalfield, Bengal, India.

DESCRIPTION

Plumsteadia gen. nov.

Generic Diagnosis — Female reproductive organ borne on leaf *Glossopteris taenioides* Feistmantel, attached by short stalk to midrib of leaf in basal region; fructification elliptical, consists of seed bearing receptacle and spathe-like protective bract of same shape, closely covering it; protective bract with few strong midveins persisting right up to apex and secondary veins bifurcating and fusing to form meshes; seed bearing receptacle unwinged, elliptical, studied with small, oval seeds all round it; seeds many, arranged in close spiral, but in compression marginal seeds appear arranged in a row one below the other, all along margin except at base where stalk interrupts them; seeds platyspermic winged, *Pterygospermum* type.

Type Species — *Plumsteadia ellipticus* sp. nov.

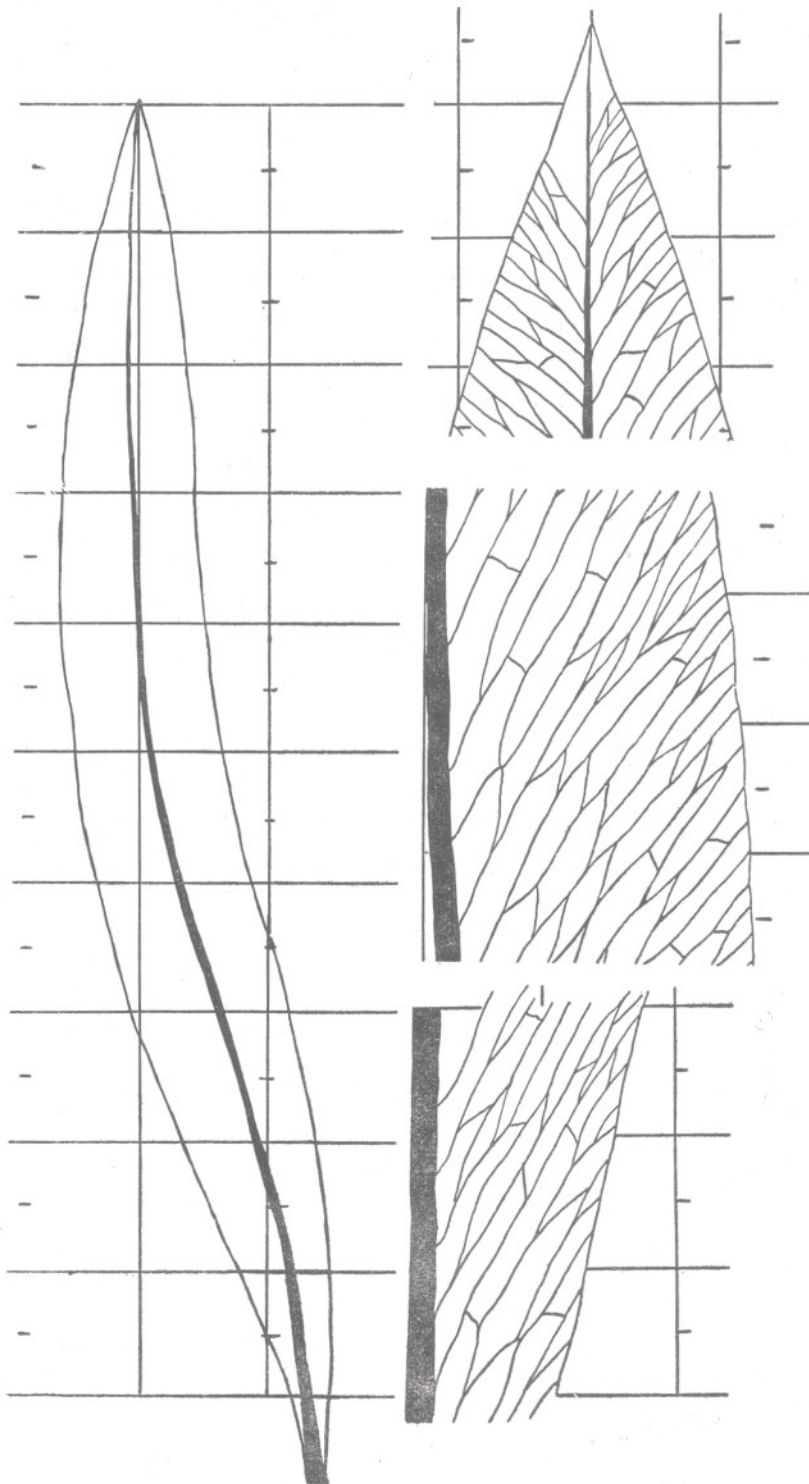
1965 — *Cistella indica* Maheshwari, pp. 144-145, pl. 1, fig. 1.

1968 — *Plumsteadia indica* (Maheshwari) Rigby, p. 93.

1968 — *Gonophylloides indicum* (Maheshwari) Maheshwari, p. 238.

Diagnosis — Multiovulate, elliptical, female reproductive organ, attached to midrib of *Glossopteris taenioides* Feistmantel by short pedicel; reproductive organ consists of seed bearing receptacle and a spathe-like protec-

TEXT-FIG. 1 — Leaf of *Glossopteris taenioides* Feist. drawn on a two centimetre grid. It has a prominent midrib persisting right up to the apex. The venation from the base, middle and apex is also shown on a two centimetre grid. Note the steeply rising lateral veins, Y-shaped vein junctions and cross connection. Leaf $\times 2$, Venation $\times 4$.



TEXT-FIG. 1

tive bract, borne on a common pedicel and closely fitting the receptacle; protective bract prominently veined, mid-veins strong, persist up to apex, secondary veins bifurcate and anastomose to form meshes; protective bract yields two types of cuticle, cuticular cells tetra- to pentagonal with arched walls, large, stomata present only on one surface; receptacle with many small seeds, arranged in close spiral, marginal seeds stand out and seen arranged in a row all round margin; seedless receptacle possesses small, hemispherical seed cushions; cuticle of receptacle possesses many small, lens-shaped openings or holes, lined by small rectangular cells arranged in radial rows all round the hole, cells in between holes large, polygonal with curved walls, cell walls stiff, slightly thickened; receptacle cuticle also possesses secretory cells (hair bases?) surrounded by cells with moderately thick walls; seeds *Pterygospermum raniganjense* Pant and Nautiyal type, platyspermic, wing narrow, but broader at micropylar end, outer cuticle of integument showing rectangular to polygonal cells with characteristic imprints of crystals, cells of wing very large, thin, polygonal; nucellus thickly cutinized with excavated pollen chamber, two winged pollen grains of *Faunipollenites* types.

FRUCTIFICATION BEARING LEAF —
GLOSSOPTERIS TAENIOIDES FEISTMANTEL

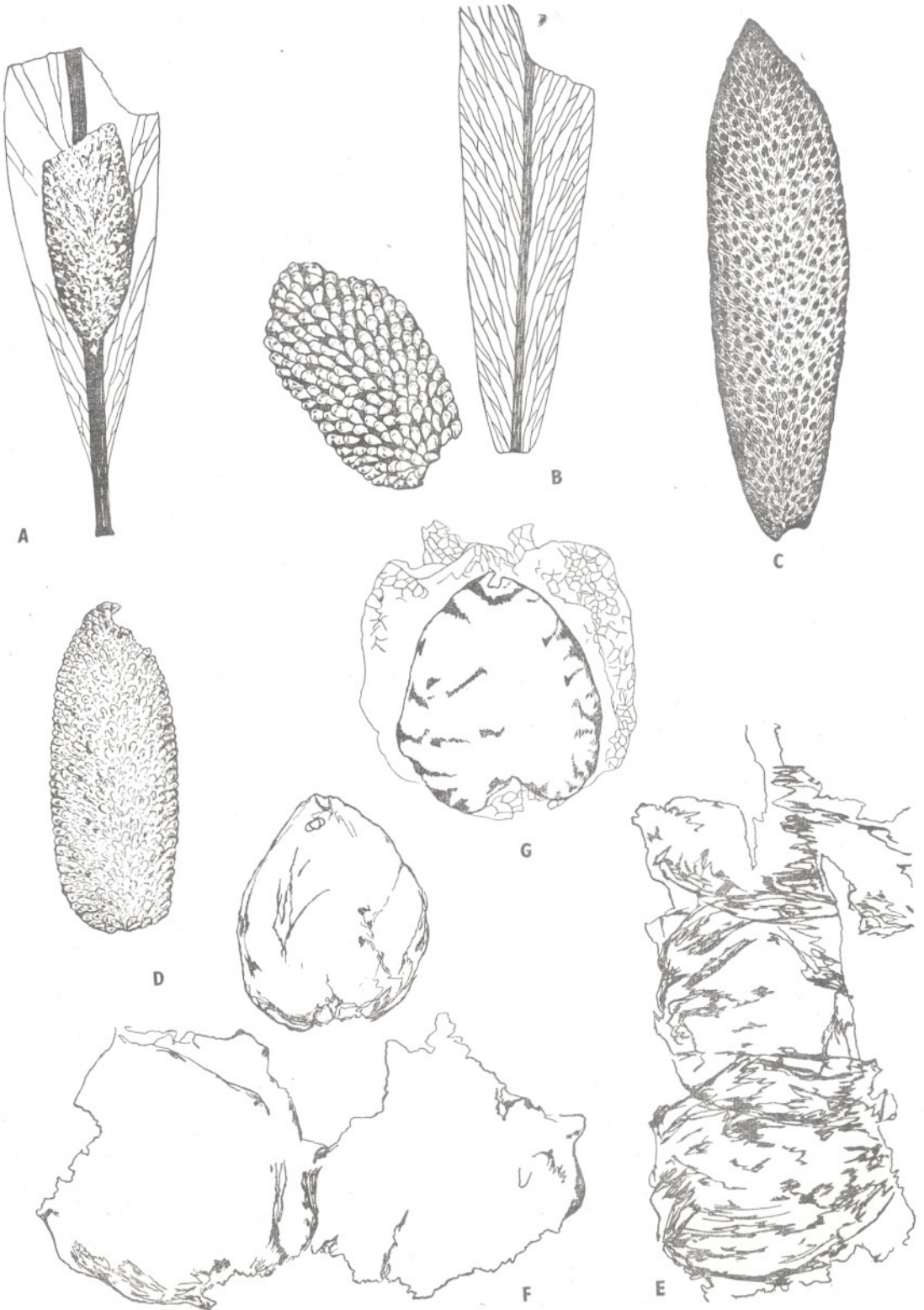
Srivastava (1956) described cuticular structure of a leaf identified by him as *Glossopteris taenioides* Feistmantel which he collected from the Raniganj Stage. Later Pant and Gupta (1971) described a leaf identical with Srivastava's *Glossopteris taenioides* under a new specific name *Glossopteris gondwanensis* on the basis that Feistmantel's only available specimen (No. 5490) is devoid of carbon and, therefore, no epidermal structure of this leaf specimen could be

known. We are convinced that Feistmantel's *G. taenioides* as described by Srivastava and *G. gondwanensis* of Pant and Nautiyal are identical and would prefer to retain the original specific name of Feistmantel.

A large number of detached leaves of this species are present in our collection. A few of them are found with *Plumsteadio-strobos* fructification attached to them. However, the vegetative and fructification bearing leaves show no difference whatsoever in external morphological characters as well as in cuticular structure. It appears that some leaves on a shoot might become fertile and bear reproductive organs. The leaf is small, linear, ribbon like, 13-15 cm long and about 1 cm broad (Pls. 1, 2, figs. 1-4, 5, 6; Text-figs. 1, 2A, B). The venation of this leaf is very characteristic (Text-fig. 1). The midrib is strong and persistent to the apex. The lateral veins arise very steeply from the midrib and sometimes arch slightly or run straight upwards to reach the margin. The lateral veins in the basal region arise more acutely and the meshes are narrow (Text-fig. 1) than those in the middle region. Each lateral vein bifurcates two to four times and meet the adjoining branches to form somewhat broad, elongate meshes. Some meshes are pentagonal or quadrangular. Cross connections are common and the vein junctions are mostly Y-shaped.

The cuticular structure of these leaves is identical with that described for *G. taenioides* by Srivastava (1956) and for *Glossopteris gondwanensis* by Pant and Gupta (1971). The cells of the upper cuticle are trianguloid to polygonoid in shape with arched walls. The lower cuticle is thinner and the cells are mostly obscure but the stomatal pores are clearly seen (Pl. 3, figs. 10, 11). The cells over the veins are rectangular, straight-walled and are arranged end to end. The cells in the mesh areas are somewhat

TEXT-FIG. 2 — A, *Plumsteadio-strobos* fructification attached on *Glossopteris taenioides* leaf. Note the venation of leaf $\times 2$, specimen no. 35228; B, receptacle studded with seeds lying near the leaf of *G. taenioides*, specimen no. 35231 $\times 2$; C & D, seedless receptacles with seed cushions, specimen nos. 35235 and 35236 $\times 2$; E, three seeds isolated from a seed bearing receptacle, seeds overlap each other, slide no. 5016 $\times 25$; F, one seed of *Plumsteadio-strobos* opened up and the nucellus taken out (shown above), slide no. 5012. The nucellus and the integument are free except perhaps at the base $\times 25$; G, a seed of *Plumsteadio-strobos* showing a wing broad at the micropylar end than at the chalazal end. Note thin walled cells of the wing, slide no. 5011 $\times 25$.



TEXT-FIG. 2

similar in shape to those of the upper cuticle. They are trianguloid, rectanguloid or polygonoid with arched cell walls. Stomata irregularly orientated and scattered. Stomatal pores are elongated and slightly thickened. Subsidiary cells are 5 to 6 in number.

The cuticles of leaf bearing fructification and those of leaf without fructification are identical.

The fructification is attached in the basal region of the leaf (but not at the base) by a short pedicel, apparently to its midrib (Pl. 1, figs. 1, 2; Text-fig. 2A). It is adnate to the midrib up to some distance from the base. Mostly it is attached at an angle to the midrib, but sometimes it is preserved in the centre, covering almost the entire lamina of the leaf subtending it (Pl. 1, fig. 1). *Plumsteadia* has never been found borne at the base of the leaf as is the case with *Dictyopteridium* and *Scutum*. In this respect *Plumsteadia* differs from both of them. The detached fructifications often show a very short pedicel.

THE FEMALE REPRODUCTIVE ORGAN

1. SEED BEARING RECEPTACLE

The present study is based on more than seventy specimens. Only a few were found attached to *Glossopteris taenioides* (Pl. 1, fig. 1; Text-fig. 2A) leaf. The specimens with attached seeds were few; most of them were preserved as seedless receptacles. Pl. 1, fig. 1 shows a specimen of *Plumsteadia ellipticus* attached to the midrib of the leaf, *Glossopteris taenioides*, at a little distance from the base and occupying almost the entire lamina. Maheshwari's specimen of *Cistella indica* is also similar looking, but it has no preservation and so it is not possible to say whether it is identical with ours. In Pls. 1, 2, figs. 2-5; Text-fig. 2B are illustrated some specimens of fructifications which lie near the leaves of *Glossopteris taenioides* in such a position as to suggest that they might have been attached on them. Pl. 2, figs. 7, 8 show some detached specimens. The specimen in figure 8 illustrates a typical seedless receptacle showing small, round cushions with round marks in the centre. Text-figs. 2A to D and Pls. 1, 2,

figs. 1-8 illustrate the range in size and shape of *Plumsteadia*. All of them yielded identical cuticles and so we have placed them all in one species, viz., *Plumsteadia ellipticus*. Most of them are without seeds. Only two specimens (Pl. 4, fig. 17) have seeds compressed on the receptacle.

The fructification is either preserved with the protective bract or without it. In the latter case the bract as well as the seeds had fallen off, leaving behind only the receptacles with seed cushions (Pl. 2, figs. 7, 8; Text-fig. 2C, D). It appears that along with the seeds, the protective bracts were also shed off. The majority of our specimens are preserved as seedless receptacles.

The fructification is 3-4 cm in length and about 1 cm in breadth (Text-figs. 2B, C, D). It is elliptical in shape with pointed or round apex. The seed bearing receptacles must have been somewhat cylindrical in living state. It sometimes leaves a thick impression on the rock, with margins raised (Pl. 2, fig. 7). The stalk is rarely preserved in detached specimens. The seedless receptacle is studded with small, round to oval impressions or small hemispherical cushions. Each cushion shows a small knob or circle in the centre (Pl. 2, fig. 8) which corresponds with the hole seen in the receptacle cuticle. The marginal cushions which are arranged in a row one below the other all along the margin are larger, somewhat elongated or oval and distinct. The cushions are arranged in close spirals and number from ten or more across in a row. In some specimens the central region of the receptacle is disturbed by impression of the midrib of the bract which covers it closely (Pl. 2, fig. 7). Conversely the hemispherical bulges on the receptacle also leave imprints on the protective bract disturbing the venation. In specimens with preserved seeds (Pl. 4, fig. 17) the seeds are seen as round to oval masses, closely crowded together on the receptacle.

We macerated all the fructifications in our collection, with and without seeds. Many showed excellent preservation. The cells of the receptacle are characteristic, and the receptacle cuticle can easily be recognised as against those of the bracts from small bits of cuticles. The cuticle of the receptacle is further characterised

by lens-shaped openings or holes (Pl. 4, figs. 14, 15; Text-fig. 3C) and slightly thickened cells arranged in radial rows all round the holes. The opening is irregularly oval and the cells bordering the hole are broken, mostly incomplete with inner polar walls missing (Pl. 4, fig. 14; Text-figs. 3A, B, C). These cells are thinner, smaller, elongated and arranged one above the other in radial rows for some distance. Often the rows are distorted, disturbing the radial arrangement of the cells. The rest of the cells in between the holes are larger, trianguloid, rectanguloid or polygonoid. In some specimens the receptacle cells give an impression that they contain one papilla each in the centre but we are not sure about it. The cell walls are slightly thickened, arched or straight and firm (Pl. 4, figs. 14, 15; Text-fig. 3C, D). The epidermal layer of the receptacle is dotted with what looks like secretory cells (? hair bases). They are of the same size as other epidermal cells, or a little larger and irregular (Pl. 4, fig. 15; Text-fig. 3D). The cell wall is thickened. The secretory cell is lined by encircling cells, some of which are divided by tangential walls into 2 or 3 cells. They look like subsidiary cells and encircling cells of a stoma.

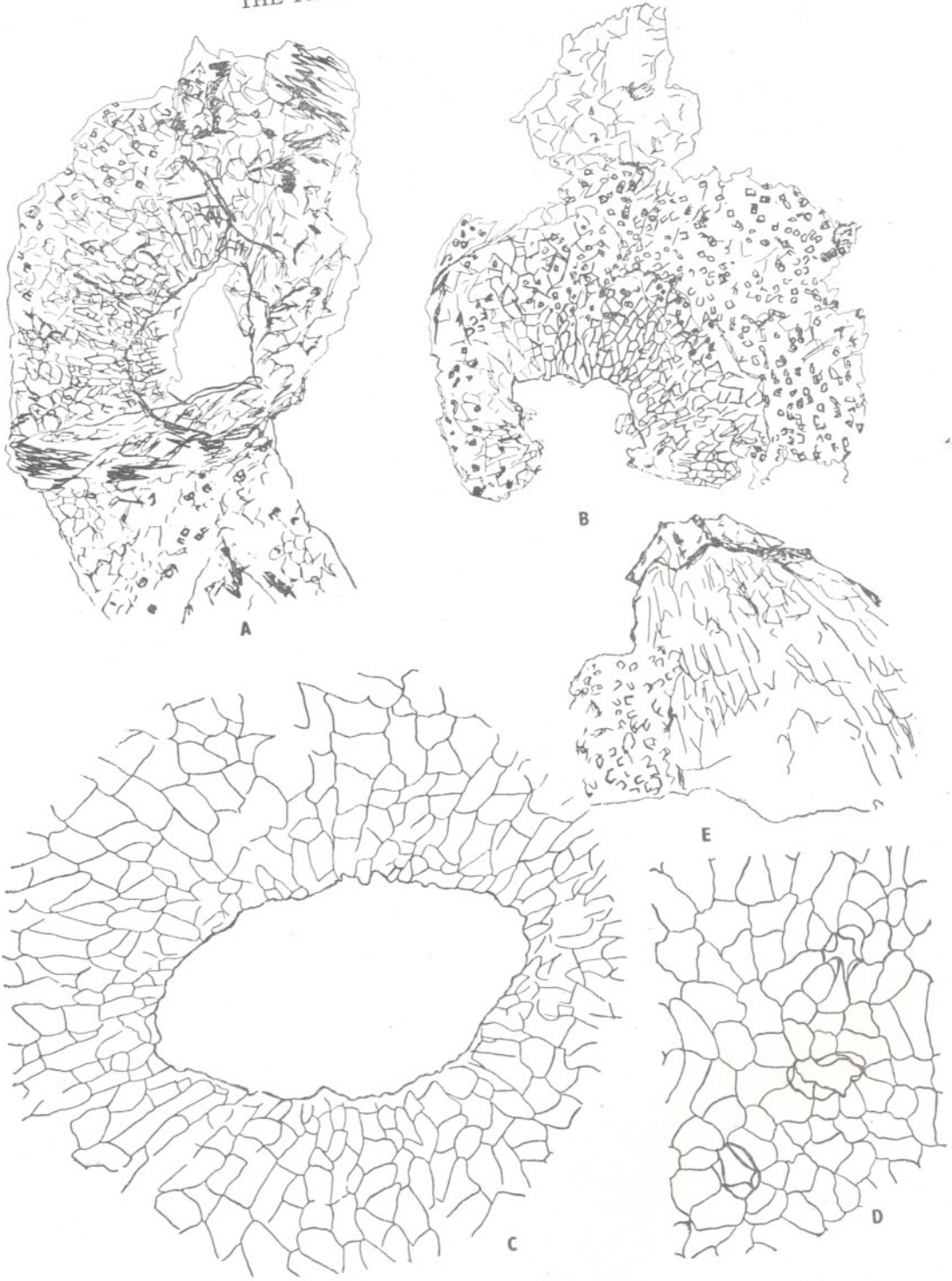
It is obvious that lenticular openings on the receptacle are the places where the ovules were seated. The ovule bearing specimens were carefully macerated and we invariably obtained the ovule integument attached to or overlapping the lenticular openings on the receptacle (Pls. 5, 6, figs. 18, 21; Text-fig. 3A, B). The holes correspond to the knob like impression in the centre of the hemispherical cushion seen on the receptacle (Pl. 2, fig. 8) through which the vascular supply from the receptacle must have passed to the ovule. Pl. 5, fig. 18; Text-fig. 3A show a lenticular hole lined by radially arranged cells and beneath it lies the ovule integument easily recognizable by the characteristic imprints of rhomboidal crystals. Pl. 6, fig. 21; Text-fig. 3B shows another example where the receptacle cuticle and the ovule integument (on the right) have been separated and spread out. It seems that Pant and Nautiyal (1960) have also come across such cases of receptacle cuticle and the seed cuticle entangled together. They (Pant & Nautiyal, 1960, p. 48) observed, "some seeds have

been found entangled in larger delicate cuticular fragments but those may only be foliar cuticles of some kind. A piece of tough cuticle apparently looking like that of a leaf shows a single clear impression of seed (or its closely adhering outer cuticle?), where the crystalline imprints of the outer membrane are seen all over its surface". Since their specimens were isolated, it was not possible for them to understand the relationship of these two different cuticles. We have obtained our preparation from the macerated receptacle with attached seeds and so it becomes apparent what these cuticles are. In Pant and Nautiyal's preparation one cuticle is not foliar but it is that of the receptacle and the other cuticle is that of the *Pterygospermum raniganjense* seed. There is absolutely no doubt that the ovules in *Plumsteadiaostrobos* are attached on the receptacle where lenticular holes are situated and through which the vascular supply from the receptacle must have passed into the ovules. Text-fig. 5 illustrates how the seed must have been attached on the receptacle. Text-fig. 2E shows three under-macerated seeds from the receptacle still held in the same original position as on the receptacle. The seeds are closely situated and are obviously arranged in close spiral, each seed is covered partially by the neighbouring seeds.

Seeds — The seeds attached on *Plumsteadiaostrobos ellipticus* are identical with the detached seeds described as *Pterygospermum raniganjense* by Pant and Nautiyal (1960). The seeds are arranged in close spirals with adjacent seeds overlapping one another by their lateral sides (Text-fig. 2E). Pl. 6, fig. 22 shows two seeds thus arranged. We have isolated bunches of 4 to 5 seeds and their arrangement is as described above.

The genus *Pterygospermum* has been instituted by Pant and Nautiyal (1960) for compressions of small winged seeds found dispersed in the Lower Gondwana beds of India. Their material, also like ours, has been collected from the Raniganj Coalfield. This genus differs from *Stephanostoma* and *Platycardia*, two genera instituted by the same authors (1960) for seeds, in having a wing round the seed and in the absence of having an open funnel above the micropylar tube.

One complete seed isolated from *Plumsteadiaostrobos ellipticus* is shown on Pl. 6,



TEXT-FIG. 3

fig. 23; Text-fig. 2G, F. The seed is orthotropic and platyspermic. The lense-shaped hole on the receptacle supports this observation. In Text-fig. 2F is shown the integument cut open and spread out and the nucellus which came out is shown just above the two flaps. The nucellus must have been attached with the integument only at the base which is found generally torn, thus releasing the nucellus. The seed measures about 1.5 mm in length and about 0.8 to 1 mm in breadth. The outer covering of the seed expands into a wing, which is broad at the micropylar end and narrow at the chalazal end (Pl. 6, fig. 23; Text-fig. 2G). The chalazal end is generally found torn. The wing, which is an extension of the integument, is continued on either side of the micropyle. The cells of the wing are large, thin walled, devoid of crystalline imprints (Text-fig. 4E) and delicate looking than the cells of the integument covering the nucellus. They are rectangular to polygonoid in shape and being delicate, they are easily destroyed in maceration. Pl. 5, fig. 19 also shows the outer cuticle of integument and the wing. It seems that the part of integument, which is outside the nucellus, expands and forms into a wing. The cells of the integument covering the nucellus are small rectangular or polygonal and contain crystalline imprints (Pl. 6, figs. 25, 26; Text-figs. 3A, B, 4F, E). The crystalline imprints are mostly hexagonal or rectangular and are very characteristic for this seed (Pl. 6, figs. 25, 26). They persist even when the cell walls of the integument become obscure in maceration. In fact this seed can easily be identified by these characteristic crystalline imprints. The inner cuticle of the integument is very delicate and shows elongated thin walled cells (Text-fig. 3E). The nucellus is thickly cutinized (Pl. 6, fig. 24) and show an

excavated pollen chamber on top (Pl. 5, fig. 20; Text-fig. 4A). It is round at the bottom and acute at the top. Surface cells of the pollen chamber are elongated and have delicate wavy walls. The processes which radiate into the pollen chamber may be folds of the cuticles as observed by Pant and Nautiyal (1960). The cells on the rest of the surface of the nucellus are thin, elongated and deeply sinuous or almost zig-zag. We have not been able to observe megaspore or megaspore membrane.

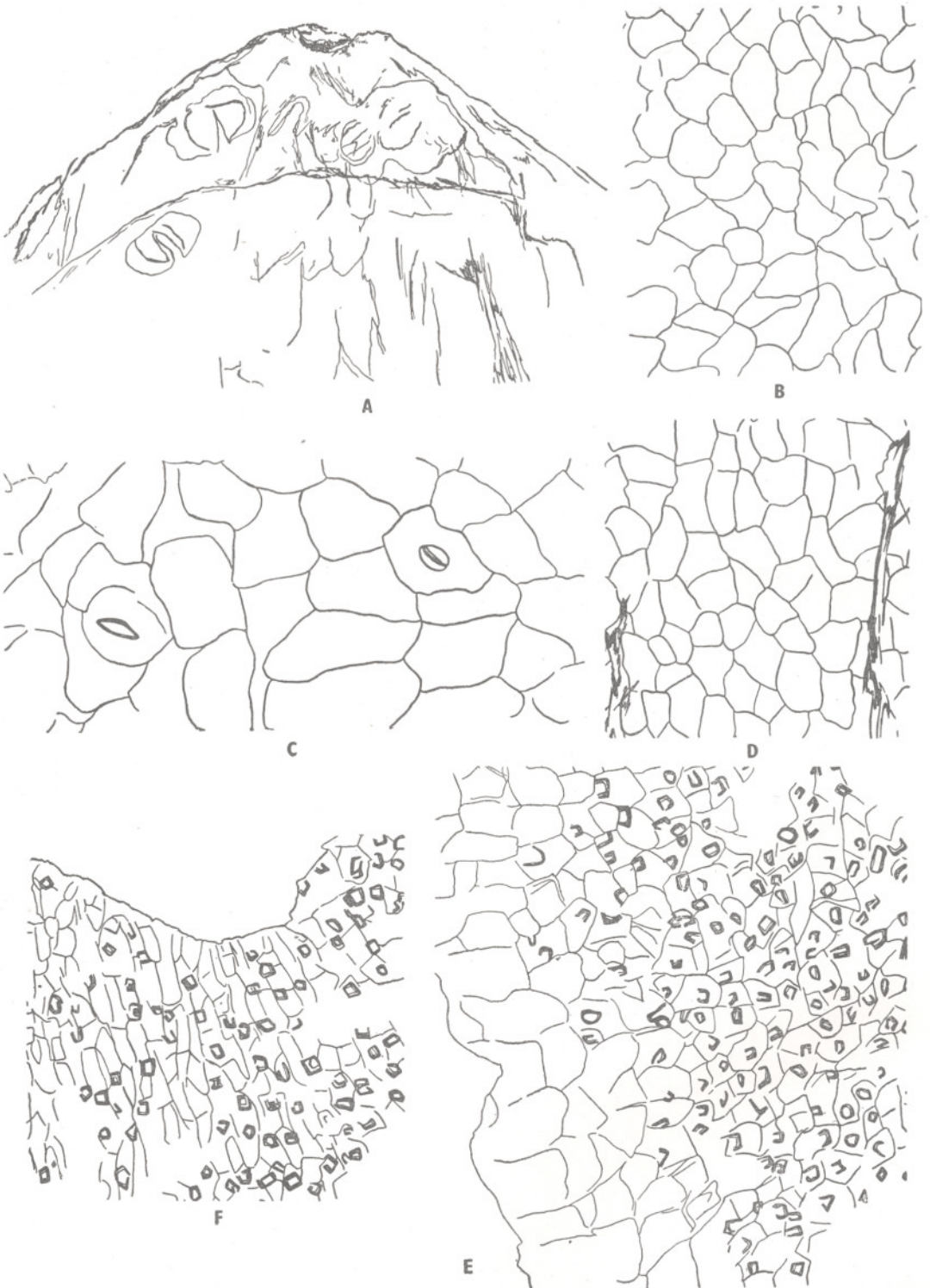
Two winged pollen grains are seen inside the pollen chamber of some seeds (Pl. 5, fig. 20; Text-fig. 4A). The wings are hemispherical and helmet-shaped and attached on two side of the central body. They are *Fauxipollenites* type.

2. PROTECTIVE BRACT

The protective bract and the ovule bearing receptacle are borne on a common pedicel, which in its turn is attached to the midrib of *Glossopteris taenioides*. The receptacle occupies a middle position, in between the bract and the vegetative leaf (Text-fig. 6). The bract is almost of the same shape as the receptacle and in many specimens the venation generally gets obscured by the imprints of the seeds which it covers. The central vascular bundles, which persist right up to apex, are very strong and prominent. The lateral veins arise at an acute angle from the central bundles, bifurcate once or twice and join with one another to form meshes.

The protective bract yields two types of cuticles (Pl. 3, figs. 9, 12, 13; Text-fig. 4B, C, D). One is comparatively thick and the other thin (Pl. 3, fig. 13). Mostly the thin cuticle shows imprints of stomata but the cells are generally not preserved (Pl. 3,

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TEXT-FIG. 3 — A, B, Two receptacle cuticles showing outer membranes of the seeds superimposed on the lenticular openings on the receptacle cuticle. The latter is recognizable by radial arrangement of cells round the opening. The integument is recognized by crystalline imprints and big thin walled cells of the wing. It indicates that the seeds are attached on the holes on the receptacle cuticle, slide no. 5015-5018 × 75; C, one lens-shaped hole on the receptacle cuticle. Some cells lining the hole are torn, they are smaller in size than the cells away from the hole, slide no. 5014 × 175; D, cells of the receptacle cuticle with three secretory (?) cells and their surrounding cells, slide no. 5014 × 175; E, apical end of the nucellus a part of the integument is attached on the left, slide no. 5017 × 90.



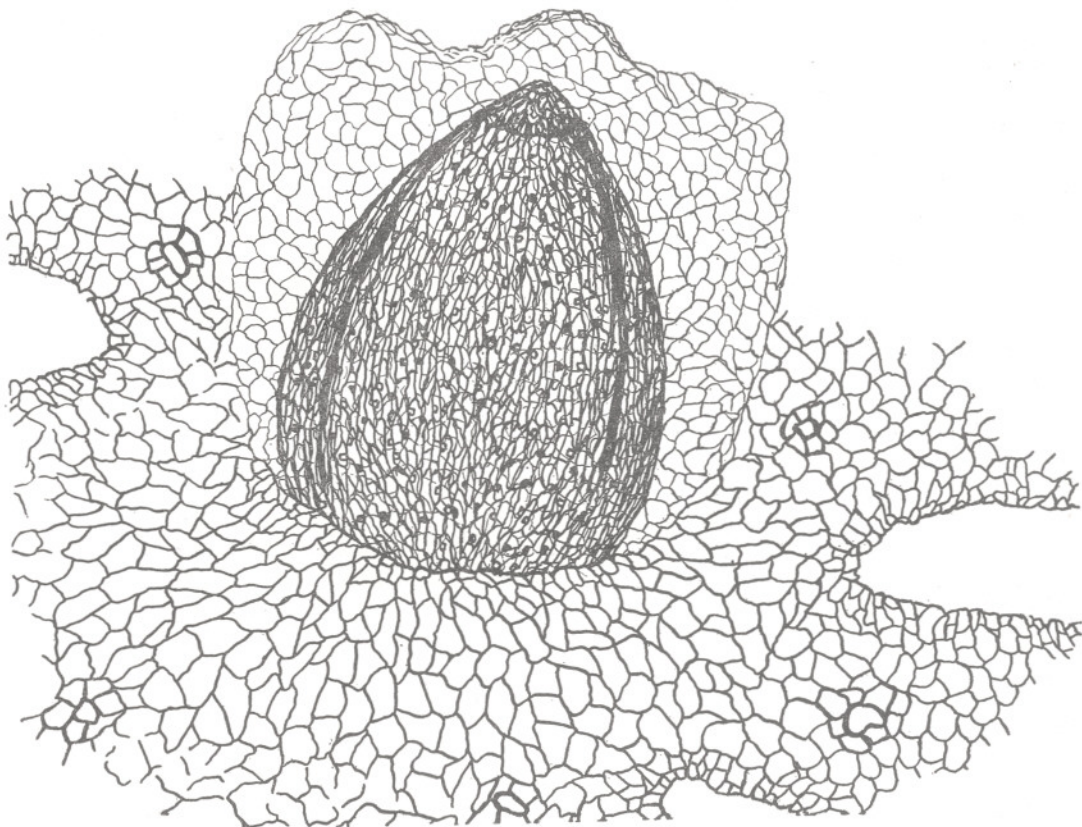
TEXT-FIG. 4

figs. 10, 11). The thick cuticle is devoid of stomata (Pls. 3, 4, figs. 9, 16).

The preservation was satisfactory in a very few specimens. The thick cuticle of the bract is differentiated into vein and mesh areas (Pl. 3, fig. 9). However, in some this arrangement was not clear. Cells over veins are rectangular, more long than broad and arranged in longitudinal rows. The

cells in the mesh areas are large, arranged haphazardly, rectanguloid or polygonoid with arched lateral walls and anticlinal walls. The cells are of various shapes and sizes.

The cells of the thinner cuticles are large, trianguloid, rectanguloid to polygonoid and of various shapes and sizes (Pl. 3, fig. 12; Text-fig. 4C). The cell walls are usually arched. The stomata are irregularly orien-



TEXT-FIG. 5 — A diagrammatic representation of how a winged *Plumsteadiostrobis* seed is attached on a lens-shaped hole of the receptacle cuticle. Seeds are not drawn on other holes on the cuticle. They would overlap one another. Dark cells on the cuticle represent secretory cells $\times 50$.

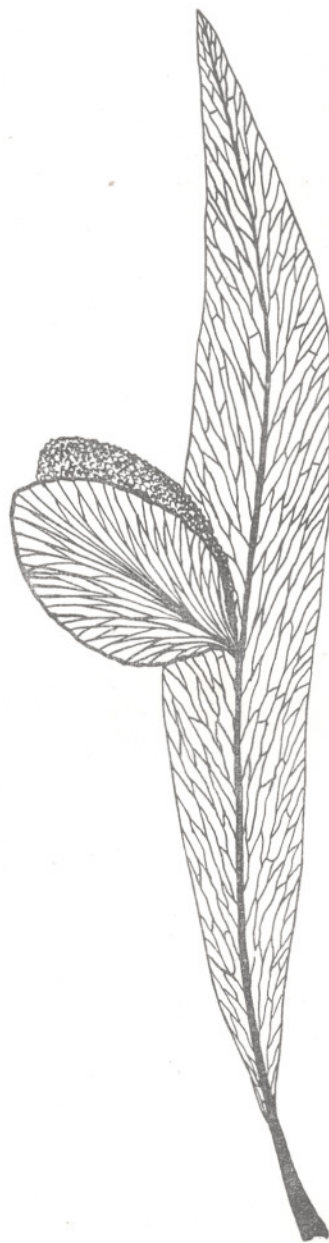
TEXT-FIG. 4 — *A*, Micropylar end of the seed of *Plumsteadiostrobis* showing the pollen chamber and trapped two winged pollen grains, slide no. 5011 $\times 125$; *B*, epidermal cells from the non-stomatiferous cuticle of the bract, slide no. 5021 $\times 200$; *C*, two stomata with subsidiary cells and other epidermal cells from the stomatiferous cuticle of the bract, slide no. 5025 $\times 300$; *D*, epidermal cells of the bract, slide no. 5020 $\times 200$; *E*, the integument of the seed of *Plumsteadiostrobis*. The large thin walled cells on the left are those of the wing. Smaller cells of the integument contain one big crystalline imprint, slide no. 5017 $\times 20$; *F*, integument cell with crystalline imprints near the micropylar end of the seed, slide no. 5019 $\times 200$.

tated and scattered. Subsidiary cells are usually 5 to 6 in number. Sometimes stomata are closely grouped together so that some subsidiary cells become contiguous. Often they are obscure, only large stomatal openings are seen on the cuticle. Lenticular thickenings of the guard cells are clearly visible (Pl. 3, fig. 11).

MORPHOLOGY AND COMPARISONS

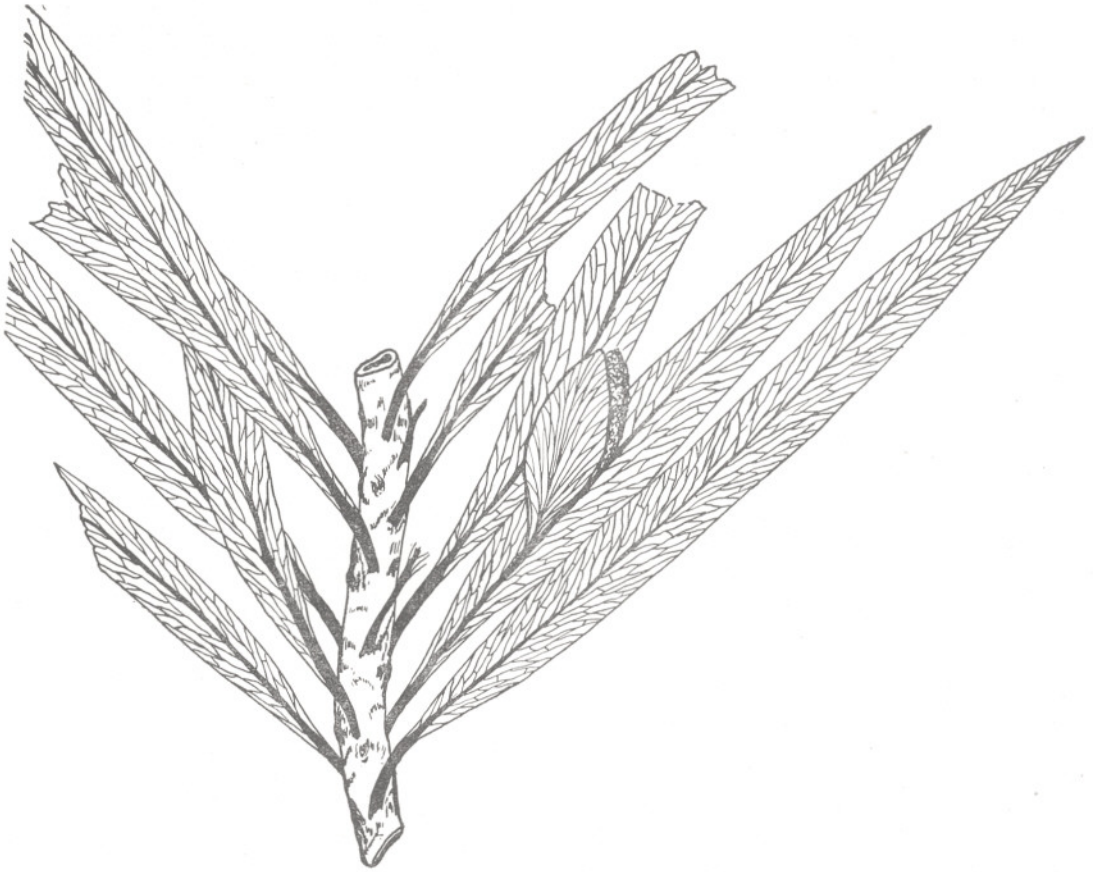
The receptacle compressions of *Plumsteadia* in our material yield three types of cuticles. Out of which two cuticles belong to the veined protective bract and do not look very different from the cuticle of the vegetative leaf. The stomata are confined to one cuticle which perhaps represents the outer exposed surface of the bract. The shape of the epidermal cells on both the bract cuticles is somewhat similar. The third cuticle is quite distinct and belongs to the receptacle. It is devoid of stomata and shows lenticular holes or openings on which the ovules were attached (Text-fig. 5). When seed bearing receptacles are macerated the integument of the ovules are very often found superimposed on these holes (Text-fig. 3A, B). The vascular supply from the receptacle to the ovules must have passed through these openings. Text-fig. 5 shows how a seed is attached on the cuticular openings of the receptacle.

The cuticular evidence thus clearly shows that the reproductive organ of *Cistella* type, in particular *Plumsteadia*, consists of a more or less cylindrical receptacle, bearing a number of small ovules in close spiral all round it. The receptacle is borne in the axil of the bract which closely covers the ovules and must have acted like a protective sheath when the ovules were immature. The short common pedicel of the bract and the receptacle is adnate to the midrib of a vegetative leaf of *Glossopteris taenioides* Feistmantel (Text-fig. 6). Thus it can be said that the reproductive organ is borne in its axil. The fructification bearing leaf is identical to any vegetative leaf of *Glossopteris taenioides* in external morphological characters as well as in cuticular structure. It means that any vegetative leaf was capable of bearing the reproductive organ in its axil. Since a large number of sterile leaves are generally found preserved near the



TEXT-FIG. 6 — A diagrammatic reconstruction to show how *Plumsteadia* fructification is attached to the midrib of the leaf *Glossopteris taenioides* Feist. The seed bearing receptacle is situated between the vegetative leaf and the protective bract $\times 1$.

reproductive organs, we presume that the shoot bearing *Plumsteadia* fructification was a mixed one; there were a few



TEXT-FIG. 7 — A diagrammatic reconstruction of a mixed shoot showing sterile leaves and one fertile leaf bearing *Plumsteadiostrobus* fructification. The fructification is attached on the midrib at some distance from the base. The receptacle is situated in between the protective bract and the vegetative leaf on which it is attached. *ca* \times 1.

leaves bearing female reproductive organs here and there, mixed with a large number of ordinary vegetative leaves. We have shown this in a diagrammatic reconstruction in Text-fig. 7.

In its general morphology, *Plumsteadiostrobus* is similar to *Dictyopteridium*, but the two female reproductive organs are quite different in many characters. *Dictyopteridium* and *Plumsteadiostrobus* are borne on two different types of *Glossopteris* plants. Again, *Dictyopteridium* is borne on the petiole at the base of the leaf whereas *Plumsteadiostrobus* is attached to the midrib, at some distance from the base. Furthermore, the venation and the cuticles of the

protective bract, size, shape and cuticular structure of the receptacle and finally the structure of the seed is quite different in *Dictyopteridium* and *Plumsteadiostrobus*. *Dictyopteridium* and *Plumsteadiostrobus* are, therefore, distinct at least at the generic level. Scutum type of fructification, which we will describe in a separate paper, is also similar to both in general construction, but again quite distinct in detailed structure. In fact *Dictyopteridium*, *Plumsteadiostrobus* and *Scutum* stand equidistant from one another. It is difficult to say at present whether these three are different genera of a single family or more than one family.

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EXPLANATION OF PLATES

PLATE 1

1. Specimen no. 35228 showing a leaf of *Glossopteris taenioides* Feist. with attached *Plumsteadistrobis* fructification. The veined side of the protective bract of the fructification is exposed. $\times 3$.
2. Specimen no. 35229. A seedless receptacle with seed cushions is lying near the leaf of *G. taenioides* in such a position as to suggest its attachment to the midrib. Note the venation of the leaf. $\times Ca$ 4.
- 3 & 4. Specimen no. 35230 and its counterpart. The leaf near the fructification is *G. taenioides*. $\times 1.5$.

PLATE 2

5. Specimen no. 35231. Holotype. The receptacle is studded with round to oval seeds. It is lying near, *G taenioides* leaf. Seeds are shown enlarged on Plate 4, fig. 17. $\times Ca$ 3.
6. Specimen no. 35232. Leaf of *Glossopteris taenioides* showing venation. A part of the receptacle is seen on its left side. $\times 1.5$.
7. Specimen no. 35233. Receptacle and the protective bract. Note the midrib region and the marginal seed cushions. $\times Ca$ 2.
8. Specimen no. 35234. A receptacle head enlarged to show marks of seed cushions. Each seed cushion has a small round marking in the centre. $\times Ca$ 4.

PLATE 3

9. Thick cuticle of the protective bract showing veined and mesh areas. Note the shape of the cells in mesh area. No stomata present. Slide no. 5023. $\times 150$.
- 10 & 11. Thin cuticle from *G. taenioides* leaf. Fig. 11 shows three stomata and faint outlines of

the subsidiary and the epidermal cells. Slide no. 5022 & 5023. $\times 100$ & 300.

12. Stomata bearing cuticle from the protective bract magnified. Note the epidermal cells and the stomata. Slide no. 5025. $\times 300$.

13. The two cuticles of the bract, one stomatiferous and the other nonstomatiferous attached together. Slide no. 5025. $\times 100$.

PLATE 4

14. Cuticle of the receptacle enlarged to show a lenticular opening. Note the incomplete, broken and radiating cells round the hole. The cells round the hole are smaller than those in between the holes. Slide no. 5014. $\times 150$.

15. Receptacle cuticle showing lenticular openings. Note the shape and arrangement of cells. Secretary cells are clearly seen in between the two lenticular holes. Slide no. 5014. $\times 50$.

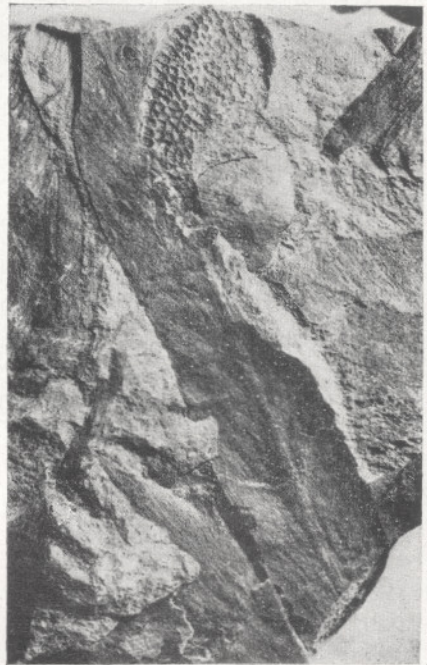
16. Epidermal cells from the nonstomatiferous cuticle of the protective bract. Slide no. 5020. $\times 80$.

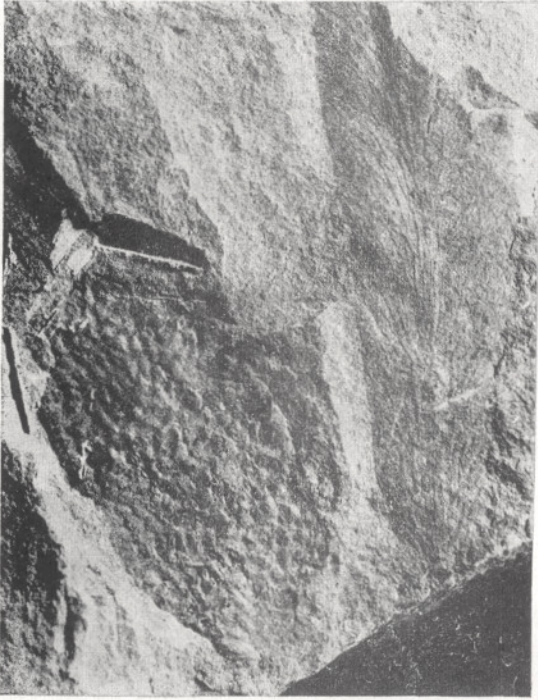
17. Compressed seeds on the receptacle shown in fig. 5 enlarged. Specimen. no 35231. $\times 7$.

PLATE 5

18. Lenticular hole of the receptacle cuticle (note the cells arranged in radiating rows round the opening) superimposed by the integument of the ovule (note the characteristic crystalline imprints on the right and left sides). It indicates that the ovules were seated on the lens-shaped openings on the receptacle cuticle. Slide no. 5015. $\times 100$.

19. The integument of the seed of *Plumsteadistrobis*. The delicate cells on the left are those of the wing which is an extension of the integument. Note the crystalline imprints in the cells of the integument. Slide no. 5013. $\times 100$.

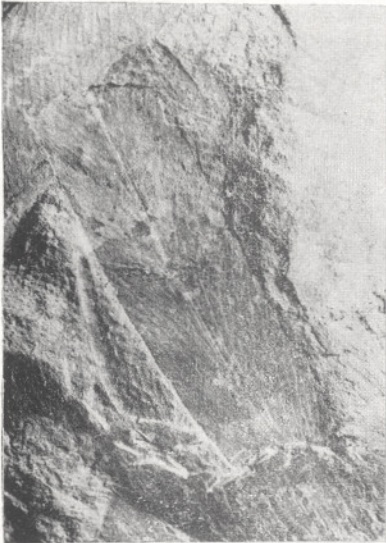




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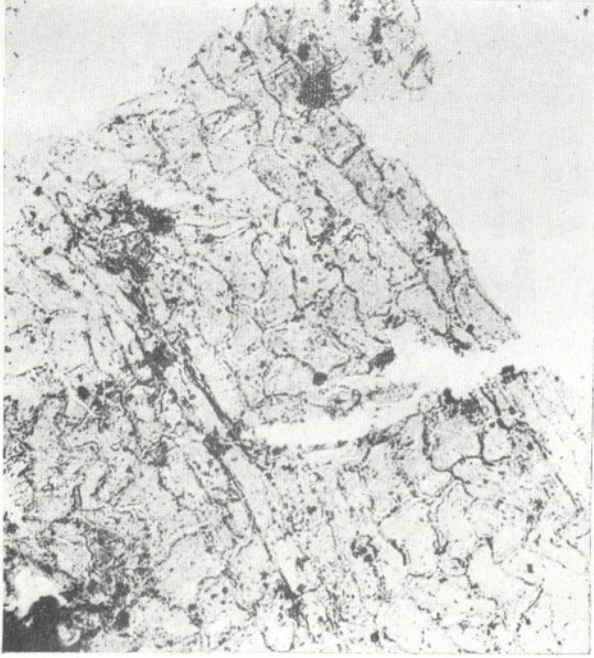
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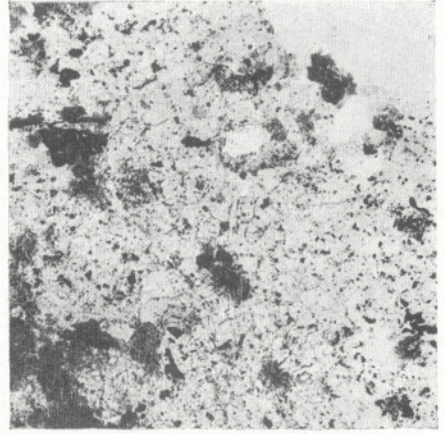
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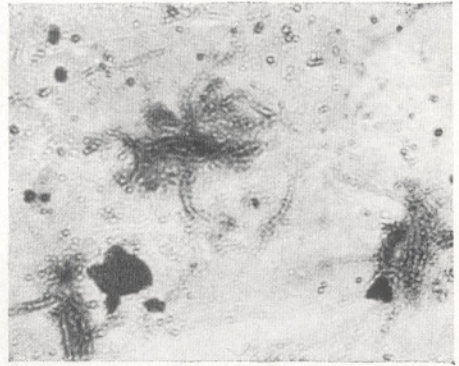
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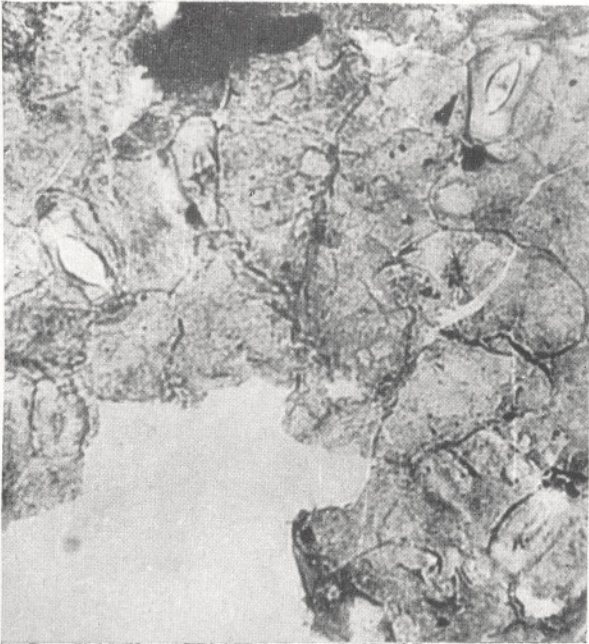
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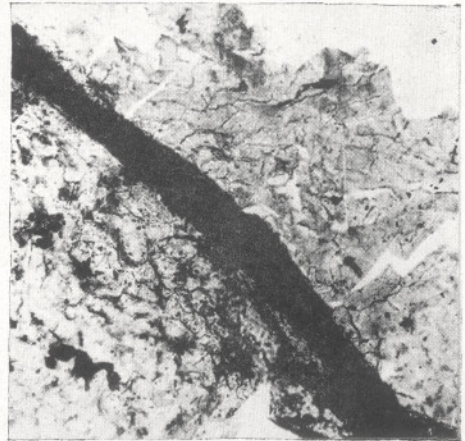
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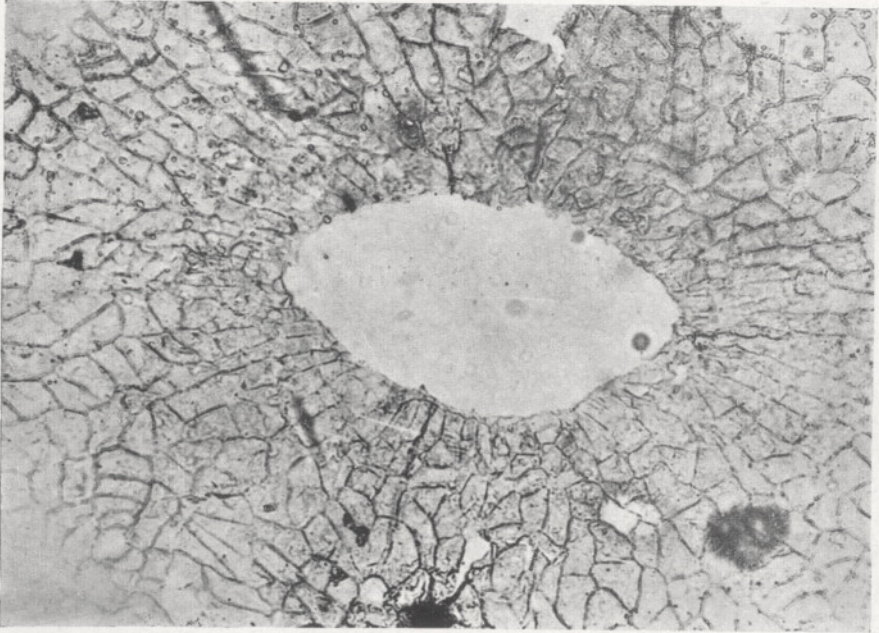
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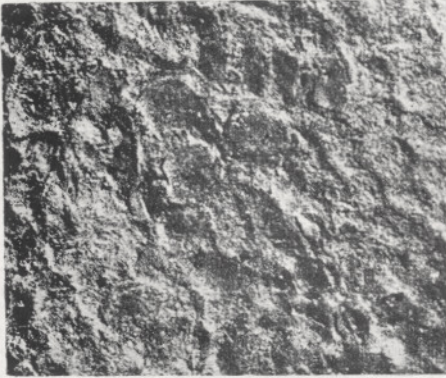
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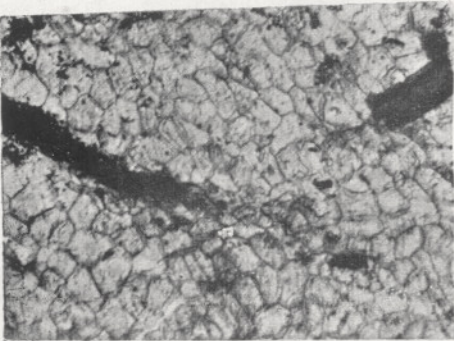
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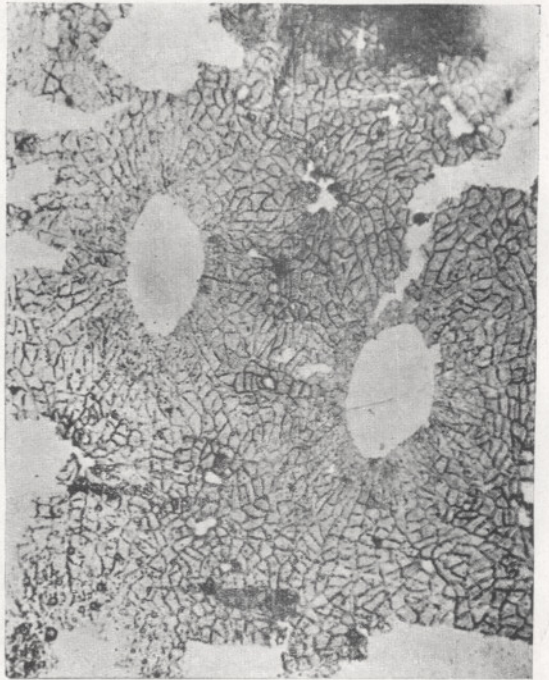
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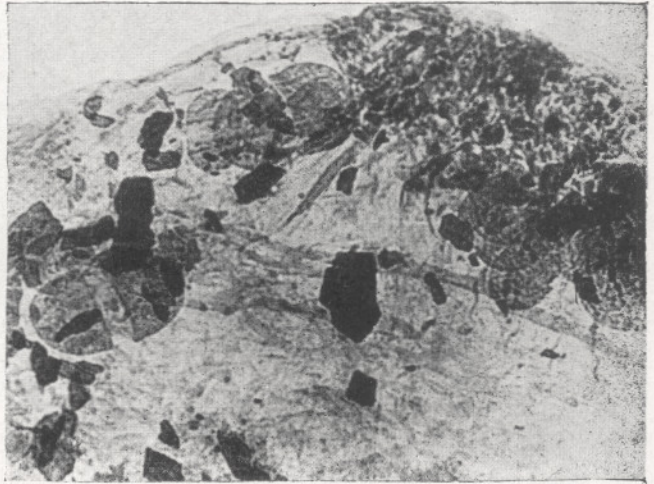
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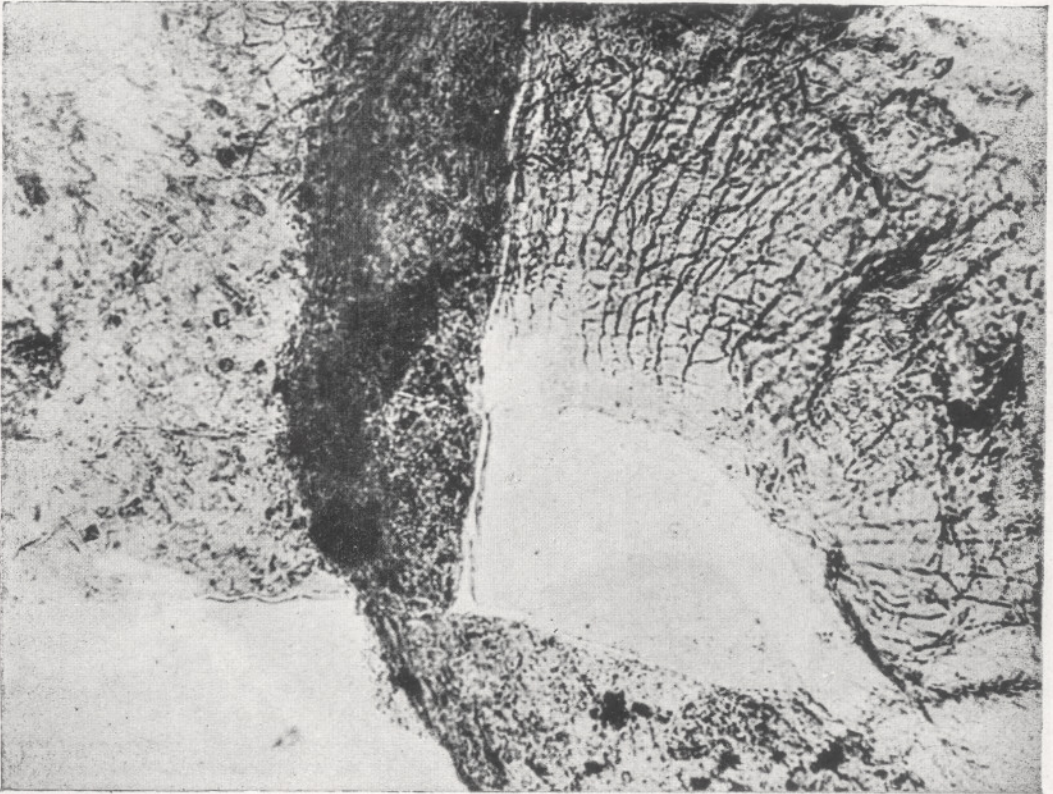
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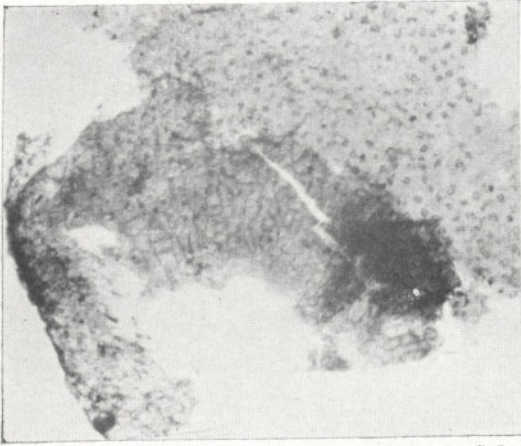
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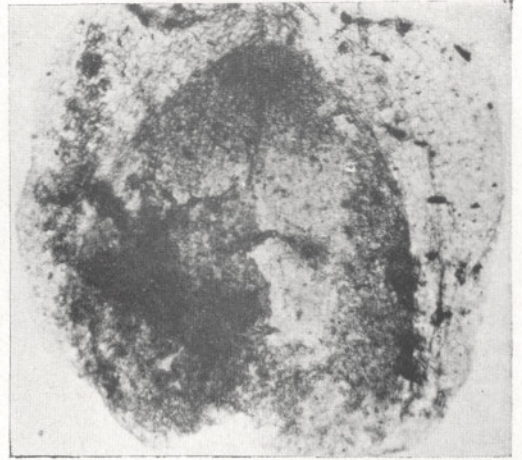
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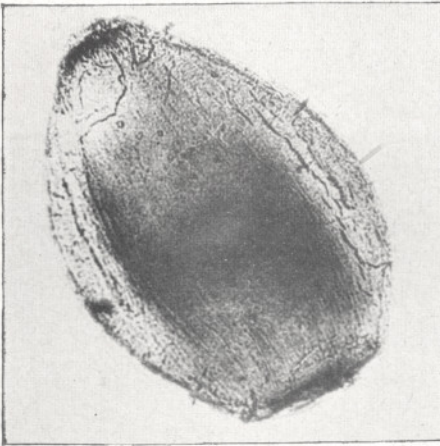
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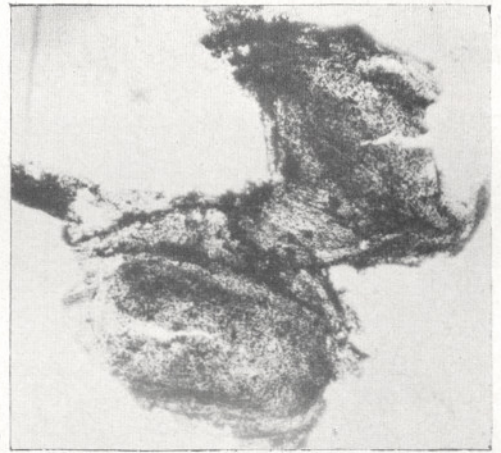
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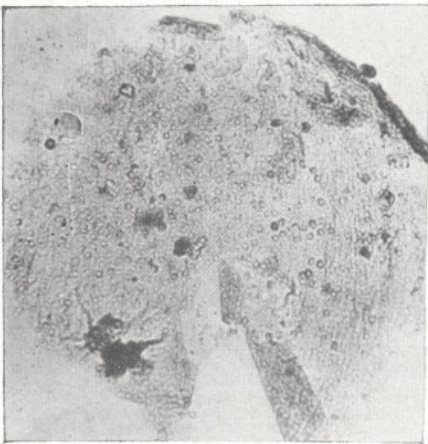
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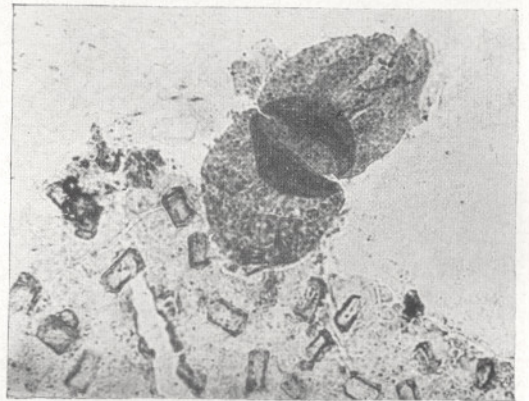
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20. Micropylar end of the ovule enlarged to show the pollen chamber. Note entrapped two winged pollen grains. Slide no. 5011. $\times 200$.

PLATE 6

21. Integument of the ovule with crystalline imprints over-lapping the lenticular hole of the receptacle. Slide no. 5018. $\times 80$.

22. Two seeds isolated from the receptacle. The

seeds are overlapping by their sides. Slide no. 5016. $\times 30$.

23. Winged seed of *Plumsteadirostrobis*. The chalazal end is torned. The wing is broad at the micropylar end. Slide no. 5011. $\times 40$.

24. Nucellus of the seed without integument. Slide no. 5013. $\times 50$.

25. Integument of the seed. Slide no. 5013 $\times 60$.

26. Crystalline imprints on the seed integument. Also two winged pollen grain. Slide no. 5018. $\times 300$.