THE STRUCTURE OF THE HUMAN

TEMPOROMANDIBULAR MENISCUS.

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by
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The subject matter of the thesis has been prepared under the following chapters:-

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INTRODUCTION.

The mandibular articulation is usually classified as a ginglymo-arthrodial joint. (1) This means that the two main movements are a hinge movement and a sliding movement. However, whilst undoubtedly the hinge movement is adequately expressed in this terminology the sliding movement is much more comprehensive than inferred in the above classification. This is due to the fact that there is a forward translatory movement of the mandibular meniscus and condyle during opening of the mouth and reverse movement occurs during closing the mouth. (2) The sliding movement itself is related more to reflex masticatory shift which is to a large extent involuntary as apposed to voluntary opening and closing movements. One might consider we have the problem, on the one hand, of conscious proprioceptive mechanisms, on the other, unconscious proprioceptive mechanisms. (3) It may be that in clinical experience it is the unconscious proprioceptive mechanisms that are operative in giving rise to temporomandibular joint dysfunctions and associated reflex disturbances of locomotion.

It is the purpose of this thesis to describe in some detail the histological components of the temporomandibular meniscus and point out those areas of the meniscus that normally are under compression during normal articular movements and those areas which would come under compression during abnormal articular movements. As well as this an attempt is made to show how the histological structure of the meniscus contributes not only to the mechanical efficiency of the articular movements and, of course, is also concerned by virtue of its nervous components in regulating vascular homeostasis so necessary in locomotion.

Various menisci were examined for their histological structure and schematic reconstruction was a factor in the assessment of various areas. In order to do this all the menisci removed were serially sectioned usually at 12 to 15 micra intervals.

The menisci were obtained post-mortem. This was done by making a vertical incision behind the ear and reflecting the ear anteriorly. This immediately exposed the lateral ligament, and the lateral margin of the condyle could be palpated. The superficial tissue was removed from the neck of the condyle leaving the lateral ligament as far as possible intact. A Gigli saw was passed round the neck of the condyle and it was sectioned. An incision was then made through the periosteum covering the superior-lateral margin of the articular fossa and extended anteriorly from the post glenoid tubercle as far as the anterior boundary of the articular eminence following the curvature of the articular fossa and the articular eminence. A muco-periosteal elevator was then inserted between the bone and periosteum of the articular fossa. The meniscus was depressed by forcing the elevator as far medially as the medial capsule. The periosteum adhering to the squamo-tympanic fissure was then incised, also the periosteum adhering to the anterior margin of the articular eminence. Two incisions were made, one obliquely postero-inferiorly in the case of the posterior incision and in the case of the anterior incision obliquely antero-inferiorly. In the case of the anterior incision it was usually necessary to cut with a pair of scissors the superior and inferior fibres of the lateral pterygoid muscle. Here after in this thesis the superior fibres of the lateral pterygoid muscle will be referred to as the spheno-meniscus muscle, [8] and the inferior fibres as the lateral pterygoid muscle.

The foregoing technique usually resulted in the removal in toto of the temporomandibular meniscus and the head of the condyle. When the specimen was removed, the periosteum around the neck of the condyle including the tendinous insertion of the lateral pterygoid muscle into the pterygoid fovea was completely incised and with a muco-periosteal elevator it was stripped in an upward direction from the condyle.

This resulted in the meniscus being freed from its bony attachments and it could be reasonably well orientated. In all specimens, except two, the meniscus was removed by this technique from the head of the condyle. In one specimen (no. 6 aged 18 years) the head of the condyle was retained and in another specimen (no. 1 foetus at term) the temporomandibular joint was removed "en bloc". The specimens were fixed in 10% formalin and embedded in paraffin wax. In those cases where the bony components were retained, they were decalcified before embedding in paraffin wax. All except one were orientated as nearly as possible in the sagittal plane when embedding in paraffin wax. The other was orientated as nearly as possible in the coronal plane during the embedding stage. All were cut in serial sections at 12-15 micra intervals and stained.

The following stains were used:-

(1) haematoxylin and eosin.

(2) haematoxylin and phloxin.

(3) Verhoeffs Van Gieson.

(4) aldehyde fuchsin haematoxylin and light green.

(5) carmalum picro-indigo carmine.

(6) aldehyde fuchsin without counter stain.

(7) Davenport silver nitrate.

(8) aldehyde fuchsin haematoxylin and picro-indigo carmine.

<u>Details of the specimens used in the preparation of this thesis appear hereunder.</u>

<u>Specimen no. 1.</u>

The temporomandibular joint was removed "en bloc" from a foetus at term which was decalcified and orientated as nearly as possible in the sagittal plane at the embedding stage in paraffin wax and serially sectioned at 12 micra intervals.

<u>Specimen no. 2.</u>

The temporomandibular meniscus and the fibrous covering of the head of the condyle was removed from an infant male cadaver aged 19 mths. Cause of death was cerebral diplegia.

Orientation was carried out as nearly as possible in the sagittal plane at the paraffin wax embedding stage and serially sectioned at 10 micra intervals. The sections from this specimen were stained with aldehyde fuchsin, haematoxylin and picro-indigo carmine.

Specimen no. 3.

Temporomandibular menisci were removed from a male cadaver aged 28 years. Cause of death was coronary occlusion. Orientation was made as nearly as possible in a sagittal plane when the specimens were paraffin wax embedded. The sections were cut serially at 12 micra intervals.

Specimen no. 4.

Temporomandibular menisci were removed from a male cadaver aged 58 years. Cause of death was cardio-vascular disease. Orientation, again, was nearly as possible in a sagittal plane when the specimens were paraffin wax embedded. Sections were taken serially at 12 micra intervals.

Specimen no. 5.

Temporomandibular menisci were removed from a female adult cadaver aged 72 years. Cause of death was carcinoma. Again, orientation of the specimens was carried out as nearly as possible in the sagittal plane at the paraffin wax embedding stage. The sections were cut serially at 12 micra intervals.

Specimen no. 6.

The condyle and meniscus were removed from a male cadaver aged 18 years. Cause of death was medullo blastoma. Orientation was carried out as nearly as possible in the coronal plane at the paraffin wax embedding stage. 28 sections were taken at 120 micra intervals through the pars posterior menisci, the pars gracilis menisci, and the pes menisci. The sections were approximately 10 micra thick.

CHAPTER 1.

MICRO ANATOMICAL AREAS OF THE TEMPOROMANDIBULAR MENISCUS.

For the purpose of making a logical histological assessment of the temporomandibular meniscus it is essential to define micro anatomical areas, both from an anatomical and functional basis.

Rees (4) recognised the fact that the temporomandibular meniscus consisted of four morphologically distinct parts. He recognised an anterior moderately thick band, an intermediate thin band, a posterior thick band, and posterior extensions of this latter band which were the superior and inferior attachments of the meniscus superiorly through the squamo-tympanic fissure, and inferiorly to the posterior slope of the mandibular condyle; and between these extensions, a zone which he called the bilaminar zone. He pointed out that the meniscus was continuous medially and laterally with the medial and lateral capsule of the temporomandibular joint. He pointed out that the lateral capsule was reinforced by the lateral ligament and that fibres of the masetter and temporal muscles were incorporated in the lateral capsule. He also noted that the superior stratum had an elastic component.

Orban (5) does not recognise anatomical distinct parts of the articular disc, but says that it is composed of dense fibrous tissue which resembles a ligament because the fibres are straight and tightly packed. The main cellular component of the disc according to Orban (5) are elongated fibroblasts. He also recognised that the fibroblasts might develop into chondroid cells with advancing age. As regards elastic fibres he stated that they are only found throughout the disc in relatively small numbers. Rees (4) also thought that chondroid tissue was not the predominant tissue and that its predominant component was dense white fibrous connective tissue.

It is apparent therefore that the statements made as regards the histological components of the temporomandibular meniscus with one exception, namely Rees (4) statement as regards the elastic component of the superior stratum, are not definite concerning the different areas. This may be because anatomically and functionally definable areas of the temporomandibular meniscus have not received the attention they warrant.

Griffin & Barnett (6, 7.) suggested that the anterior moderately thick band be called the pes menisci and recognised a hela of the pes menisci. They suggested also that the thin or intermediate band be called the pars gracilis menisci and the posterior thick band they called the pars posterior menisci. They retained Rees (4) terminology for the posterior extensions of pars posterior menisci namely the superior stratum and the inferior stratum and the tissue between these strata which actually is not a part of the temporomandibular meniscus although closely associated with it, as the bilaminar zone. They recognised further a medial and lateral pterygo-condylar area.

Griffin & Sharpe (8) defined the histological predominant tissue in the above areas and recognised the peculiar form of the attachment of the superior stratum of the bilaminar zone not into but rather through the squamo-tympanic fissure; and also the peculiar mode of the attachment of the meniscus to the articular eminence. They pointed out also that synovial membrane was restricted to definite areas of the meniscus and that these areas were normally not subject to compression. They further pointed out that a constant morphological structure was a vascular canal (9) which conveyed nutrition to the synovial membrane just postero-inferiorly to the pars posterior menisci. They termed this canal the genu vasculosis menisci.

Apart from the above descriptions Sicher (10) has described the meniscus as composed of thin, elliptical, fibrocartilaginous lamella filling up the space between the articulating surfaces, and is fused anteriorly, medially and laterally to the capsule, whilst posteriorly it continues into a thick layer of loose and vascularized connective tissue. Steinhardt (11) and Sicher (10) state that the meniscus varies in thickness from individual to individual with the prominence of the articular eminence, the more prominent the articular eminence the thicker the meniscus. Therefore before commenting on the histological assessment of these areas they require definition.

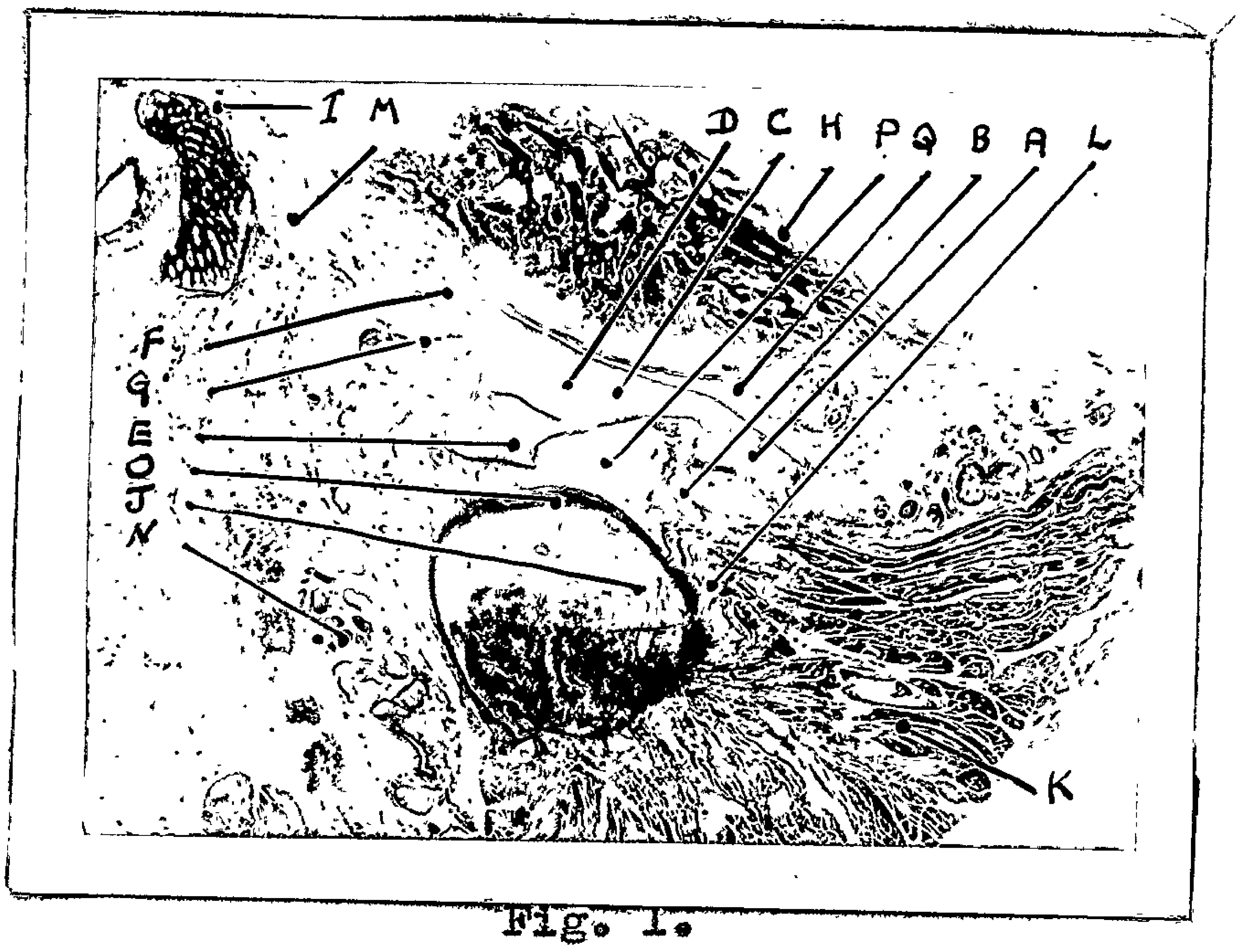

Fig. I.

Specimen no. 1. foetus at term.

Sagittal section X 5 approximately through the middle of the temporomandibular joint and indicates structural components of the temporomandibular joint which will be described in this thesis.

A. Pes menisci.
B. Hela of pes menisci.
C. Pars gracilis menisci.
D. Pars posterior menisci.
E. Inferior stratum.
F. Superior stratum.
G. Bilaminar zone.
H. Temporal bone.
I. Tympanic bone.
J. Condyle.
K. Lateral pterygoid muscle.
L. Pterygo-condylar area.
M. Squamo-tympanic fissure.
N. Auricular temporal nerve.
O. Perichondrium.
P. Inferior joint cavity.
Q. Superior joint cavity.

<u>Note</u>. Articular eminence is not fully developed at this stage. (12,13,14,15,16) How the superior stratum becomes continuous with loose connective tissue which fills the squamo-tympanic fissure. Also how the pes menisci is associated with loose connective tissue inferior to the temporal bone.

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Pes Menisci.

The pes menisci is the anterior extension of the temporo-mandibular meniscus and resembles a foot. It exhibits a heel, termed the hela of the pes menisci, and receives the inserting fibres of the spheno-meniscus muscle. The hela of the pes menisci also receives the insertion of the antero-inferior capsule.

In describing the histological components of the pes menisci the following methods have been adopted:-

(1) the predominant tissue in the main structure.

(2) the method of insertion of the spheno-meniscus muscle.

(3) the hela of the pes menisci.

(4) the insertion of the antero-inferior capsule; and

(5) the attachment of the pes menisci to the articular eminence.

It is located in the rest position anterior to the condyle and occupies the area between the articular eminence and the inserting tendons of the lateral pterygoid muscle. It has a postero-inferior protuberance which is the hela of the pes menisci.

Fig. 2.

Specimen no. 4. 58 years.

Sagittal section X 5 middle third meniscus. Indicates the more usual relationship of the structures which constitute the pterygo-condylar area in the adult.

A. Spheno-meniscus muscle which has a tendinous insertion into the pes menisci.
B. Tendinous insertion of lateral pterygoid muscle into the periosteum of the head of the condyle.
C. Hela of the pes menisci.
D. Pterygo-condylar area.
E. Pes menisci.

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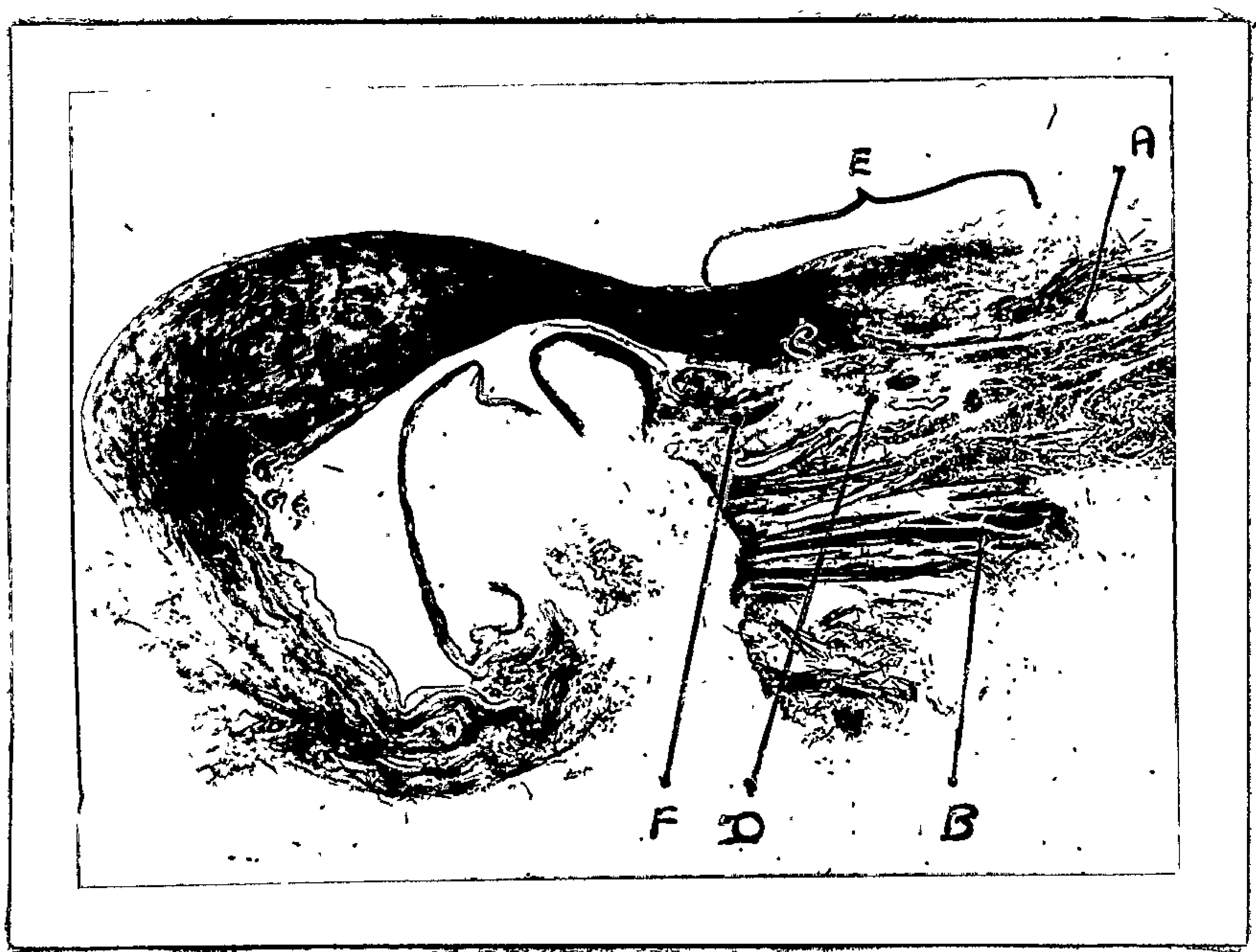

Fig. 3.

Specimen no. 4. 58 years.

Sagittal section X 5 lateral third meniscus. Indicates the less usual relationship of the structure which constitutes the pterygo-condylar area in the adult.

- A. Spheno-meniscus muscle which has a tendinous insertion into the pes meniscus.
- B. Tendinous insertion of the lateral pterygoid muscle into the periosteum of the head of the condyle.
- C. Hela of the pes menisci.
- D. Pterygo-condylar area.
- E. Pes menisci.
- F. Superior tendon of lateral pterygoid muscle.

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Pterygo-condylar Area.

The pterygo-condylar area essentially comprises an area between the insertion of the spheno-meniscus muscle into the pes menisci and the hela of the pes menisci, and the insertion of the lateral pterygoid muscle into the pterygoid fovea of the condyle. It is not quite constant in its boundaries, usually the superior boundary is constituted by the hela of the pes menisci and the tendinous insertion of the spheno-meniscus muscle into the pes menisci and the hela of the pes menisci, whilst its inferior boundary is constituted by the tendinous insertion of the lateral pterygoid muscle into the pterygoid fovea of the condyle, and its base is the periosteum covering the condyle between the latter insertion and the synovium constituting the antero-inferior extremity of the inferior joint cavity.

However it may be complicated by the fact that the superior fibres of the lateral pterygoid muscle sometimes diverge and approximate the hela of the pes menisci and excludes it from the pterygo-condylar area. In this instance, the superior boundary is the superior tendinous insertion of the lateral pterygoid muscle into the most superior part of the pterygoid fovea of the condyle and its inferior boundary is constituted by a similar inferior insertion into the pterygoid fovea of the condyle.

The first anatomical relationship described above is the more constant.

Fig. 4.

Specimen no. 1 - foetus at term.

Sagittal section X 10. middle third of temporomandibular joint. Demonstrates the wedge shaped projections of synovial membrane, which are located at the anterior and posterior extremities of both joint cavities.

- A. Pars gracilis menisci.
- B. Genu vasculosis menisci.
- C. Inferior joint cavity.
- D. Wedge shaped projection of synovial membrane at the anterior and posterior periphery of inferior joint cavity.
- E. Wedge shaped projection of synovial membrane at the anterior extremity of superior joint cavity.
- F. Bilaminar zone.

....

Pars Gracilis Menisci.

The pars gracilic menisci is the intermediate thin portion of the meniscus and is located in the rest position between the anterior articular slope of the condyle and the anterior slope of the articular fossa. (17) In roentgen rays of the temporomandibular joint with the teeth in classical centric occlusion, the narrowest radiolucent area is that area between the articular slope of the condyle and the anterior slope of the articular eminence and this area is occupied by the pars gracilis menisci (fig. 243a).

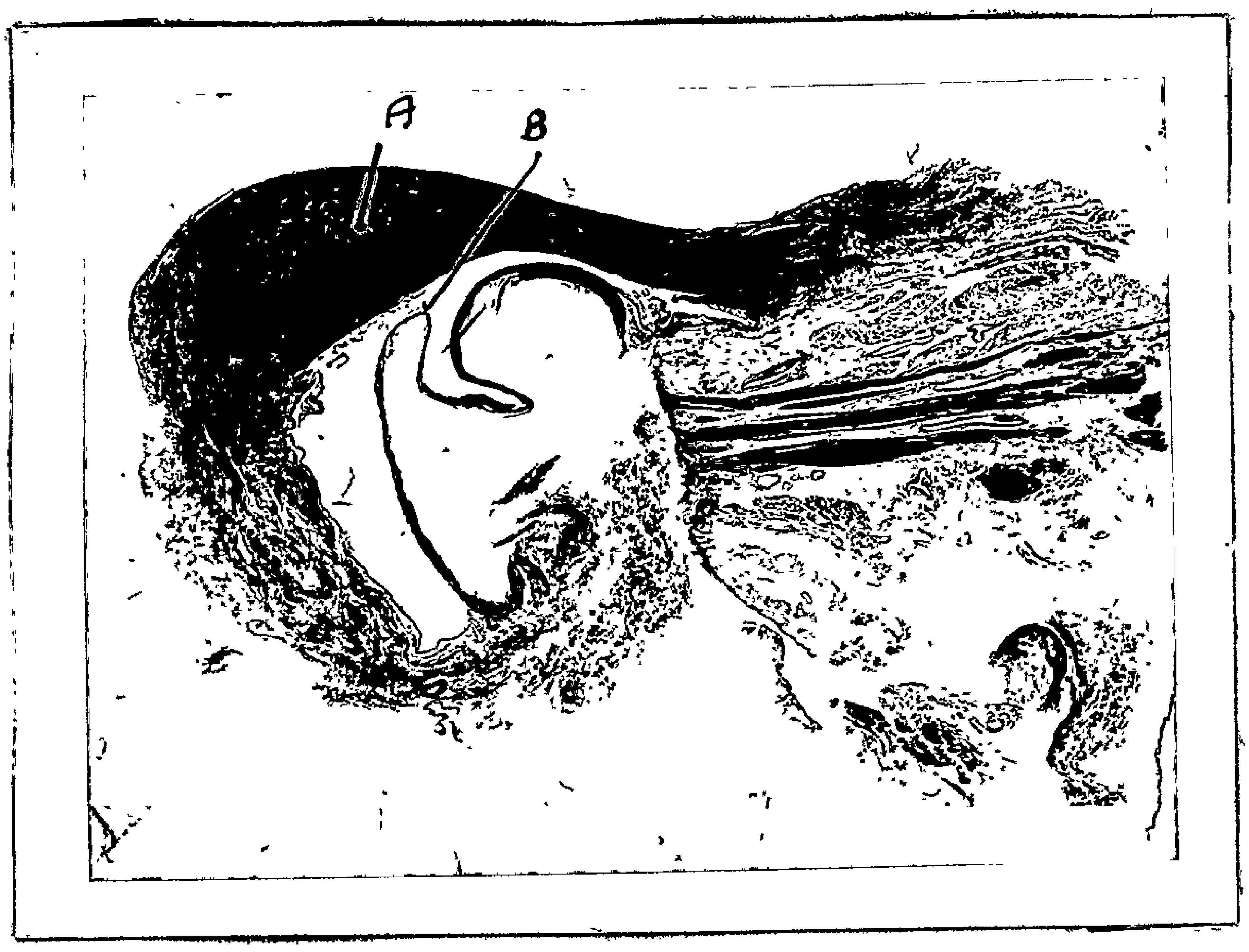

Fig. 5.

Specimen no. 4 - 58 years.

Sagittal section X 5 medial third meniscus. Indicates the usual structure of the pars posterior menisci in the adult.

A. Pars posterior menisci.
B. Perichondrium of the condyle.

....

Pars Posterior Menisci. (Fig. 5)

The pars posterior menisci is the thickest part of the meniscus with the teeth in classical centric occlusion. It occupies that area between the sagittal crest of the condyle and the approximate superior one third of the posterior articular slope of the condyle and the roof of the articular fossa. (17)

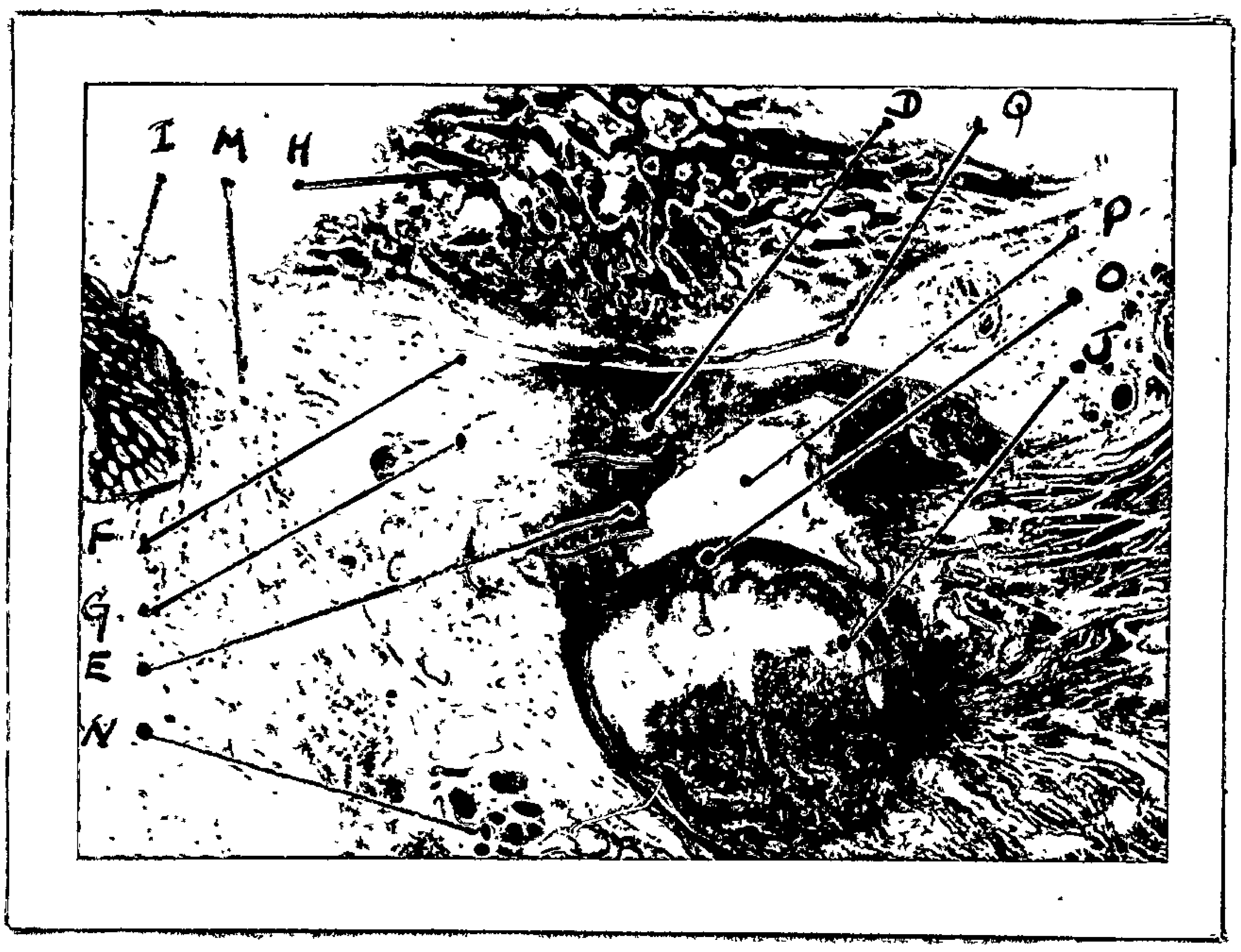

Fig. 6.

Specimen no. 1. - foetus at term.

Sagittal section X 10 middle third temporomandibular joint. (cf. fig. 1.) Indicates the respective attachments of the inferior and superior strata of the bilaminar zone and the relationship of bilaminar zone to these strata.

- D. Pars posterior menisci.
- E. Inferior stratum.
- F. Superior stratum.
- G. Bilaminar zone.
- H. Temporal bone.
- I. Tympanic bone.
- J. Condyle.
- M. Squamo-tympanic fissure.
- N. Auricular temporal nerve.
- O. Perichondrium.
- P. Inferior joint cavity.
- Q. Superior joint cavity.

....

Superior Stratum of the Bilaminar Zone.

The superior stratum is the posterior extension of pars posterior menisci and is inserted through the squamo-tympanic fissure. The method of insertion is peculiar and requires further refinement which will be discussed under the heading "insertion of the superior stratum of the bilaminar zone of the temporomandibular meniscus through the squamo-tympanic fissure".

Inferior Stratum of the Bilaminar Zone.

The inferior stratum is the posterior inferior extension of the pars posterior menisci and it is inserted into the posterior articular slope of the condyle.

Bilaminar Zone.

The bilaminar zone is the tissue which is contained between the above mentioned strata.

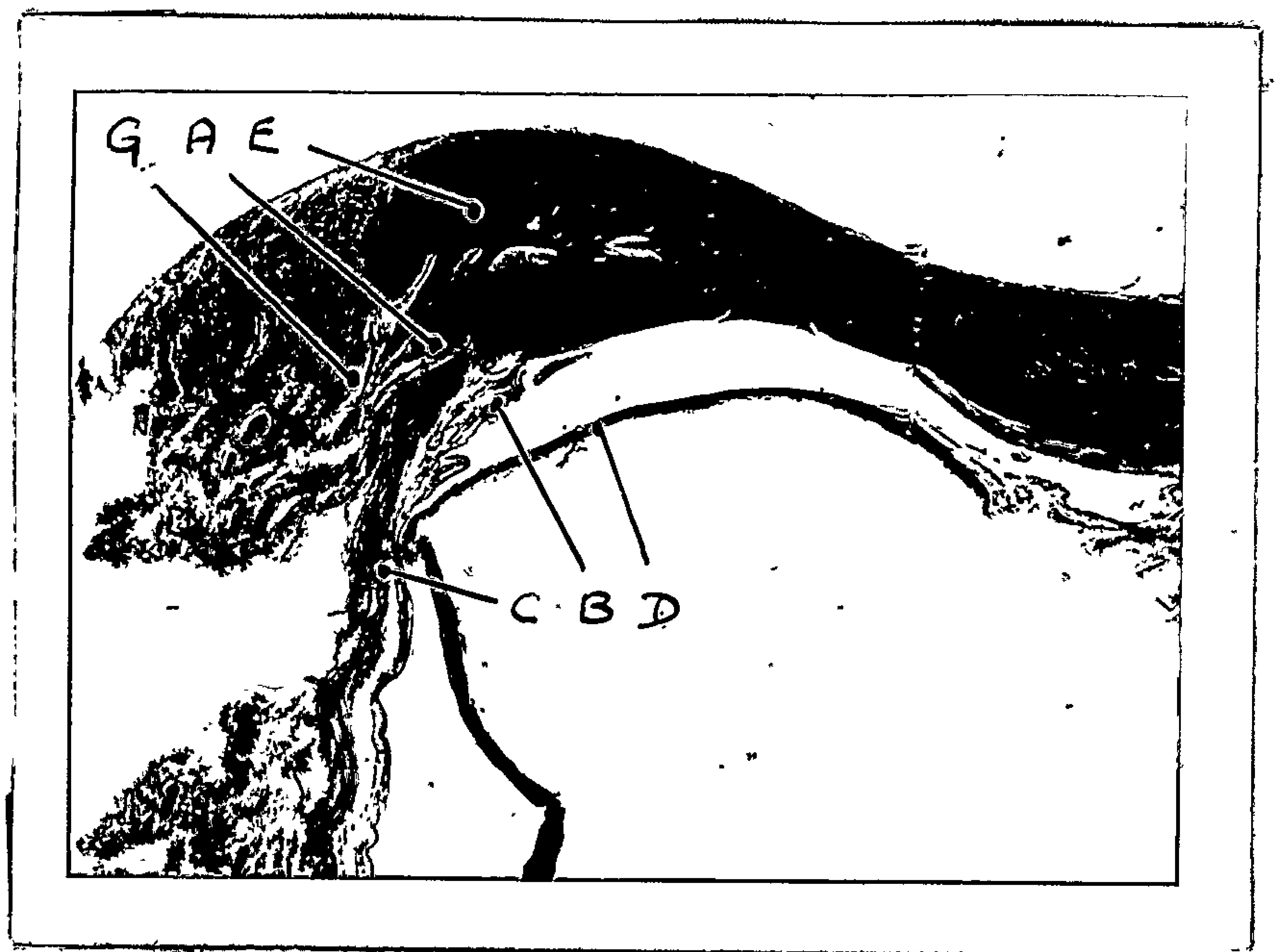

Fig. 7.

Specimen no. 3 - 28 years.

Sagittal section X 5. middle third meniscus. Indicates the usual position of the genu vasculosis menisci.

A. Genu vasculosis menisci.
B. Synovial membrane at the most anterior extremity of the inferior stratum.
C. Inferior stratum of bilaminar zone.
D. Perichondrium.
E. Pars posterior menisci.
G. Origin of blood vessels which traverse the genu vasculosis menisci.

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Genu Vasculosis Menisci.

This vascular canal commences at the apex of the bilaminar zone and runs obliquely antero-inferiorly to the junction of the inferior stratum of the bilaminar zone with the pars posterior menisci. Here also on the inferior surface of the meniscus, a fold of synovial membrane commences, which extends posteriorly to be reflected onto the fibrous covering of the posterior non articular part of the condyle. This is the inferior part of the genu and forms the inferior lip of the canal's orifice. The vascular contents of the canal consists of arteries and veins in close proximity to each other.

CHAPTER 2.

THE STRUCTURE OF THE TEMPOROMANDIBULAR JOINT IN THE FOETUS AT TERM.

In order to assess the morphology of the temporomandibular meniscus, the standard has been the appearance as seen at the foetus at term and this will be described as it appears in its lateral third, middle third, and medial third.

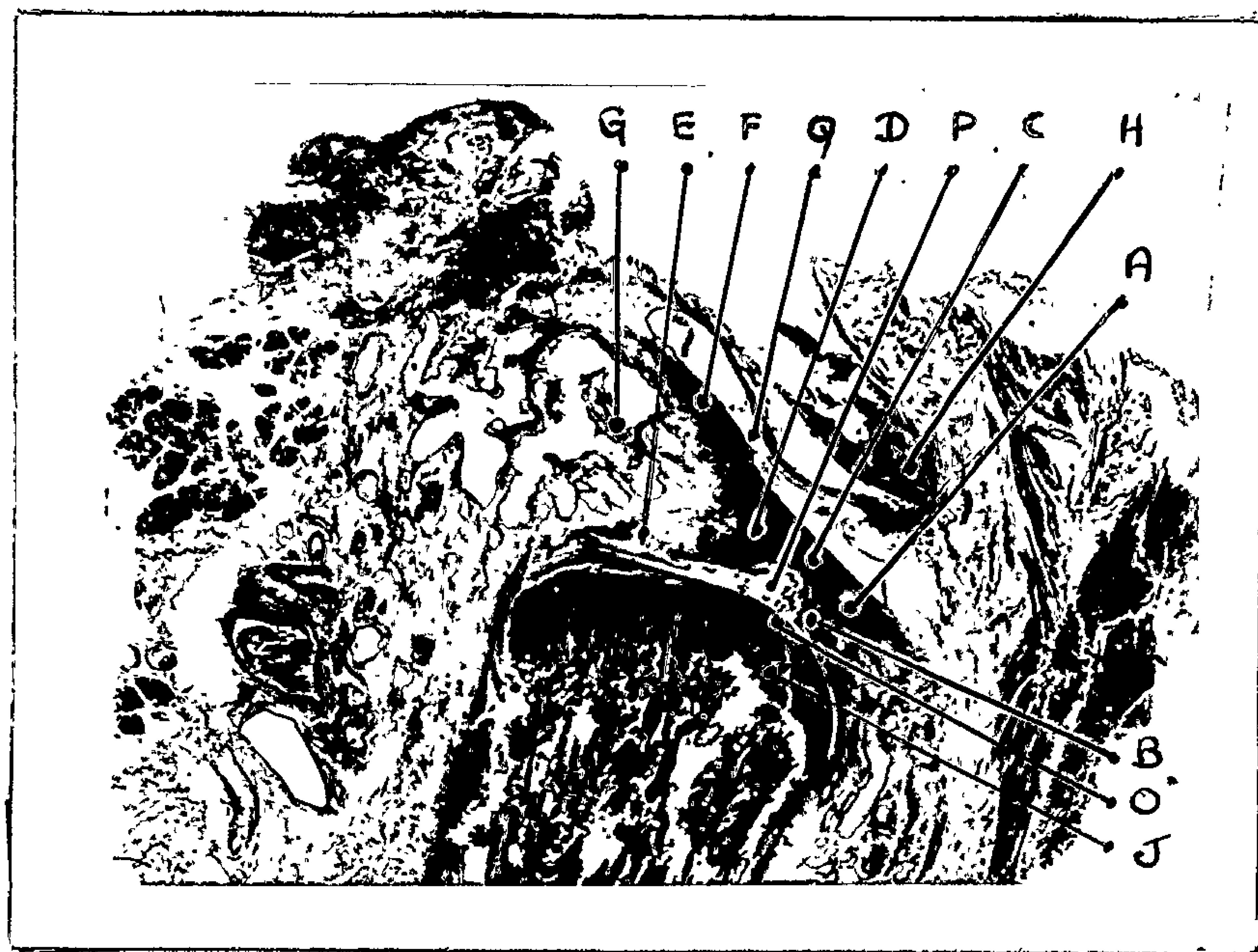

Fig. 8.

Specimen no. 1 - foetus at term.

Sagittal section X 5. lateral third temporomandibular meniscus. Note that one does not see the insertion of lateral pterygoid muscle into the pterygoid fovea nor the spheno-meniscus muscle into the meniscus.

A. Pes menisci.
B. Hela of pes menisci.
C. Pars gracilis menisci.
D. Pars posterior menisci.
E. Inferior stratum.
F. Superior stratum.
G. Bilaminar zone.
H. Temporal bone.
J. Condyle.
O. Perichondrium.
P. Inferior joint cavity.
Q. Superior joint cavity.

Lateral third of the temporomandibular joint.

(1) Head of the condyle.

Active osteogenesis is seen to be occurring at the head of the condyle. The condyle is covered by a marked layer of perichondrium at its articular surface, and periosteum just inferior to the articular surface. The periosteum and perichondrium both exhibit a well defined outer fibrous layer in which the collagenous fibres are orientated parallel to each other, and in between which are typically elongated fibroblasts.

Fig. 9.

Perichondrium showing respective layers and its relationship to the articular cartilage of the condyle. (X 390 cf. fig. 8.)

A. Fibro elastic layer.
B. Superficial layer.
C. Cellular layer.

Beneath the fibro elastic layer of the perichondrium the cellular layer is apparent, and also beneath the fibrous layer of periosteum a cellular layer can be seen which is best evident where the section in certain areas is oblique.

Fig. 10.

Fibro elastic layer of the perichondrium and the cellular layer beneath it which merges with the proliferative zone of the condylar head, beneath which is a zone of flattened chrondrocytes. (X 780 cf. fig. no. 8.)

A. Fibro elastic layer.
B. Cellular layer and layer of proliferating cartilage cells.
C. Layer of flattened chondrocytes which corresponds to the zone of orientation in the metaphysis of a long bone.

....

It should be mentioned that whilst the superficial layer of the perichondrium is mainly fibrous its surface which faces the inferior joint cavity is not nearly so fibrous and contains much more ground substance. It is also much more cellular. The cells are 2 to 3 layers thick and are fibroblastic and chondrocytic in nature. The fibro elastic layer of the perichondrium exhibits collagenous fibres and elastic fibres which are orientated parallel to each other. It could be said that the outer layer of the perichondrium forms a fibro elastic capsule round the head of the condyle and that the surface immediately opposed to the joint cavity is of a fibroblastic and chondrocytic nature. Beneath the fibro elastic layer of the perichondrium is a cellular layer. This consists of cells embedded in an amorphous matrix around which here and there can be distinguished a basophilic capsule. The nuclear membranes are clearly defined and what are apparently fine chromatin granules are dispersed in the nuclei. The cellular zone of the perichondrium increases markedly at certain areas, so that tongue-like extensions of this cellular zone are seen to invade the underlying cartilage cells of the developing condyle. This invasion of vascular perichondral tissue divides the cartilage of the condyle into compartments and the invasive tissue is notable for the nature of thin walled blood vessels which in these sections are full of erythrocytes.

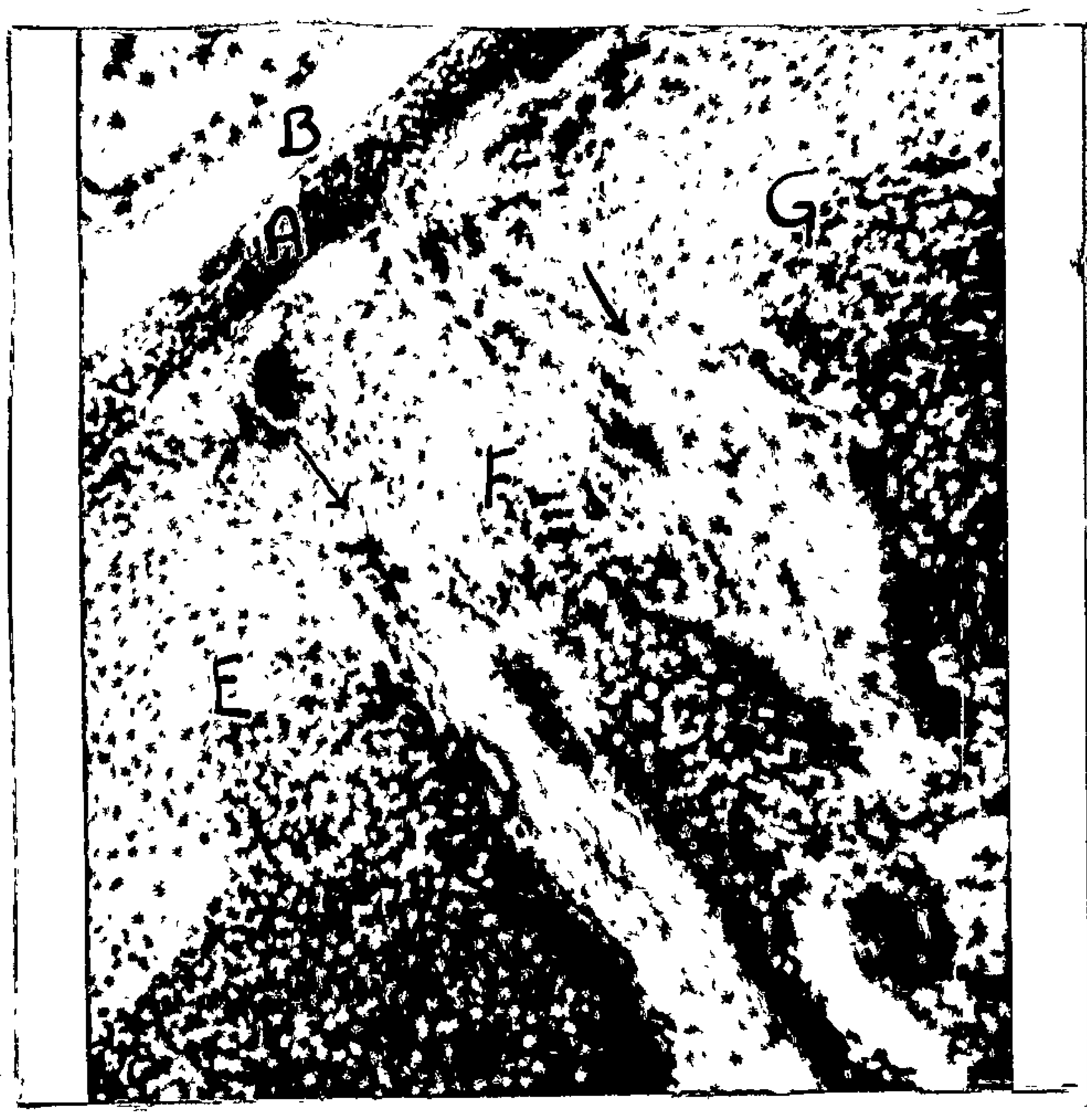

Fig. 11.

Invagination of sub perichondral tissue into the head of the condyle dividing it into compartments. (X 80 cf. fig. 8)

A. Perichondrium.
B. Inferior joint cavity.
E,F,G. Indicating compartments, where cytomorphosis of cartilage cells is occurring. The arrows indicate invasive subperichondral tissue.

....

At the anterior and posterior margins of the cartilaginous condyle the fibro elastic tissue of the perichondrium becomes continuous with the periosteum.

Fig. 12.

Anterior margin of the inferior joint cavity indicating junction of synovial membrane with the perichondrium and continuation of the fibro elastic layer onto the non articular surface of the condyle. (X 270 c.f. fig. 8.)

A. Junction of perichondrium with synovial membrane.
B. Reflection of the synovial membrane.
C. Continuation of fibro elastic tissue onto the anterior non articulating surface of the condyle.

....

Fig. 13.

Junction of the perichondrium of the head of the condyle with synovial membrane of anterior extremity of the antero-inferior joint cavity. (Also demonstrating synovial membrane below the inferior surface of the pes menisci. (X 270 cf. fig. 8.)

A. Inferior joint cavity.
B. Pes menisci.
C. Synovial membrane of areolar type.

Periosteum.

The fibrous layer of the periosteum does not contain nearly so many elastic fibre components as the perichondrium and indeed the fibrous layer of the perichondrium and the periosteum in these sections are not nearly as vascular as the cellular layers. Also in these sections there is extra vasation of red blood corpuscles in the surrounding tissue.

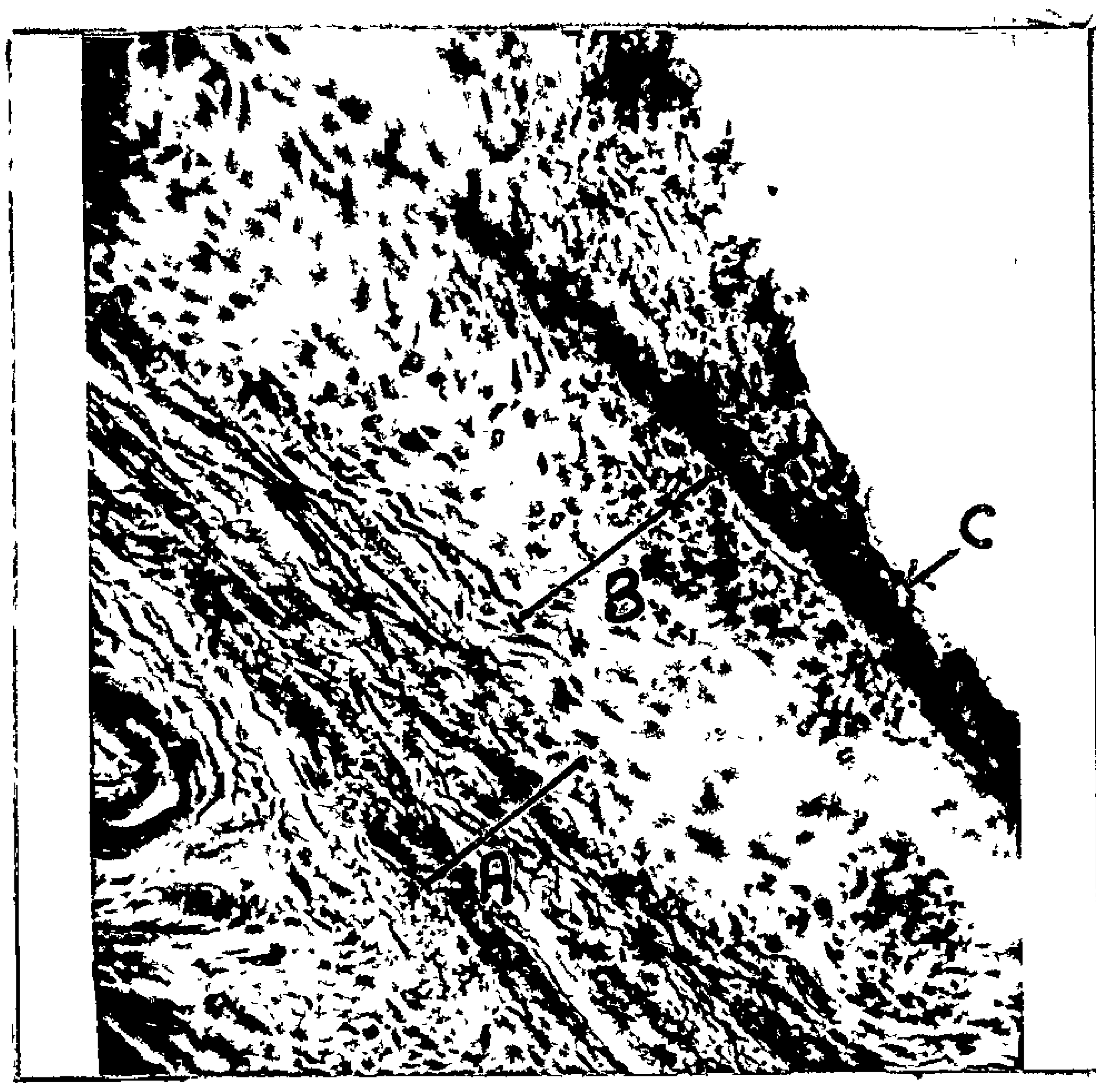

Fig. 14.

The fibrous and cellular layer of the periosteum and periosteal bone of the head of the condyle. (X 270 cf. fig. 8.)

A. Fibrous layer.
B. Cellular layer.
C. Periosteal bone.

The dominant cell type in the cellular part of the periosteum is cells with large nuclei and cell boundaries which are hard to define. The nucleus is very pale but here and there a few granular condensations.

Intercellular substance is constituted by fine collagenous fibres and an amorphous ground substance. The nuclei of these cells are mesenchymal in type and there are very few cells discernable which can be designated as pre osteoblasts. (18) As mentioned above, perichondral tongues invaded the cartilage of the perichondrium and in certain areas these tongues can be seen to be continuous with osteogenic mesenchyme associated with endochondral trabeculae of the condyle.

Indeed this raised the question as to whether the osteogenic mesenchyme originates from the articular part of the condyle or arises from osteogenic mesenchyme of the mandible proper. It would probably be safe to assume that the osteogenic mesenchyme has both an articular and diaphyseal origin since one can compare the developing ramus of the mandible with the diaphysis of a long bone.

The position is somewhat unique in that one cannot recognise a definite epiphyseal centre of ossification nor a definite metaphysis and the inference is that growth of the condyle is achieved by osteogenic invasion both from the diaphyseal centre and the epiphyseal centre of ossification without any sharp delimitation of the two centres.

For the purpose of description the cartilage of the condyle is considered as a metaphysis although realising that it retains some qualities of an epiphyseal nature. Regions which are peculiar to metaphyseal cartilage plates are easily recognisable.

Growth region of the Condyle.

Zone of proliferation.

Beneath the cellular layer of the perichondrium apart from the tongue-like extensions into areas of active bone depositions, there can be recognised a layer of proliferating cartilage cells. The zone is distinctive for the number of cells of small round oval nuclei packed fairly close together. The nuclei of these cells stain lightly and in the nucleoplasm fine chromatin granules can be discerned with here and there a fairly course granular component. The granular component presumably is chromatin granules. The zone of proliferating cells forms as it were a cap to the more mature cartilage cells of the condyle. Immediately beneath this zone of proliferating cartilage cells is a layer of orientated and mature chondrocytes.

Fig. 15.

Zone of flattened cartilage cells. (X 900 cf. fig. 8.)
Note the flattened eccentric position of nuclei and basophilia of capsule.

....

The Zone of Orientation and Maturation.

Mature chondrocytes are easily distinguished by the appearance of basophilic cytoplasm, a definite capsule and large size. They are on the whole flattened cells orientated transversely and due to invagination of subperichondral mesenchyme form a cell orientation in a semi-circular fashion beneath the cap of proliferating cartilage cells. The intercellular substance is amorphous but it may be said that the distinctive nature of the cells is due to the basophilia of the capsule whilst the nucleus is elongated and eccentric.

The Zone of Hypertrophy and Degeneration.

Immediately beneath the layer of orientated chondrocytes are larger chrondrocytes. The nuclei of these cells is 2 to 3 times larger than the nuclei of the mature chondrocytes. The intercellular substance still retains the appearance typical of hyaline cartilage. Certain cells show definite degenerative changes, which is indicated by degeneration of both nucleus and cytoplasm.

Fig. 16.

Hypertrophic cartilage cells. (X 900 cf. fig. 8)

Note the large and pyknotic nuclei, and in some, degenerative changes can be seen.

....

<u>The Zone of Calcified Cartilage.</u>

The zone immediately beneath the zone of hypertrophy and degeneration is again a fairly broad semi-circular zone, being thinnest at the apex. In this zone the intercellular substance is calcified and the cartilage cells are pyknotic, or disintegrated. At the thin apical region of this zone eruption is conspicuous and appears to consist of penetrations of vascular mesenchyme amongst the calcified cartilage.

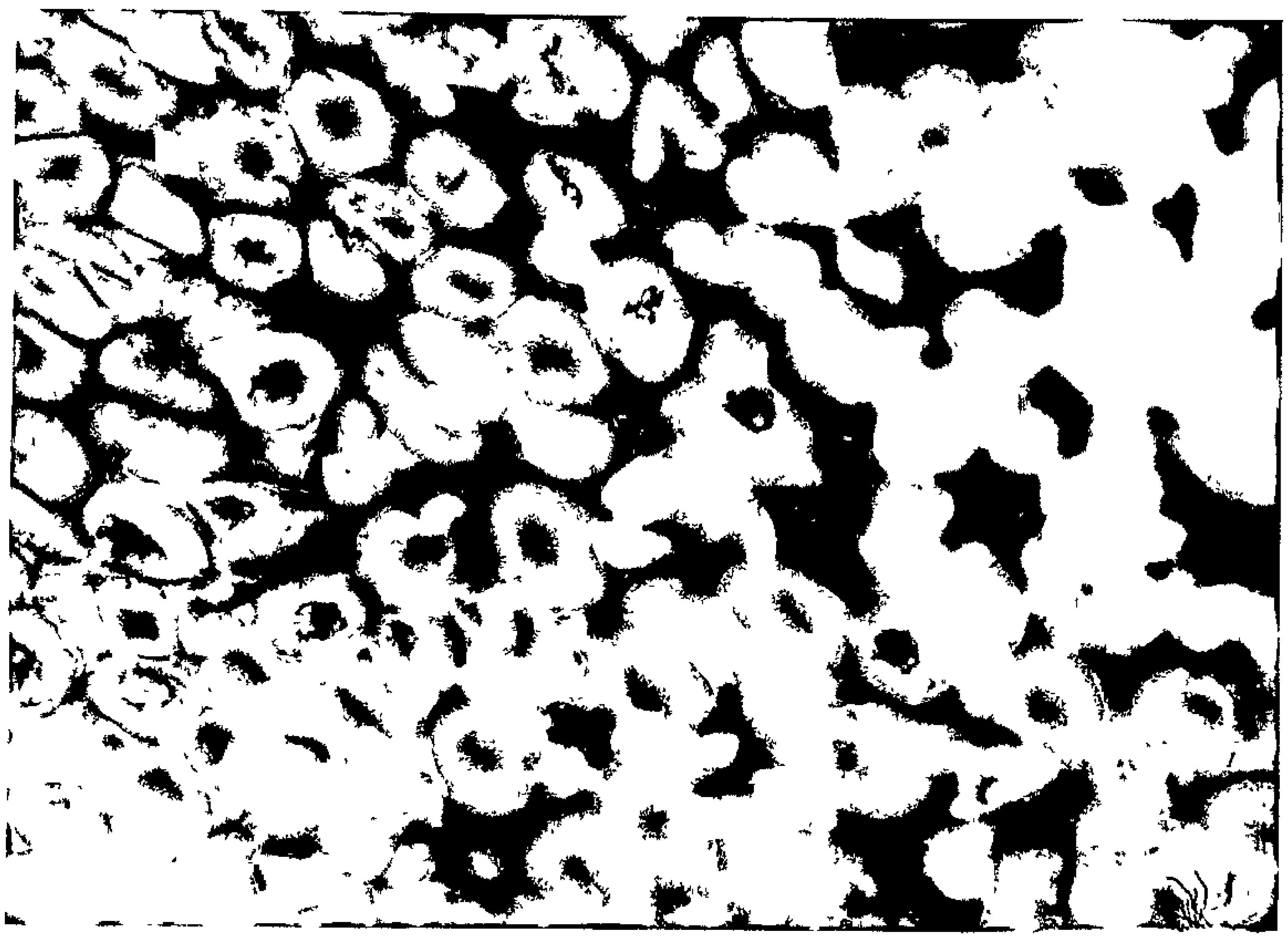

Fig. 17.

Indicates calcification of cartilage matrix. Nuclei of some of the cartilage cells are pyknotic and in others dissolution has occurred. (X 900 cf. fig. 8.)

Zone of Eruption.

The eruptive phenomena apparently consists of dissolution of portion of the calcified cartilage so that vascular osteogenic mesenchyme invades in a tunnelling fashion and undifferentiated mesenchymal cells are clearly apparent in the vanguard of this tissue. It would seem that the osteoblasts differentiate in situ.

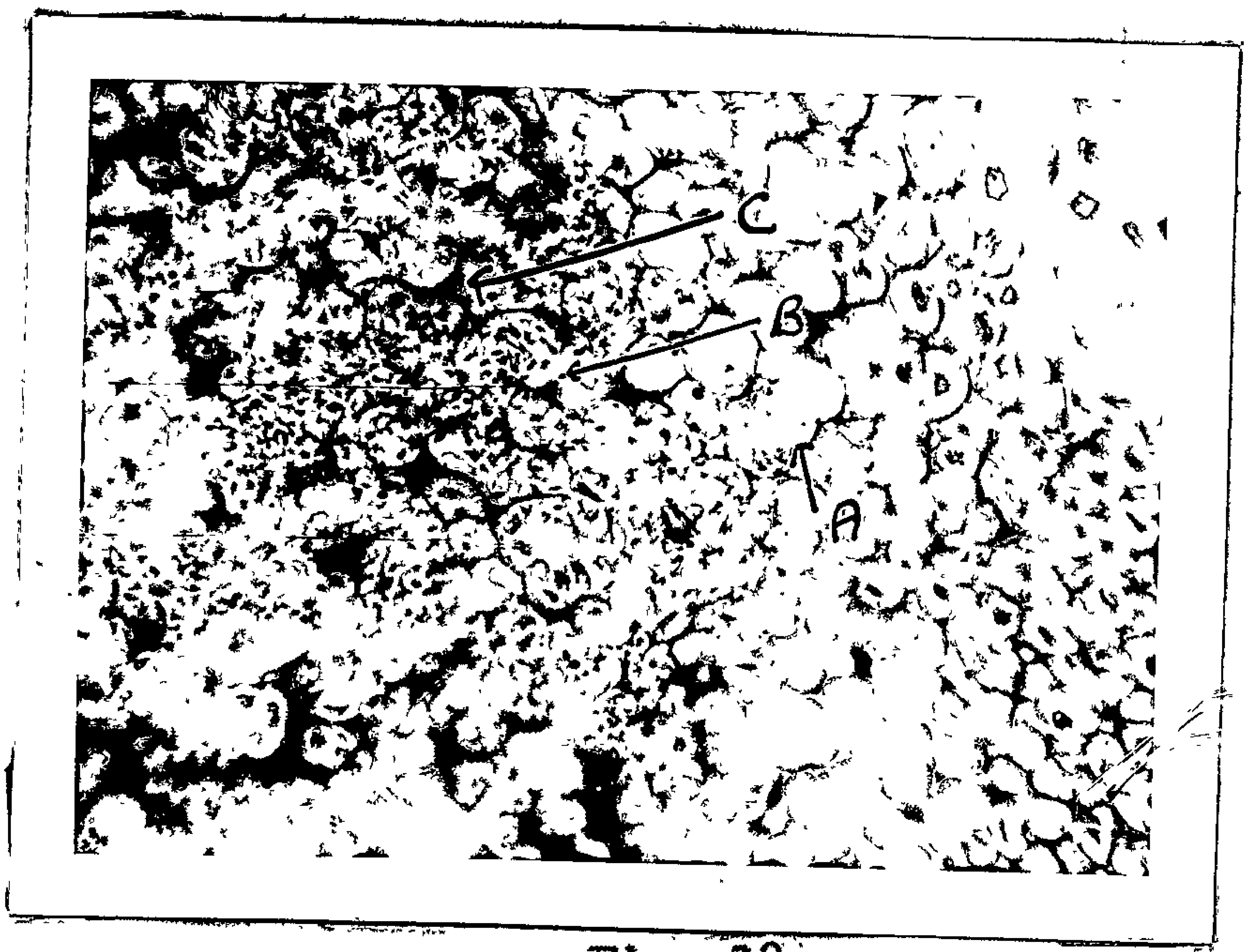

Fig. 18.

Zone of eruption in which hypertrophic and degenerative cartilage cells and thin borders of calcified cartilage around groups of degenerative chondrocytes can be seen. Invasion of osteogenic mesenchyme appears to be from below. (X 540 cf. fig.8)

A. Thin layer calcified cartilage matrix around degenerative chondrocytes.
B. Osteogenic mesenchyme.
C. Cores of calcified cartilage.

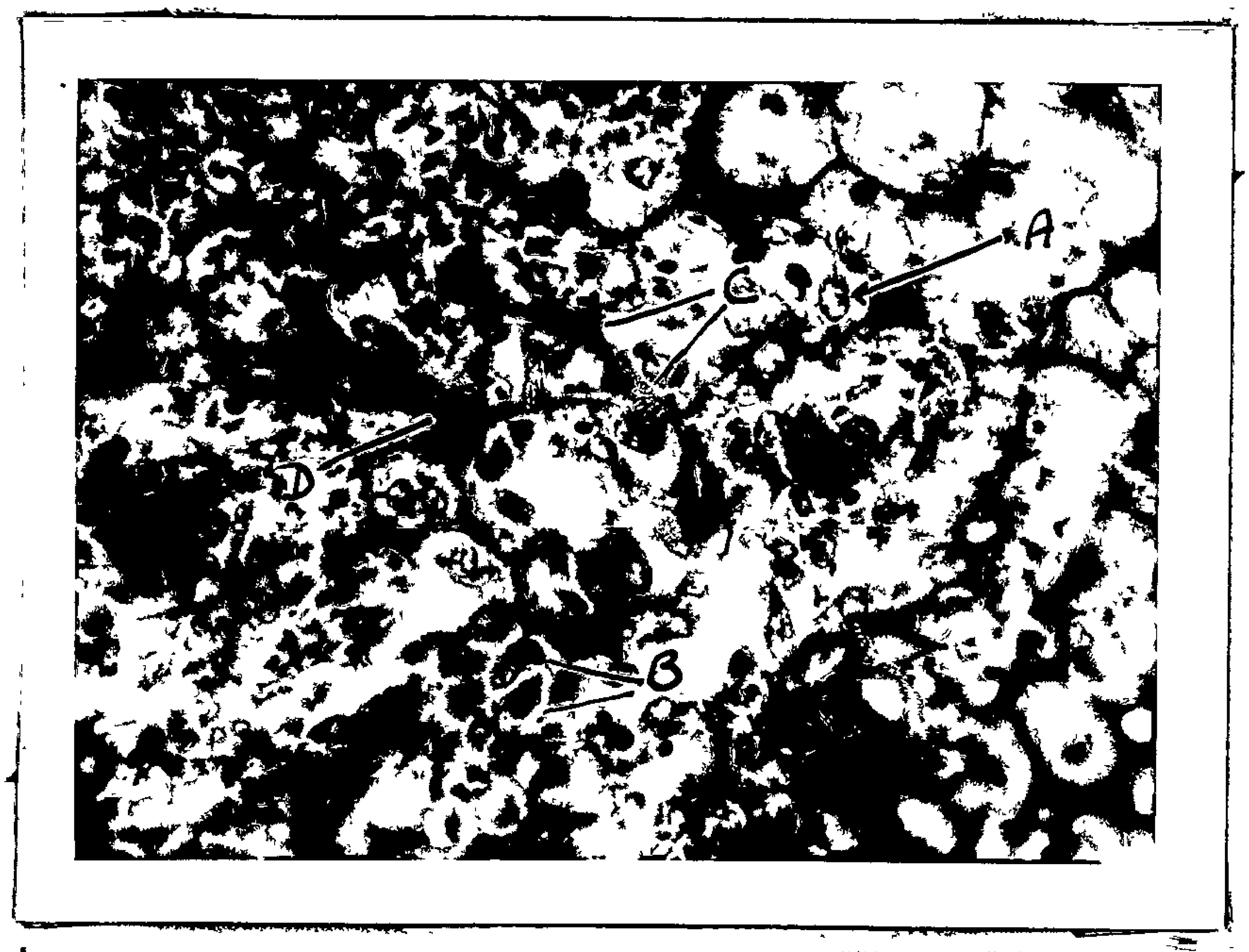

Fig. 19.

Indicates osteoblasts aligning themselwes against cores of calcified cartilage and undifferentiated mesenchymal cells. Also probably deposition of osteoid tissue. (X 900 cf. fig. 8.)

A. Undifferentiated mesenchymal cell.
B. Osteoblast with intense basophilia of cytoplasm.
C. Cores of calcified cartilage.
D. Osteoid tissue.

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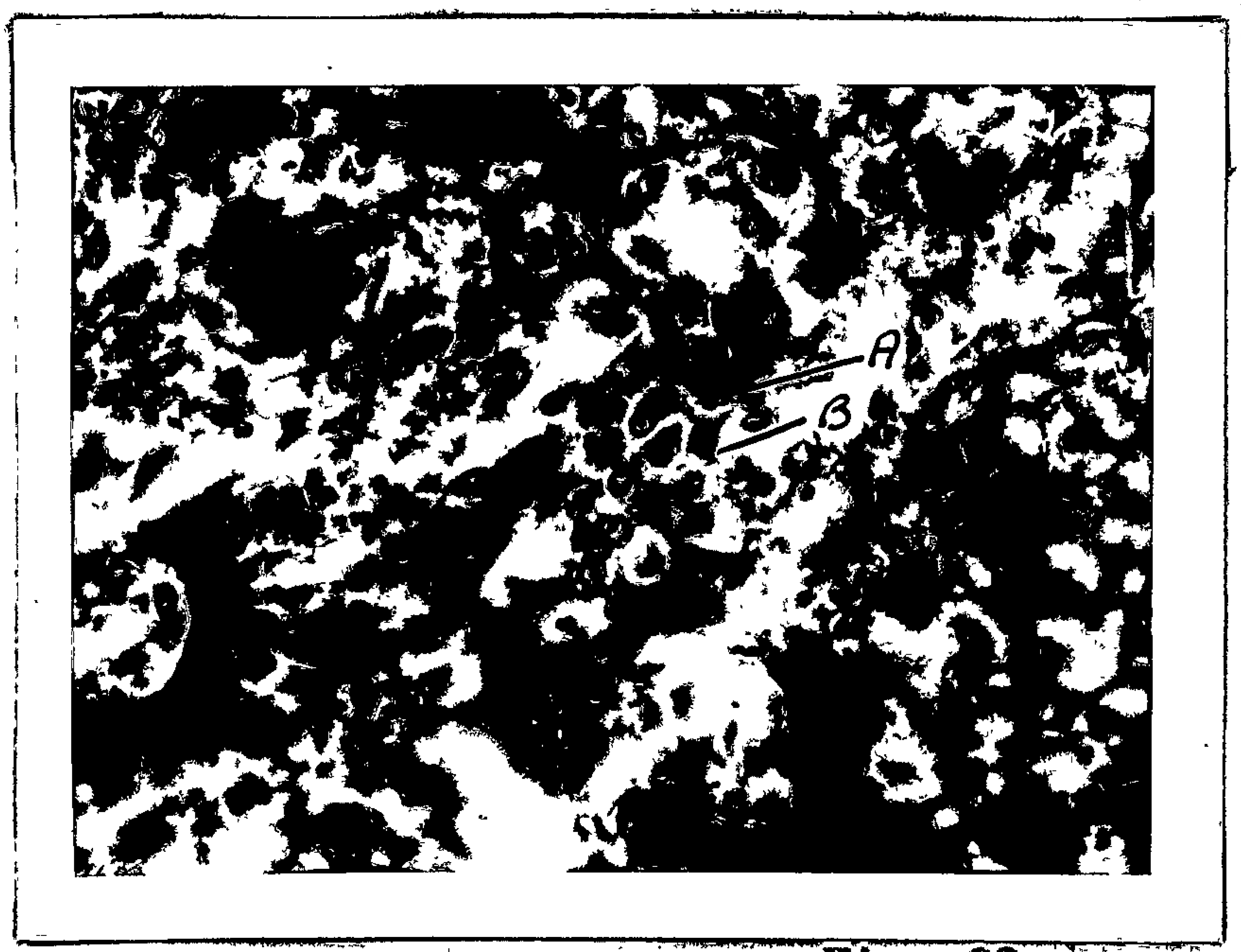

Fig. 20.

Indicates differentiation of osteoblasts in situ. The pre osteoblasts do not exhibit the intense basophilia of the cytoplasm as to the osteoblasts. (X 900 cf. fig. 8.)

A. Osteoblast.
B. Preosteoblast.

....

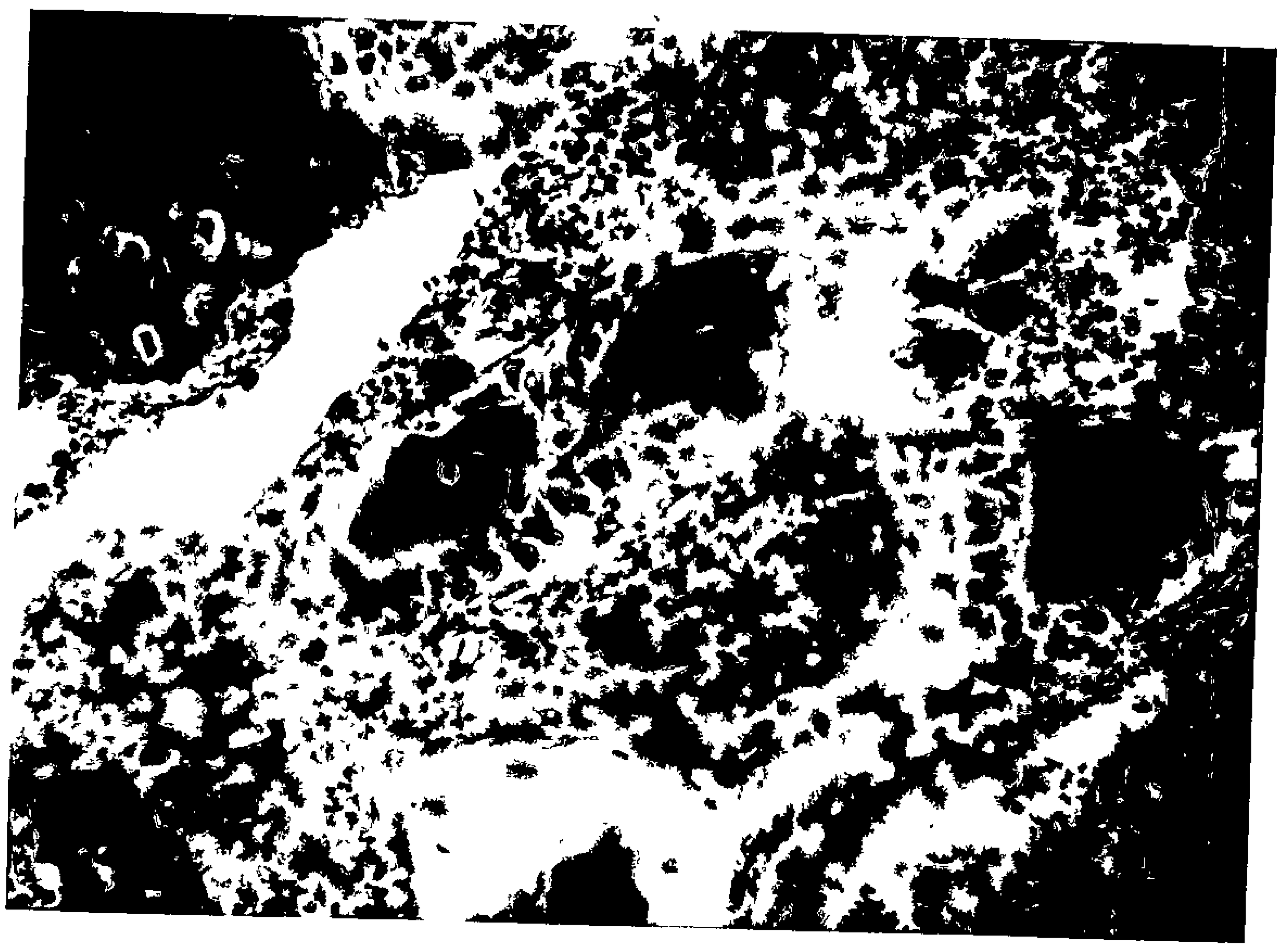

Fig. 21.

Immature endochondral trabeculae. (X 270 cf. fig. 8.)

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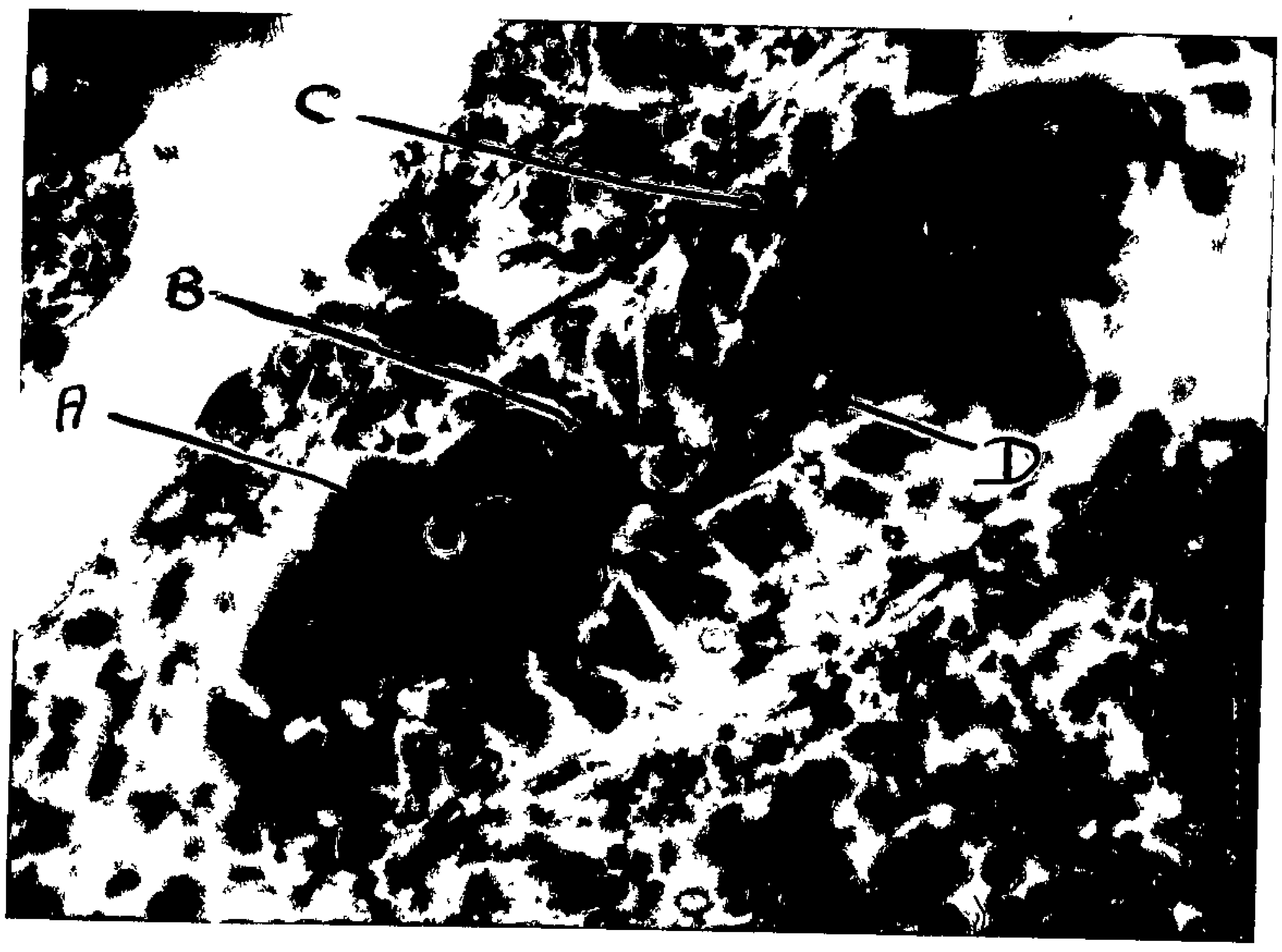

Fig. 22.

Immature endochondral trabeculae of fig. 21 at higher power (X 900 cf. fig. 8.) Indicates formation of primary endochondral trabeculae. The osteoblasts align themselves in a pseudo epithelial fashion around the developing trabeculae in the centre of which there is a thick core of calcified cartilage and the bone is deposited around the core of calcified cartilage. Some of the osteoblasts are embedded in the formed bone and are now osteocytes.

A. Core of calcified cartilage.
B. Bone.
C. Aligned osteoblasts.
D. Osteocytes.

Note the pear shaped appearance of the osteoblasts and how typically the pointed end is directed towards the area of bone deposition and the eccentricity of the nucleus

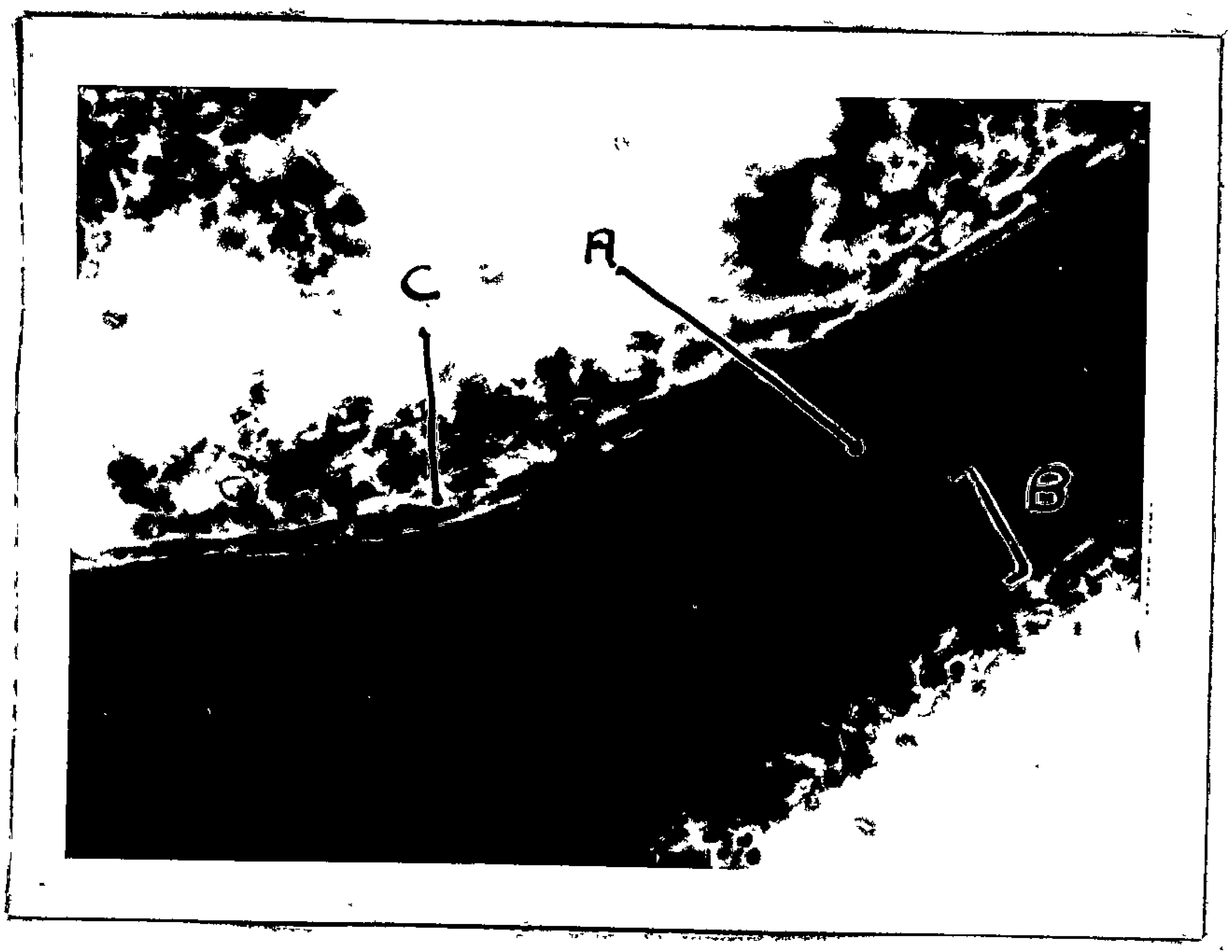

Fig. 23.

More mature endochondral trabeculae in which the amount of bone formed is much greater than the amount of calcified cartilage. (X 270 cf. fig. 8.)

A. Calcified cartilage.
B. Bone.
C. Osteoblasts.

Fig. 24.

Indicates that the periosteal lamellae is devoid of calcified cartilage and it exhibits the appearance of a primitive compacta and evidence of forming Haversian systems.
(X 270 cf. fig. 8.)

Fig. 25.

Periosteal lamellae in which a Haversian space and unorientated collagenous fibres can be observed. (X 540 cf. Fig. 8.)

Fig. 26.

More mature trabeculae of developing ramus of mandible and developing periosteal compacta. (X 270 cf. Fig. 8.)

A. Primitive Compacta.
B. Trabeculae.

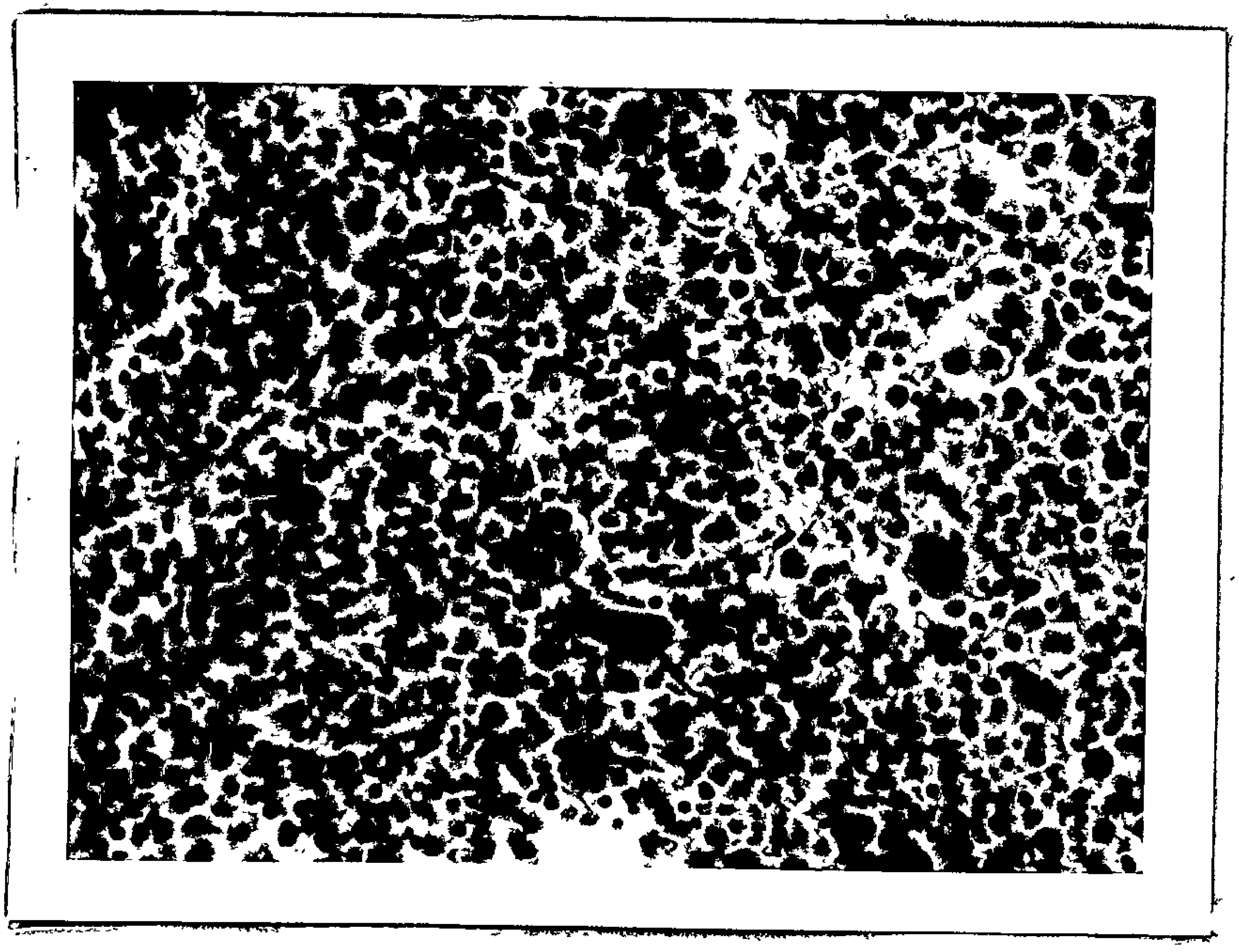

Fig. 27.

Haemopoietic tissue. (X 540 cf. fig. 8.)

....

Zone of Bone Deposition.

The zone of eruption is by no means regular but it is characterised by the above mentioned tongue-like invasions of vascular mesenchyme into the hypertrophic and calcified cartilage tissue. So that one sees in an area hitherto occupied by 3 or 4 hypertrophic cartilage cells a fairly large space, which is occupied by osteogenic mesenchyme around which is calcified cartilage. Vascular mesenchyme consists of undifferentiated mesenchymal cells, and cells which are recognisable as osteoblasts. The manner of bone deposition is from the inside of these spaces so that they become narrower whilst on the outside of the calcified cartilage bone may be deposited. This deposition of bone both from inside and outside results in the appearance of a cartilage core. Around these cartilage cores osteoblasts align themselves not always but quite frequently in pseudo epithelial fashion, and some are entrapped by the forming bone and become osteocytes. The more mature trabeculae further down the shaft are recognisable by the amount of bone formed around the cartilage core. So while it is essentially similar to the primary trabeculae the cartilage component is proportionately less.

The periosteal lamellae which has been formed by the periosteum without any cartilage precursors exhibits characteristics of a primitive compacta. In this bone the osteocytes are fairly regularly disposed and the collagenous fibres are quite evident. Primitive Haversian systems can be discerned. Between the endochondral trabeculae is haemopoietic tissue.

<u>The Pes Menisci.</u> (cf. fig. 8.)

The pes menisci as stated before is situated between the inferior articular slope of the condyle and the articular eminence. One can recognise an inferior border which forms the antero-lateral superior border of the inferior joint cavity and a superior border which forms the antero-inferior lateral surface of the superior joint cavity. The superior surface of the superior joint cavity is formed by the perichondral articular surface of the temporal bone whilst the antero-inferior lateral border of the inferior joint cavity is formed by the perichondrium of the anterior articular slope of the condyle.

The structure of the pes menisci is complicated by the fact that the spheno-meniscus muscle is inserted into its substance and also that it is attached to the articular eminence superiorly and to the anterior slope of the condyle inferiorly whilst at its margins it is continuous with the lateral and medial walls of the capsule of the joint. In general all parts of the meniscus are thickest centrally and taper medially and laterally where they become incorporated in the loose connective tissue which constitutes the capsule.

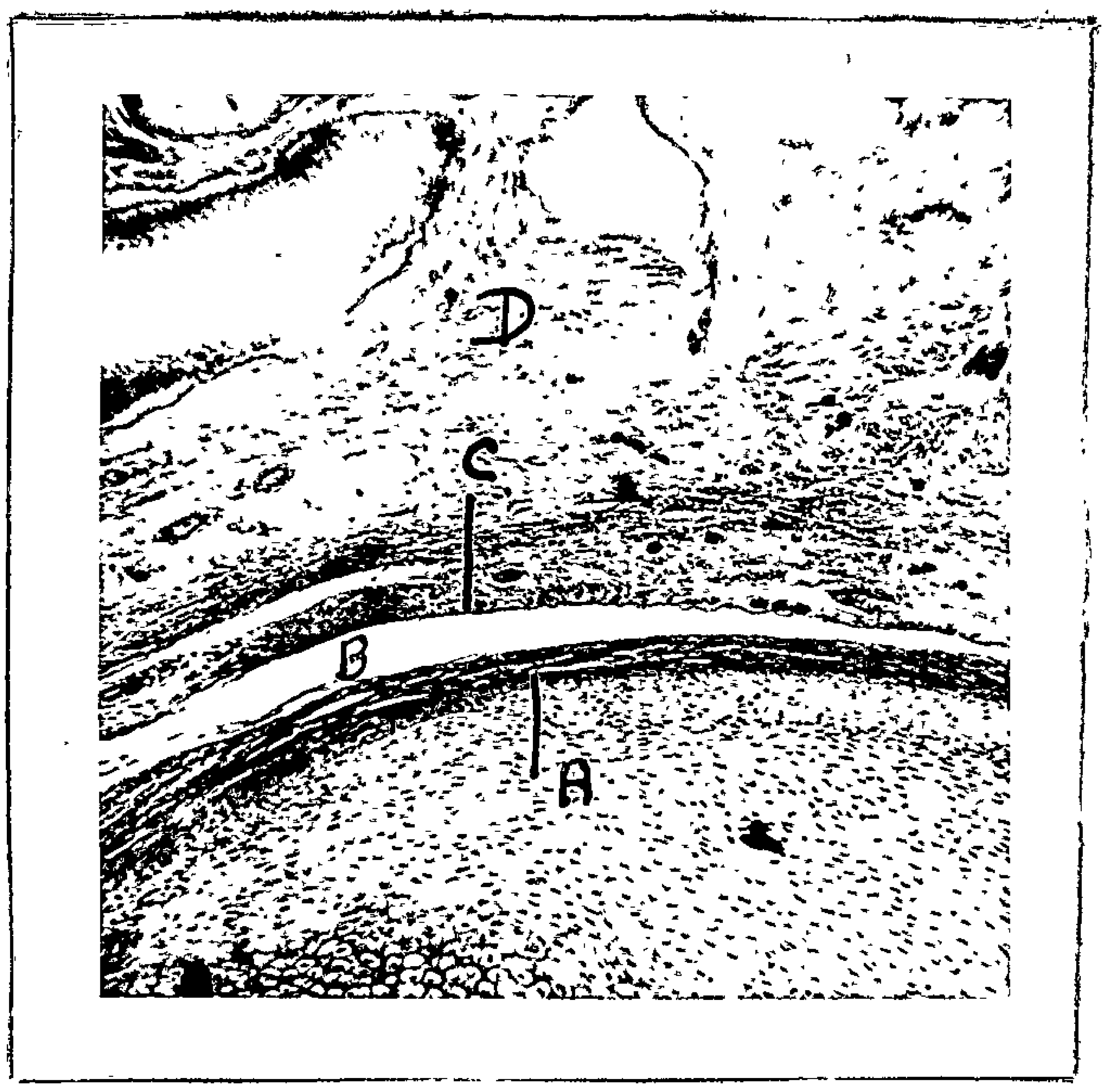

Fig. 28.

Indicates the inferior border of the pes menisci and the antero-inferior joint cavity formed by the perichondrium of the anterior articular slope of the head of the condyle. (X 80 cf. fig. 8.)

A. Perichondrium anterior articular slope of the condylar head.
B. Antero-inferior joint cavity.
C. Synovial membrane.
D. Pes menisci.

* *

Fig. 29.

Antero-superior joint cavity showing the superior surface of the pes menisci and also the articular surface of the temporal bone. (X 80 cf. fig. 8.)

A. Articular surface temporal bone.
B. Pes menisci.
C. Superior surface of the pes menisci.
D. Antero-superior joint cavity.

....

The writer sees no reason to designate the tissue covering the articular surface of the condyle as fibrous tissue since it is immediately adjacent to cartilage and by convention and also since it probably contributes to the growth of the condyle it should be termed perichondrium.

The pes menisci is moderately thick and relatively vascular. Anterior to it is a plexus of large thin walled veins and medium sized arteries. These veins drain into the anterior facial veins whilst the arteries are muscular arteries derived from the muscular branches of the maxillary artery. The veins drain the anterior part of the temporomandibular joint whilst articular arteries are derived from the above mentioned muscular arteries. This is the circulus vasculosus articuli of Hunter. [19] Bundles of nerve fibres can be seen in the tissue anterior to the pes menisci.

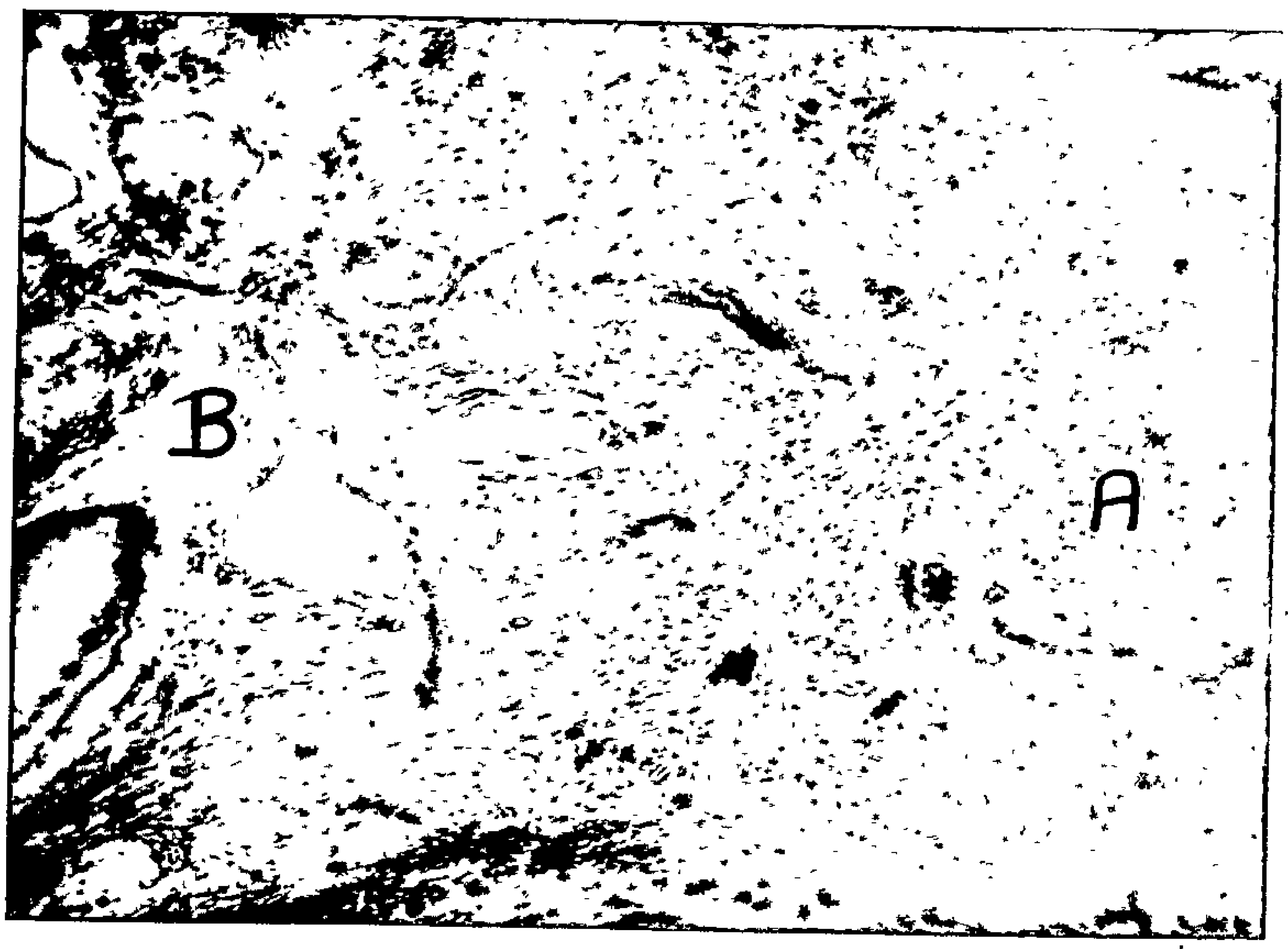

Fig. 30.

Pes menisci broadening out anteriorly to become incorporated with the vascular tissue of the anterior capsule.
(X 80 cf. fig. 8.)

A. Pes menisci.
B. Anterior capsule.

Fig. 31.

Vascular tissue anterior to the pes menisci. (X 80 cf. fig. 8.)

A. Large thin walled vein.
B. Medium sized artery.

Posteriorly the pes menisci is continuous with the pars gracilis menisci. Therefore it can be described as a moderately thick band of tissue, thinnest at its posterior border and broadening anteriorly to become incorporated in the anterior capsule.

Fig. 32.

Posterior part of the pes menisci where it becomes continuous with the pars gracilis menisci. It is quite cellular and relatively vascular. (X 80 cf. fig. 8.)

A. Pes menisci.
B. Junction of pes menisci with pars gracilis menisci.

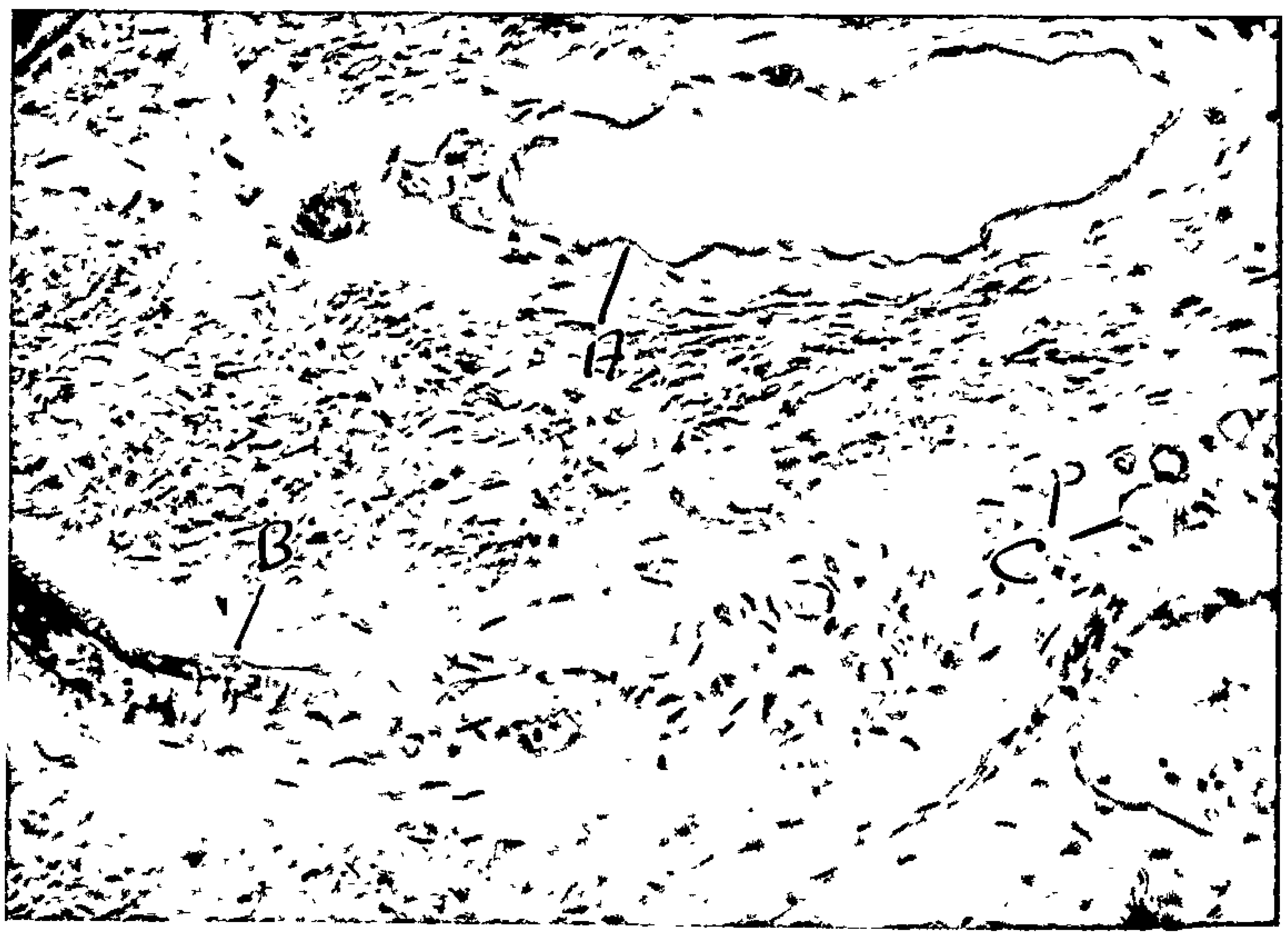

Fig. 33.

Neuro-vascular tissue of the pes menisci. (X 270 cf. fig. 8.)

A. Thin walled vein.
B. Artery in longitudinal section.
C. Capillaries.

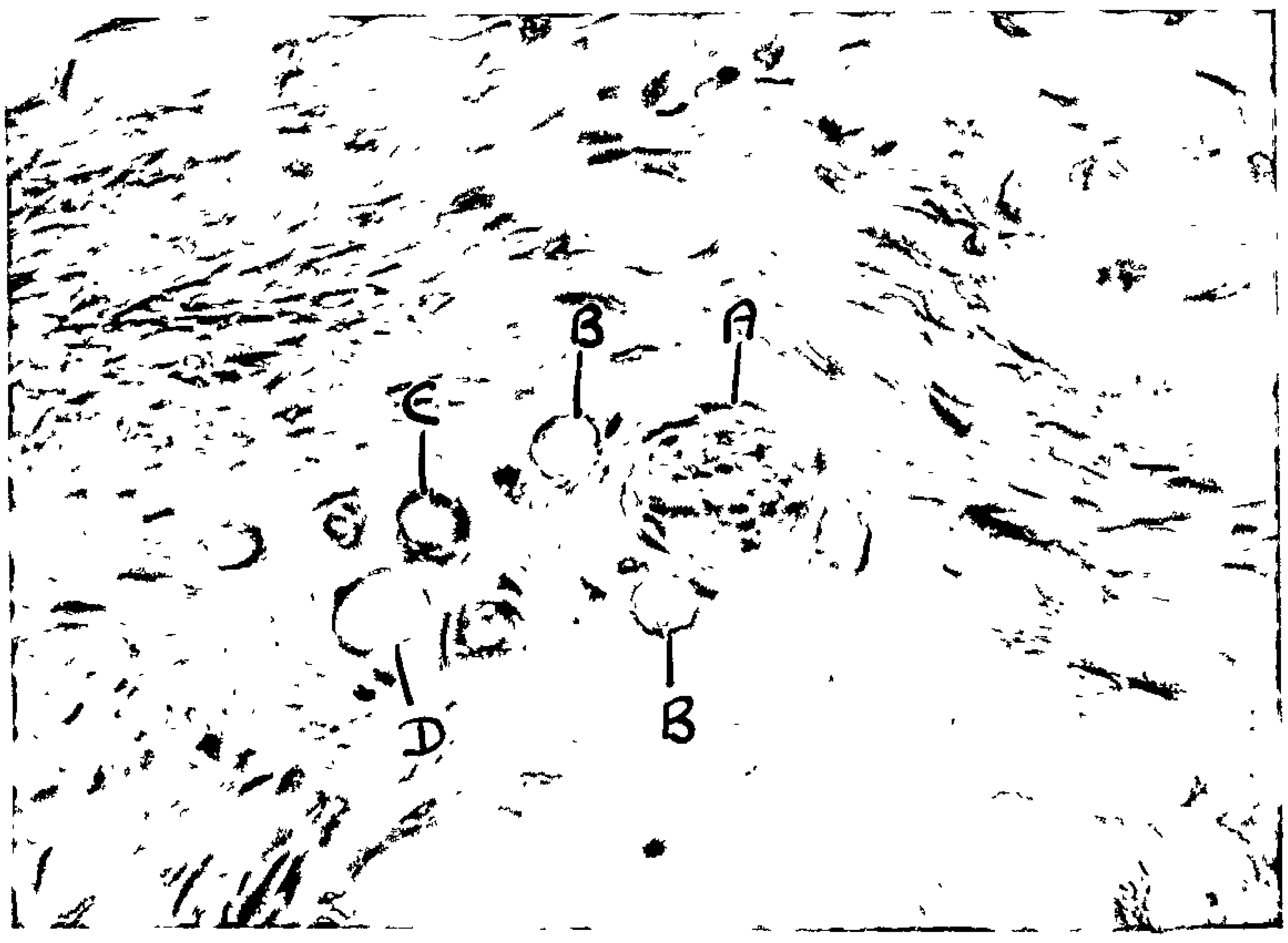

Fig. 34

Cross section of blood vessels and nerves in pes menisci.

(X 540 cf. fig. 8.)

A. Nerve in transverse section consisting of myelinated and unmyelinated nerve fibres.
B. Capillaries filled with blood.
C. Arterial capillary.
D. Venule.

It contains fine elastic fibres and collagenous fibres. The orientation of the fibres is fairly irregular. The predominant cells are flattened fibroblasts which lie between the collagenous fibres. Whilst undifferential mesenchymal cells can be seen amongst the fibroblasts.

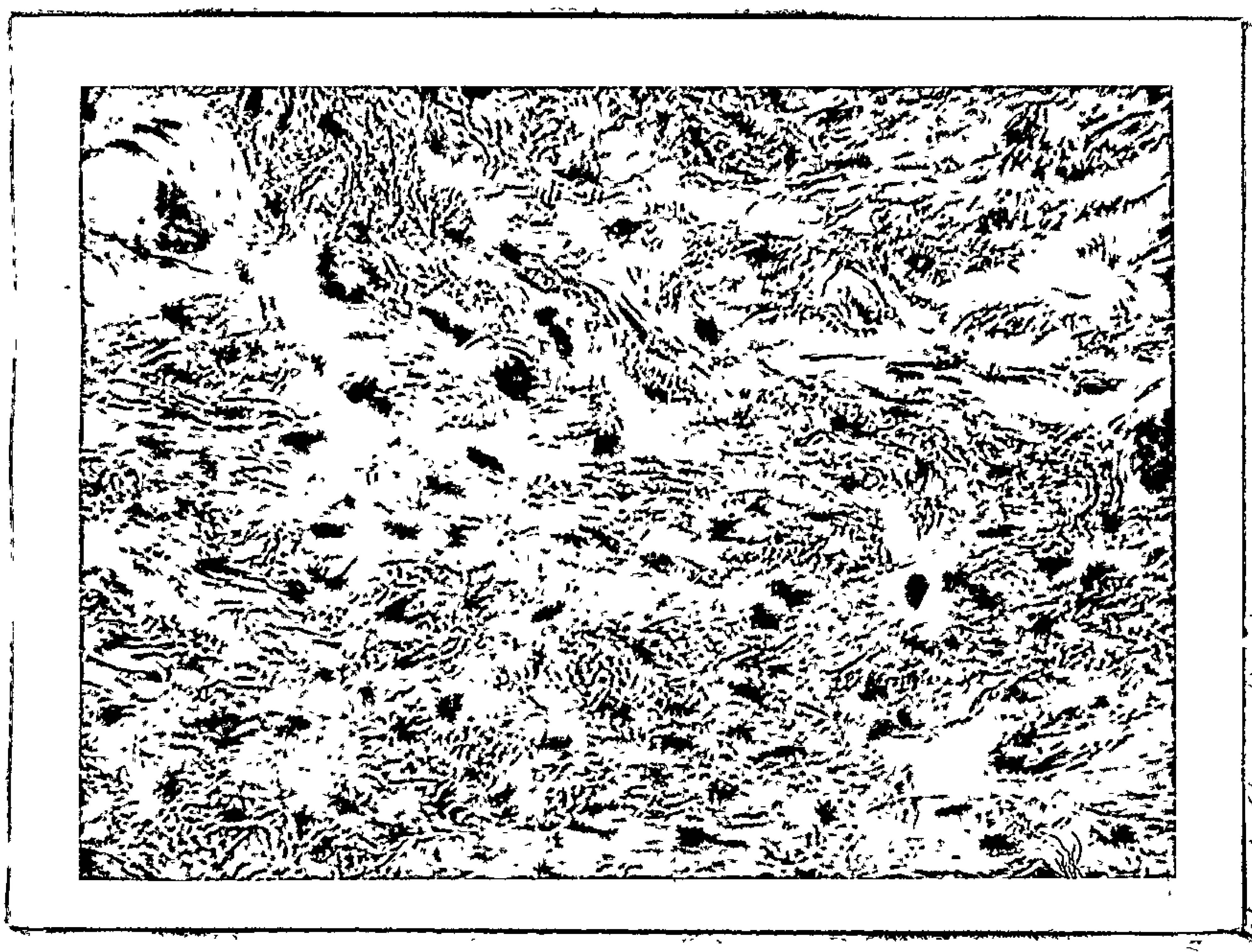

Fig. 35.

Cellular components and collagenous fibres of the pes menisci. (X 540 cf. fig. 8.) Main cell component appears to be elongated fibroblasts.

....

Fig. 36.

Pars gracilis menisci. Note synovial villi projecting into the inferior joint cavity. (X 80 cf. fig. 8.)

....

Pars Gracilis Menisci.

The pars gracilis menisci is the thinnest portion of the meniscus and is located between the anterior articular slope of the condyle and the anterior articular slope of the articular fossa. It is very cellular and relatively avascular except at its inferior surface. It consists of fine elastic fibres and collagenous fibres, which for the most are orientated parallel to each other. The elastic fibres are intimately associated with the collagenous fibres. The predominant cell component appears to be chondrocytes since they are not overtly flattened, and also because they lie in lacunae. Although undoubtedly one cannot be quite definite on this point.

The cells exhibit an oval or elongated nucleus, with a fine chromatin network. The cytoplasm is pale and fairly sparse. In longitudinal section they are pear shaped with the nucleus being eccentrically placed so that they resemble osteoblasts, except for the pale staining cytoplasm. Amongst these pear shaped cells are undifferentiated mesenchymal cells with a large nucleus and with very pale staining cytoplasm.

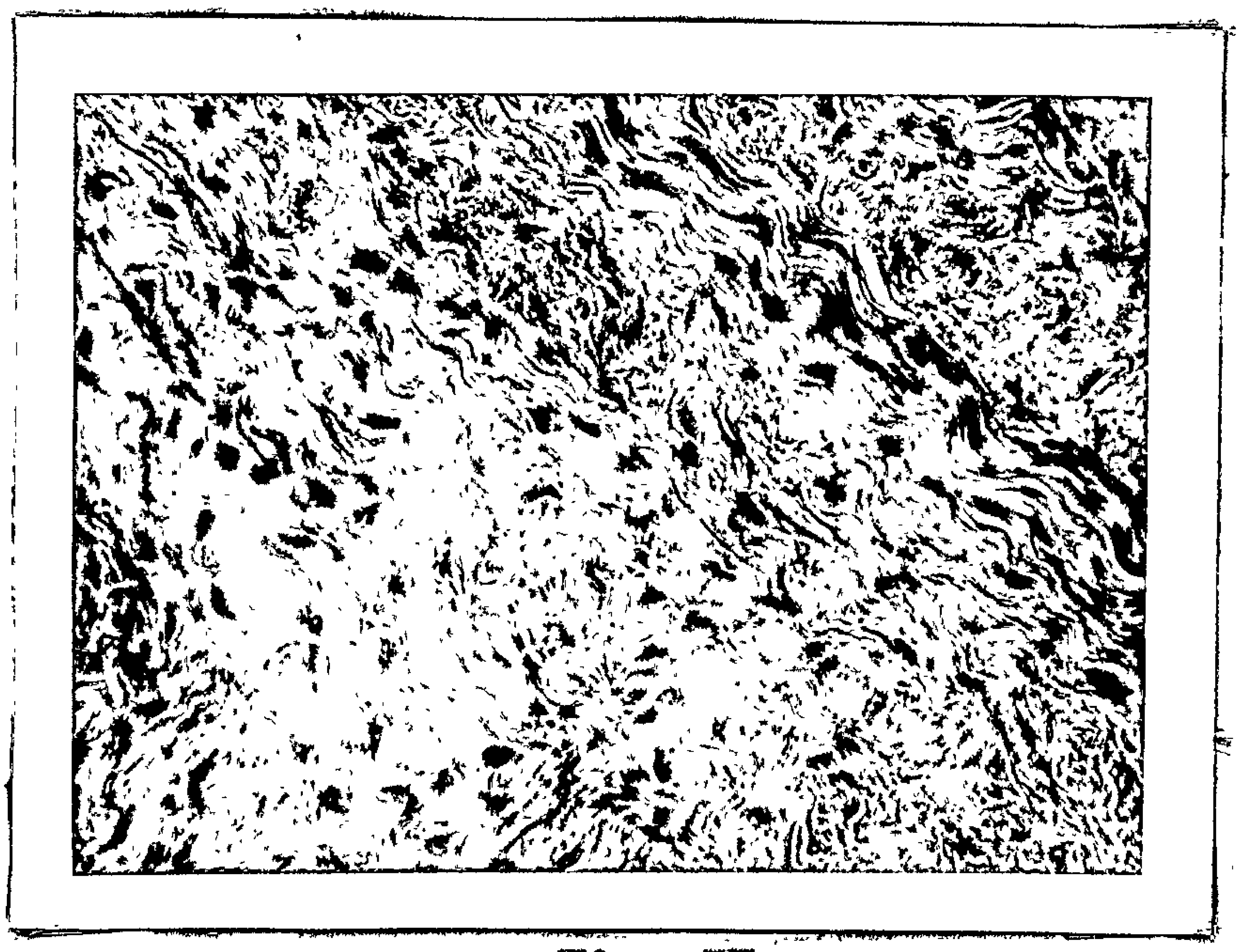

Fig. 37.

Cellular component in the central part of the pars gracilis menisci. (X 540 cf. fig. 8.) The structure exhibits at this stage of ontogeny, wavy collagenous fibres, fine elastic fibres and cells of a chondrocytic and fibroblastic nature.

At its superior surface the cells are fibroblastic in nature and form a fairly well defined vascular synovial layer although its inferior surface is not so very well defined nor is it so vascular. The cells at its inferior surface are chondrocytic in nature.

Fig. 38.

Inferior surface of pars gracilis menisci, showing chondrocytes at the synovial surface. (X 900 cf. fig. 8.)

A. Chondrocytes.

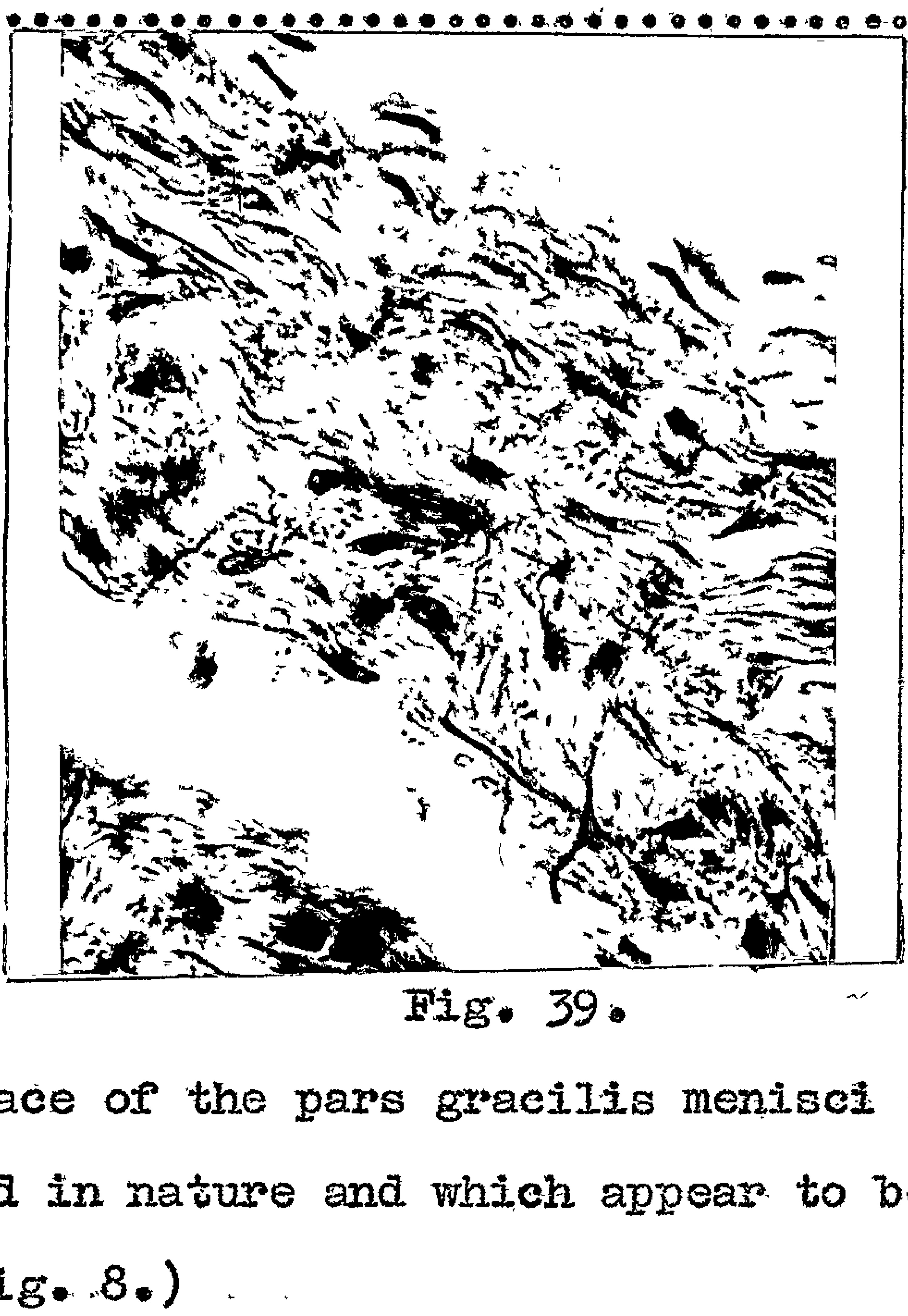

Fig. 39.

Superior surface of the pars gracilis menisci showing cells more flattened in nature and which appear to be fibroblastic. (X 900 cf. fig. 8.)

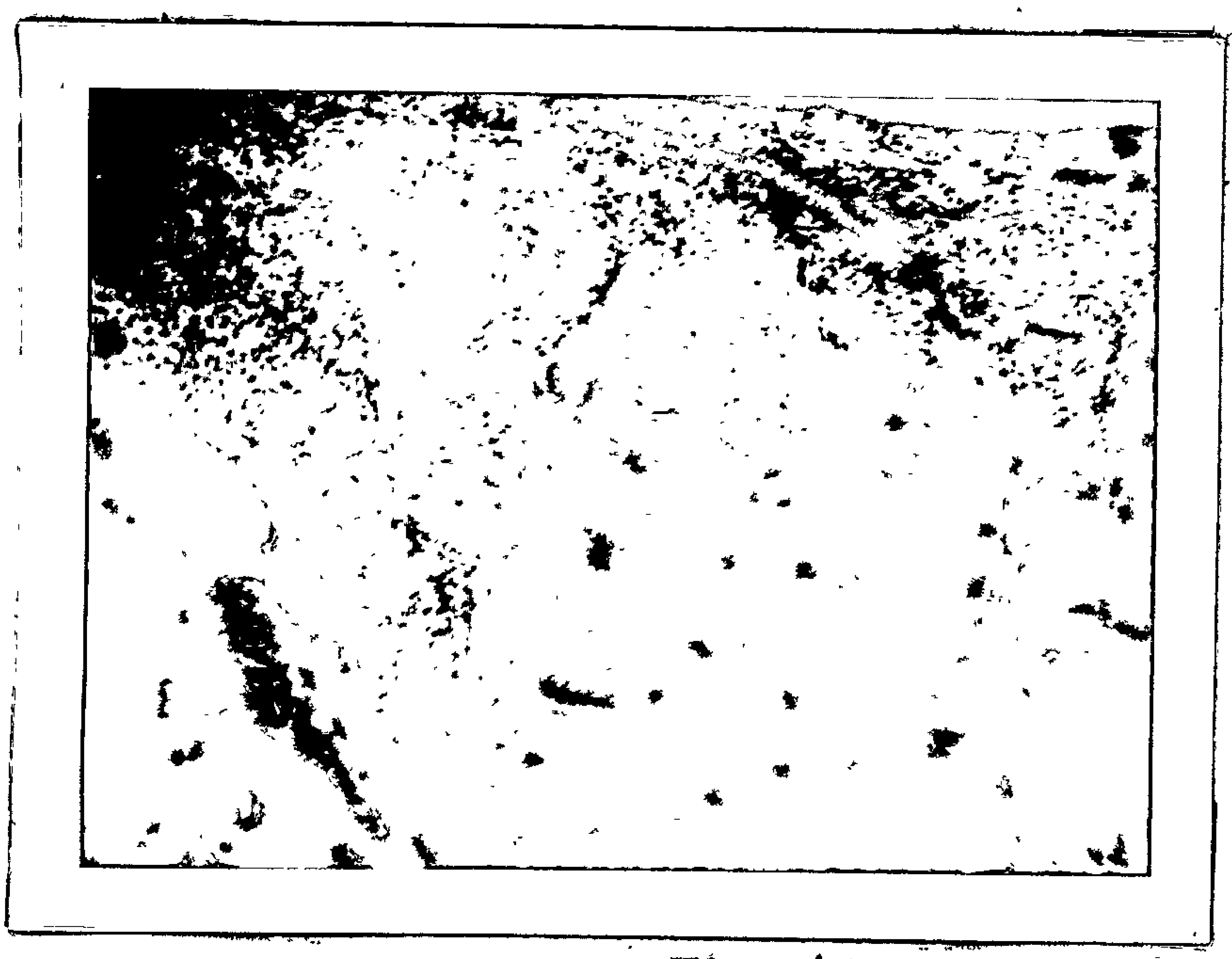

Fig. 40.

Pars posterior menisci. (X 80 cf. fig. 8.)

Pars Posterior Menisci. (cf. fig. 8.)

The pars posterior menisci is located above the sagittal crest of the condyle and below the roof of the articular fossa. It consists of unorientated collagenous fibres and fine elastic fibres similarly unorientated. At its inferior surface is a layer of definite chondrocytes about 3 to 5 cells thick whilst on its superior surface is a layer of cells 1 or 2 cells thick which appear to lie in lacunae and are orientated longitudinally.

The tissue is quite cellular but relatively avascular.

Fig. 41.

Cellular component of the central part of the pars posterior menisci. Note the unorientated collagenous fibres. (X 900 cf. fig. 8.) The cells appear fibroblastic and chondrocytic in nature.

Fig. 42.

Inferior border of the pars posterior menisci. Note the vascularity near the synovial surface. (X 80 cf. fig. 8.)

Fig. 43.

Superior border of the pars posterior menisci. Note the avascularity of the synovial surface. (X 80 cf. fig. 8.)

....

<u>Strata of the Bilaminar Zone</u>. (cf. fig. 8.)

Posteriorly the pars posterior menisci gives origin to definite strata of tissue between which is the bilaminar zone.

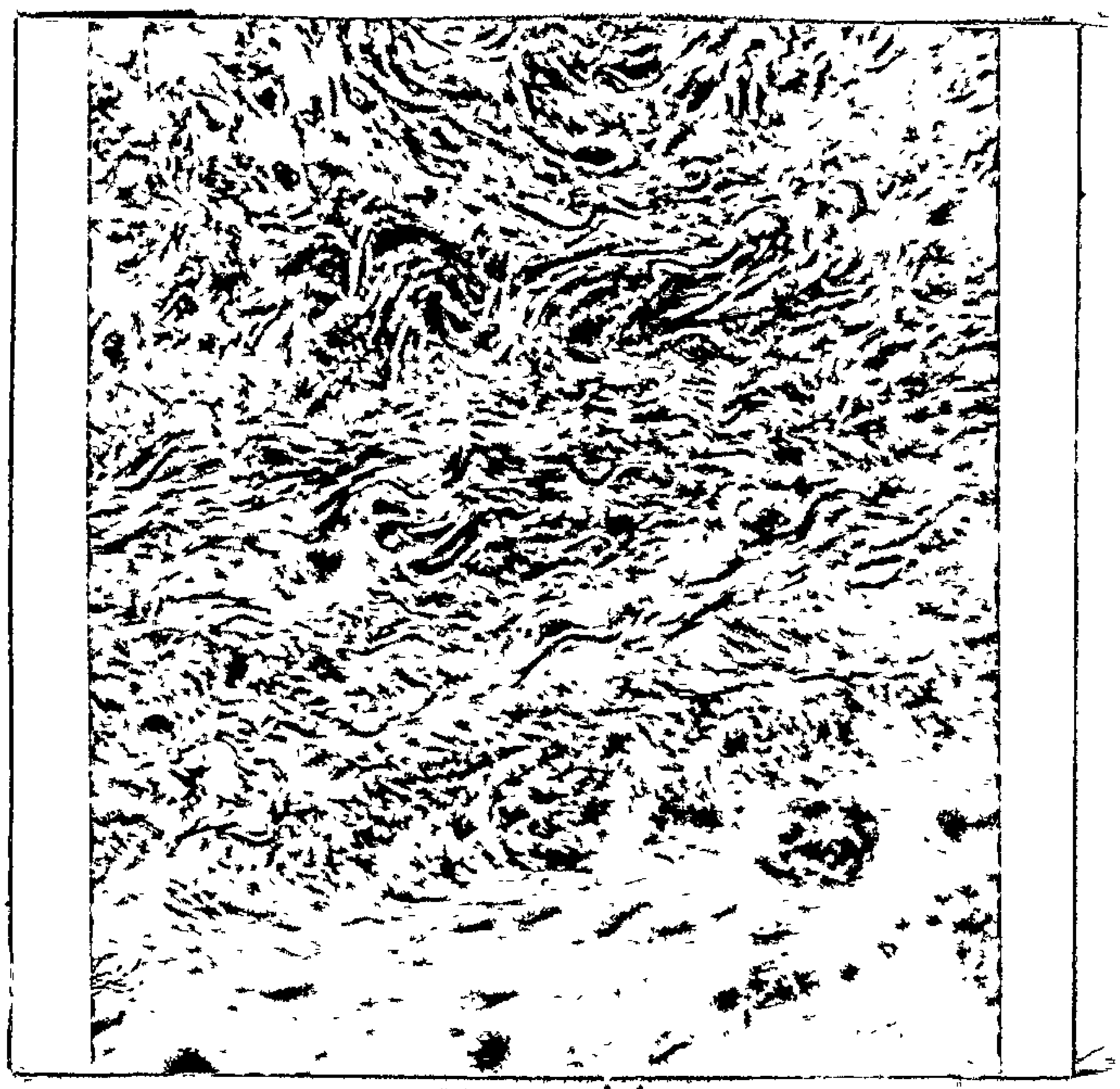

Fig. 44.

Inferior stratum of bilaminar zone. (X 540 cf. fig. 8.) Note the wavy collagenous fibres.

....

<u>Inferior Stratum</u>. (cf. fig. 8.)

The inferior stratum consists of collagenous fibres ...ntated longitudinally and which is inserted into the ...ondrium of the posterior slope of the developing condyle.

It is ligamentous like in nature and contains very few elastic fibres. Inferior to it is sub synovial connective tissue and synovial membrane.

Fig. 45.

Superior stratum of bilaminar zone. (X 540 cf. fig. 8.)
Note prominent elastic fibres.

....

Superior stratum. (cf. fig. 8.)

The superior stratum consists of collagenous fibres and elastic fibres which in the main are orientated longitudinally and which can be traced into the loose connective tissue which forms the posterior capsule.

Fig. 46.

...minar zone. Consists of fairly loose neuro-vascular ...ective tissue. (X 80 cf. fig. 8.)

....

The Bilaminar Zone. (cf. fig. 8.)

The bilaminar zone is a " V " shaped area between the two forementioned strata and consists of a prominent plexus of veins and arteries which anastomose freely.

It is limited posteriorly by a fairly definite zone of collagenous fibres which are orientated vertically and blood vessels which demarcates it from the parotid gland. Nerve fibres can also be noted in the substance of the bilaminar zone.

Middle third of the foetus at term.

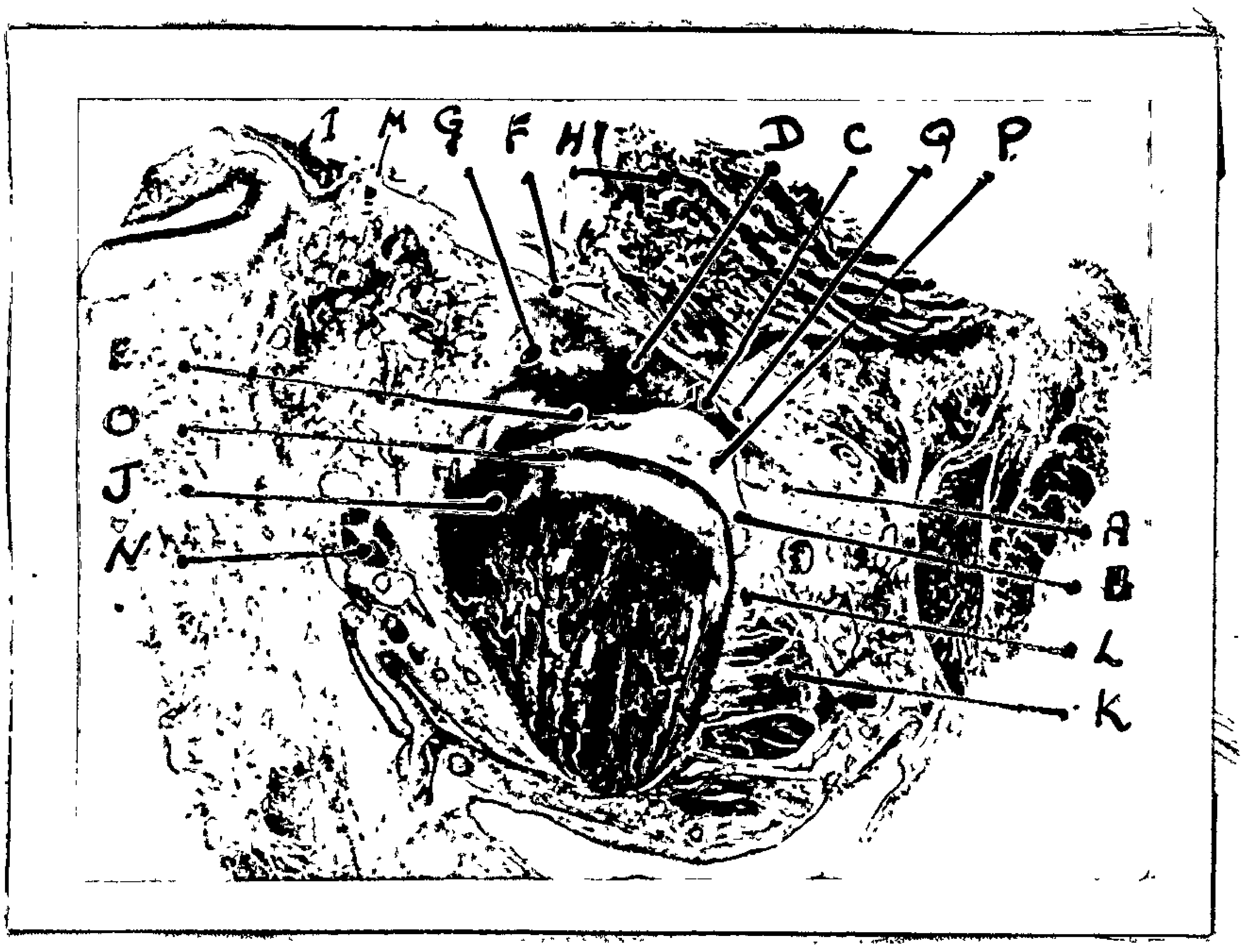

Fig. 47.

Specimen no. 1 - foetus at term.

Sagittal section x 5 middle third temporomandibular joint.

A. Pes menisci.
B. Hela of pes menisci.
C. Pars gracilis menisci.
D. Pars posterior menisci.
E. Inferior stratum.
F. Superior stratum.
G. Bilaminar zone.
H. Temporal bone.
I. Tympanic bone.
J. Condyle.
K. Lateral pterygoid muscle.
L. Pterygo-condylar area.
M. Squamo-tympanic fissure.
N. Auricular temporal nerve.
O. Perichondrium.
P. Inferior joint cavity.
Q. Superior joint cavity.