A THESIS ON DETACHMENT OF THE RETINA WITH NOTES OF AN EXPERIMENTAL RESEARCH IN THE ARTIFICIAL PRODUCTION OF DETACHMENT AND IN A METHOD FOR THE APPLICATION OF FIBRINOGEN AS A THERAPEUTIC AGENT BY ARTHUR HENRY HAVENS SINCLAIR.
Detachment of the retina though not in itself dangerous to life, is a condition of very serious importance.

According to Magnus (1) Detachment is the most frequent and the most important of all the idiopathic diseases of the retina, and constitutes 4.75%. It is only necessary to watch the cases which come to the out-patient departments of our various Ophthalmic Hospitals, to see how little can at present be done for their treatment.

In the large majority of cases no treatment is employed, or such as is admitted to be of the most doubtful efficacy.

It is unnecessary in the face of these facts, to enter upon any lengthened apology for the selection of this subject, as one of the highest importance; and as one, particularly on account of the unsatisfactory state of its therapeutics, which urgently demands attention.

This subject was also suggested to me, as one among several which might yield interesting and valuable results from experimental investigation.

The experiments carried out in this connection, have enabled me, firstly. To elucidate some points in the pathology

(1) Oliver & Norris, page 446.
Secondly. To establish some points in the production of artificial detachment of the retina, which have not previously been made clear.

Thirdly. To explain a method of preparing a fibrinogen-containing fluid, so that it may be preserved sterile, and in such a condition, that by proper treatment coagulation can be brought about at the body temperature when desired.

Fourthly. The explanation of a method by which a specially devised operation is employed to replace the fluid lying behind the detached retina, by the coagulating fibrinogen-fluid above mentioned, or with other solutions devised for a similar use.

Before the invention of the ophthalmoscope retinal detachment though recognized was considered rare.

The term "Gutta Serena" (2) was long used to indicate those conditions of the eye, in which sight was partially or totally lost, without any visible injury to the organ as viewed by the naked eye of the observer.

We find under this term many interesting cases detailed.

In 1780 George Chandler in his work (3) describes the principle of Gutta Serena as being found

(2) Lexicon Medicine. Hooper, 1831

(3) 1780 Treatise on the diseases of the eye. Chap. XXIV.
either in the Brain, Thalamus Nervorum Opticum, in the passage of these nerves or in the whole of the retina.

Interesting cases might be quoted from the writings of Weller, Travers, Watson, and others, which though described as varieties of "Gutta Serena" can in the light of our present knowledge be recognised as retinal detachment. Among the many accounts of the various forms of Gutta Serena which one finds in the writings of the end of the last and the beginning of the present century, all of which are more or less vague, it is strikingly interesting to note that one clear and well attested case is described as having been proved by post mortem examination; and a second case diagnosed and treated by the same observer, affords us an interesting example of a keen worker who was much in advance of his contemporaries.

I refer to the case described by James Ware (4).

Ware treated the second case by scleral puncture with evacuation of the subretinal fluid, and with good effect. This method has been practised in recent years, and has been regarded by some as equal to any other method of treatment.

Soon after the invention of the ophthalmoscope, Von Graefe gave a very complete clinical

account of retinal detachment.

This brings us up to the consideration of the subject from our present day point of view.

Pathology.

In the first place I propose to discuss the pathology, and afterwards to give some account of the various forms of treatment which have been employed.

The account of my own experimental work will in part come into the general text and the remainder will be summed up with the illustrations at the end of the paper.
PATHOLOGY.

Detachment of the retina may for the sake of simplifying the discussion of its pathology, be divided into Primary and Secondary cases.

The Primary, or the so called Idiopathic, cases I propose to discuss at some length.

The Secondary cases may for convenience here be again divided into A, those secondary to intraocular neoplasms to cyclitis or to some form of retinitis, a group which I do not propose to discuss at any length in this paper - and B, those secondary to traumatism which may be again referred to later on.

I. In entering upon the discussion of the pathology of the idiopathic form, I propose to give in the first place a short account of the theories which have been brought forward by the more outstanding observers; and afterwards to compare those theories, and to endeavour with the assistance of my own experimental researches, to elucidate the ground so far as the ascertained facts enable me to do so.

Von Graefe originally regarded subretinal haemorrhage as the cause of detachment.
This view was soon found to be erroneous.

The first theory which held the field for some years, was that of "Choroidal transudation."

By this theory it was understood that a collection of fluid behind the retina, the result of choroidal transudation, was the cause of detachment.

The fact that extension and sudden detachment was frequently met with in conjunction with a subnormal intragcular pressure made it evident that some other explanation must be sought.

The theory of choroidal transudation having been discarded as untenable, for the above mentioned reason, need not receive any farther notice.

The next theory is that supported by Leber and Nordenson, "The theory of Vitreous contraction" and will require to be noticed at length. A still more recent theory brought forward by Professor Rühlmann "The theory of Diffusion" will also require detailed consideration.
The second mentioned theory, that of contraction of the vitreous body, which was formerly sustained by H. Mueller, Stellwag, Wainow, etc., (4) and more recently taken up and expounded by Leber and Nordenson, may in the first place be described as set forth by Professor Leber of Heidelberg, and by Erik Nordenson, in their combined work on the subject.

Professor Leber in a lecture delivered by him, before the Ophthalmological Assembly at Heidelberg in 1882, expressed his views in support of this theory, stating that his conclusions were arrived at, partly through clinical observation, and partly by the investigations into the morbid anatomy of eyes which had been affected by spontaneous detachment of the retina. He also conducted some experimental researches on animals in the same connection.

Dr Erik Nordenson made it his special task to follow up the investigations begun by Leber, and more especially devoted himself to the study of the morbid anatomy of the vitreous body from the histological point of view.

Dr Nordenson published his book in 1887, having embodied within its pages the work carried on for from five to six years.

In Leber's introductory remarks he states his belief that "Through the labours of Dr Nordenson the correctness of the view is proved - setting aside some rarer forms - that the detachment of the retina is universally produced, not by primary effusion issuing from the choroid membrane, but by the traction made through the shrinking of the vitreous body."

Leber farther states that these investigations prove in the most convincing manner not only shrinkage of the vitreous body itself, but mainly its effects on the retina including the remarkable spontaneous ruptures of the latter.

We may now proceed to a short consideration of the sequential pathological changes which take place in the course of spontaneous retinal detachment, as described by Dr Erik Nordenson.

The vitreous body in so far as it is concerned in the pathology of this subject, first demands our attention.

It might be considered proper at this point to introduce a short description of the normal vitreous body; but as the points which demand attention in that connection can be touched upon when they come under our notice, it is unnecessary to make any such digression.
The remarkable changes in structure, and in form, which are described as taking place in the vitreous body, at once direct us to the consideration of their etiology. Dr Nordenson considers that a disturbance of nutrition, produced by inflammatory processes, particularly by those affecting the choroid, would afford sufficient explanation. He affirms that such pathological states of the choroid have been found in all his investigations. He, in support of this, refers to the fact established by statistical evidence, that detachment occurs more frequently in myopic eyes, than in other conditions of refraction, and that choroidal disease also occurs more frequently with this state of the refraction.

It is also important to notice here that intraocular tumours have been observed to produce the same marked change in the vitreous body.

In eyes with chronic glaucoma a similar change in the vitreous is observed to accompany the characteristic symptoms of the glaucoma.

The changes referred to as taking place in the vitreous body consist in an increase of its tissue elements. The firm fibrillae which normally enter into the structure of the vitreous, become thickened and tortuous; the cellular elements increase in amount, and the vitreous as a whole enters upon a progressive process of shrinkage.
The shrinkage as it proceeds gradually separates the vitreous body from the retina at those parts where it is not intimately attached.

If the case be one in which the vitreo-retinal attachments be normal, the progressive shrinkage results later in a complete funnel-shaped detachment of the vitreous body from the retina.

The connection at the optic nerve remaining intact, forms the narrow end of the funnel: and the normally more adherent zone at the equator, forms the expanded end of the funnel. The space left between the retina and the retracting hyaloid membrane fills with fluid coincidently with the vitreous shrinkage.

As the shrinkage proceeds still farther, Traction upon the retina takes place at the parts where the attachments are still intact, namely at the Papilla and the equatorial region.

It may perhaps be well to mention here that Nordenson thinks it probable that the vitreous body and the retina of man (as in the eyes of sheep and of pigs, see Schnaller, 1872) are separated over the greater part of the back of the eye by a cleft or fissure into which injections can be made.

This theory certainly serves to explain the form taken by the detached vitreous. It may happen that the retina gives way when it is dragged upon
at the equator; in such a case a retinal rupture is formed, and the sub-hyaloid fluid gains entrance to the posterior aspect of the retina; detachment being rapidly produced as a consequence.

This forms the mechanism of retinal detachment as it is stated by Leber and Nordenson.

The course of events as above mentioned is, however, according to our Author, subject to modifications.

First, the retina may rupture within the area of hyaloid adhesion and so be protected from the sub-hyaloid fluid entering at the rupture. The detachment would then proceed slowly, from the vitreous traction, and from such fluid as might accumulate behind it from the substance of the vitreous, or *en vacuo* from the choroid.

Secondly, the vitreous body may not become separated from the retina, as stated in the first described class of case, but may exercise traction from the beginning upon the posterior part of the retina, and so produce detachment primarily by the collection of fluid behind the retina from the vitreous, or *en vacuo* from the choroid. The rupture occurring in such cases from the vitreous contraction as before, but secondary to the existence of retinal detachment.

Lastly, it is not denied that such forms of
detachment as might be produced by a sub-retinal effusion of fluid, sometimes may take place in rare cases of albuminuric retinitis; but it is contended that in such cases, the retina must be pushed up against the choroid, and no free floating movements of the retina can be possible, and the process must be slow. The significant fact is noted, that there is no evidence of retinal detachment having followed suddenly upon sub-retinal haemorrhage, though clinical evidence of detachment having occurred in cases where haemorrhage into the vitreous and retina resulted in the formation of fibrous tissue deposits. It is also urged that the floating of the retina and its movements as seen on moving the head or eye-ball, could not take place unless there is free fluid both in front and behind the retina.

By the Leber, Nordenson hypothesis, we are able to understand how the retina may be detached to a very marked degree in a day's time, without raising the ocular pressure.

The sudden occurrence of spontaneous cure is also rendered comprehensible by the free communication of the fluid behind the retina with that in front, through the rupture.
The third mentioned theory, that of diffusion, which was brought forward and supported by Professor Rählmann of Dorpat, now demands our consideration.

Rählmann has explained his theory by comparing the retina to the animal membrane of a dialyser, which has on one side a saline solution, represented by the Vitreous Humour, and on the other side an albuminous solution, represented by choroidal transudation.

He regards the old basis of choroidal exudation, as the starting point which sets up an altered relationship of osmotic pressure, and causes the process of diffusion to proceed.

The fluids of the Vitreous being largely crystallloid, diffuse readily backwards through the retina, and thus a considerable quantity of fluid may be collected behind the retina without an increase of ocular pressure.

Rählmann agrees with the older view that the retina is pushed forward by fluid which has collected behind it without rupture having previously occurred; but differs from it in his explanation of how that fluid is collected there. He agrees with Leber that the Vitreous plays an important part in the production of detachment, but differs from that author in believing that only the fluid constituents of the Vitreous take part in the process.
In reference to the morbid anatomy, Rählmann points to the fact that the observations of Leber and Nordenson, which have been brought forward in support of the theory of Vitreous contraction, were made upon eyes in which detachment had been a condition of long standing.

This though an almost unavoidable circumstance, is doubtless a point of very considerable importance; and the more especially so, as from these observations made upon cases of old standing detachment, conclusions are drawn with regard to origin.

Rählmann regards the changes described by Nordenson as occurring in the solid elements of the Vitreous, as secondary to the occurrence of detachment. He believes that the altered conditions of osmotic pressure, which by diffusion cause fluid to be removed from the Vitreous, are at once accountable for detachment of the retina and for the tissue changes of the Vitreous.

In support of his view, Rählmann referred to the observations of H. Mueller, Schweigger, Schiess, Gemuseur, Wainow, and others by whose observations it has been shown that the Vitreous body may be converted into a more or less fibrous state or after foreign bodies have penetrated into it.

A very important point brought forward by Rählmann is, the marked difference which is found
between the post-retinal fluid and that of the Vitreous.

These points of difference are, 1st, colour, 2nd, proportion of albumin, and 3rd, Specific gravity.

1st. In several instances Rähmann aspirated fluid from the subretinal space when there was no rupture discoverable ophthalmoscopically. This operation was performed under ophthalmoscopic control and was performed with the syringe of Pravaz. With regard to the first mentioned point - that of colour - two points were observed (A) that the fluid so removed was of a greenish yellow colour and so markedly contrasted with that of the vitreous; and (B) that the detachment formerly of a bluish green colour, after the removal of the fluid became approximately of the colour of the general fundus. Schweigger (l.c.p. 411) also makes reference to the colour of a detachment as being due to that of the fluid underlying it.

2nd. The second point - the relatively large proportion of albumin - was established by the chemical analysis of Dr Scherl, for full details of which I must refer to (p.26. Vol. XXVII, Archiv Für Augen Heilkunde). The post retinal fluid in one recent case (of three week’s duration) containing albumin equal to that found in serous effusions and in another to much greater amount.
3rd. The phenomenon of "sinking" - as referred to by Rähllmann - or that tendency which a partial detachment has to increase towards the lower part of the fundus.

It has been observed widely that detachment, when once established, tends to increase in extent. This increase which according to our Author takes place commonly towards the lower part of the fundus, is termed by him "sinking," and is ascribed to the relatively greater density of the post-retinal fluid as compared with that in front.
In connection with the two important theories just described, certain outstanding points present themselves for special notice.

The frequent occurrence of retinal rupture, together with the important place given to it, in the process of detachment, by Leber and Nordenson, make it necessary that it should be treated in some detail.

Von Graefe (6) in his original description of detachment, after the discovery of the Ophthalmoscope, was the first to describe rupture of the retina in this relation. There is considerable difference of opinion as to the cause of Rupture.

Its frequency is also stated differently.

This latter point may be partly explained by the folded undulating appearance presented to the examining eye by the detached retina.

Rupture though present may be concealed by a fold of the retina, and so escape observation.

Galezowski (7) states (out of 649 cases) 20% as the frequency with which he has observed rupture.


(7) Recueil d'Ophth. 1883. p. 669.
Nordenson (8) has stated it (out of 119 cases) at 38% from a much less extensive observation.

Galezowski regards the ora serrata or its immediate neighbourhood, as the most frequent site of rupture. Galezowski does not regard rupture as constant, nor as an essential factor in the process of detachment.

Von Graefe originally regarded rupture as due to the pressure of post retinal fluid; this view has more recently received support from Rühlmann.

De Wecker, Schoeler and many others have agreed with Leber’s explanation.

A very interesting explanation is given by Elsching (9), who does not believe that vitreous traction alone is sufficient.

In two cases observed by Elsching, he regarded the rupture as due to an adhesion having formed between the retina and the choroid.

The contracting vitreous body in producing detachment might bring considerable tension to bear upon the margins of such an adherent patch, and cause them to give way, thus producing a tear or rupture. In this way an aperture would be formed in the retina, and a small patch of adherent retina

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(8) Die Netzhautablösung.

(9) Klinisches Monatsblatt für Augenheilkunde. p. 416.
would remain incorporated with the choroid.

It is interesting to find that this ingenious explanation is well supported by the facts of two cases observed at Moorfields Ophthalmic Hospital by Dr Collins (10).

In these cases, microscopic examination was made. A patch of intimately adherent, much degenerated, retinal tissue, was found attached to the choroid, with a corresponding breach in the detached retina.

This explanation, though it may only account for a certain proportion of cases, is supported by the generally acknowledged relationship between Myopia and Choroidal disease. The myopic condition apparently predisposes to choroidal disease, and also to retinal detachment.

Inflammatory conditions of the choroid and retinal detachment, from their common relationship to Myopia, doubtless occur frequently in association with each other. This statement is supported by the observations of Nordenson. (Concluding remarks die Netzhautablosung).

It is quite reasonable to suppose that patches of choroiditis, would lead to adhesions of the retina and choroid as a result of inflammatory

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material causing the formation of fibrous tissue.

It has been generally observed that the torn edges of a retinal rupture are turned towards the vitreous. This fact has been employed by Leber as a proof of the traction of the vitreous body. For he says that rupture takes place where the greatest tension is made upon the retina by the fibrillated vitreous.

He considers the inturned edges of the rupture as additional proof of the pulling action of the vitreous. Rählmann, on the other hand, regards rupture as the result of pressure from the post retinal fluid. He explains now the inturning of the edges is the result of the forward flow of the sub-retinal fluid, which takes place at the moment of rupture.

In my own investigations I have observed in the rabbit that the rupture which occurs as a result of post retinal pressure, when fluid has been injected behind the retina, presents the same forward turning of the margins. That rupture was sometimes produced by the needle with which the injection was made, I have observed on several occasions.

In these latter cases, however, the laceration of the choroid, which was an almost constant accompaniment, somewhat complicated the condition. I therefore only refer to those cases in which rupture was the result of fluid pressure behind the retina.
This occurred in two ways. Firstly, when fluid was injected behind the retina too rapidly, or with irregular jerking movements. Secondly, when an albuminous fluid was introduced — which shall be referred to again. (See page 20).

In two cases in which fibrous contraction of the vitreous was produced artificially by copper (Cases C. and D. p. 827), I was unable to discover rupture ophthalmoscopically, though I found it in one case by microscopic examination afterwards. Detachment was present in both these cases and diagnosed ophthalmoscopically. I am unable to make any statement with regard to the margins of rupture in these two cases.

In several instances I endeavoured to dissect off the retina from the choroid, in a rabbit's eye after death. This was done by clipping away the anterior part of the eye, including the lens, a hazy body, and some vitreous which adhered to the back of the lens capsule.

The retina was then gently separated from the choroid all round at the Equator, where the eye had been divided. A blunt pointed pair of scissors, curved on the flat, was then introduced between the retina and the choroid and the optic nerve severed.

The retina was now freed from its remaining choroidal connections and was floated in water.
The remaining vitreous attached to the anterior surface of the retina, was removed as far as possible; and the retina laid on its posterior surface on a broad glass slide.

The specimen was mounted in glycerine jelly and photographed. In the process of dissection, and in laying out the retina on the slide, I was much struck by its tendency to curl up, or to become rolled upon itself like a roll of paper which has been flattened out and let go.

This curling or folding tendency was observable to some extent in the tissue as a whole, but very markedly so at the cut edges. The curling or folding always appearing - even while the tissue was floating in water. - The Anterior or Vitreous surface always tending to become more concave, while the posterior or choroidal surface formed the convex or outer surface of the roll.

In dealing with the retinal membrane as a whole, one might have expected from its natural cup-like shape, that to lay it out flat, would be resisted by natural tissue resilience, but when the cut edges are observed to curl up while in water, the marked and positive tendency to take this form becomes obvious and striking.

In the above description neither the dragging action of strands of fibrillated vitreous, nor the
pressure of fluid are at work, but only the natural force of tissue resilience.

This natural resiliency I consider a sufficient reason why the edges of the ruptured retina are observed to turn inwards. I observe that this explanation is suggested by E. Treacher Collins (//), in connection with the two cases formerly referred to as reported by him.

With regard to rupture following upon the injection of an albuminous fluid behind the retina, I have made the following observations.

In two cases, in which the injection of sterile Blood Plasma of the Horse was made behind the retina, rupture was ophthalmoscopically diagnosed afterwards.

As shall be described in full later on, the plasma injected was so treated before its injection, that coagulation occurred in from ten to fifteen minutes after injection. In the first case (H. Left) detachment of the retina was extensively produced by the injection and ophthalmoscopically diagnosed on the day following.

On the second day after the injection a large mass of coagulated plasma of a yellow colour was found in the Vitreous. The area of detachment was

almost entirely concealed from view. This mass of fibrine which at first lay behind the retina, and had remained there for the first twenty-four hours, had on the second day found its way through the retina into the Vitreous.

In the second instance (Case F.p./2) the same preparation of plasma was injected into a rabbit's eye, in which however, artificial detachment has been previously produced. In this case the fibrine was observed presenting through a vertical cleft in the retina, an oblong mass, which gradually protruded until it lay free in the Vitreous, except at its upper extremity which remains attached by its subretinal connections. In this case the first appearance in the Vitreous of the fibrine mass was not detected till the sixth day, and it had not entirely protruded till the tenth day.

In the first of these cases there was evidence that the retina had been punctured at the time of injection; though no retinal rupture could be seen, some shreds of fibrine were seen in the Vitreous.

In the second case no such evidence could be found.

The cause of rupture was here to be looked for in factors at work behind the retina. The Vitreous was in each case healthy to begin with, though in each case some of it had escaped at the time of injection.
In the second case, previous interference in the production of artificial detachment must not be forgotten.

The only way in which the Vitreous could here act, would be by its lowered pressure, or the diminished support which it offered to the front of the retina. Behind the retina two factors are at work. First, the increasing bulk of fluid and second, the contraction of the mass of fibrine.

The increase of the volume of fluid behind the retina would arise firstly, by diffusion from the Vitreous as explained by Rähmlmann; and secondly, by choroidal transudation set up by the irritation of the choroid by the foreign substance. The contraction of the mass of fibrine would take place equally from all directions provided it was free from attachment, as a blood clot may be observed to separate itself from the sides of a glass vessel to which it is not adherent.

In this case, however, the injection having been made from above, obliquely through the sclerotic and choroid, the withdrawal of the needle would naturally be followed up by part of the fluid plasma, even through the wound in the sclera.

This was observed at the time of the operation. After the withdrawal of the needle, the wound, from its oblique direction, was closed by the intraocular
pressure, so that no after escape of fluid took place.

We now have a mass of coagulating blood plasma behind the retina, with an extension from its upper surface passing in behind the undetached retina till it reaches the scleral wound, and attaching itself to the margins of that wound.

When coagulation has taken place and contraction of the clot has set in, the fixing of its upper extremity will decidedly influence the course of contraction.

Thus it could be distinctly seen that the clot even after it had protruded into the Vitreous, became shorter and thicker in shape, its lower extremity becoming approximated to its upper, which was attached to the ocular wall at the upper part of the Fundus.

The forces at work behind the retina must here be considered as responsible for rupture.

That is to say, the pressure of the subretinal fluid, combined with the action of the contracting fibrine mass before described.

Though these two cases afford an example of how subretinal pressure may produce rupture without either Vitreous contraction, or abnormal
adhesion of the retina to the choroid; it must be admitted that here the conditions are not quite analogous to those met with in clinical experience. We have here the mass of fibrine to complicate the effect of the post-retinal fluid pressure.

It is important to note here also that in three other experimental cases - to be detailed later on - an albuminous fluid injected behind the retina, which produced an increasing detachment, did not cause rupture, so far as could be determined by Ophthalmoscopic examination: and Rähldmann regards rupture as due to the osmotic pressure of the subretinal fluid. We have here in the two experimental cases referred to, examples of rupture which afford some support to Rähldmann's theory of Rupture.

Rähldmann in refuting Leber's Theory of Vitreous contraction, refers to experiments which he performed by introducing particles of copper into the Vitreous. He admits that Vitreous contraction and retinal detachment followed, but he
holds that the Vitreous contraction was in reciprocal relation to the forward pressure of the detached retina.

He explains his statement by saying that the metallic oxides formed become absorbed, reach the vessels and alter the osmotic relationships and so cause detachment by diffusion.

In two cases observed by me in which sterile copper filings were introduced into the Vitreous of rabbits. (See Cases C. and D. later on p.82%). I observed a progressive degeneration of the Vitreous to follow, with subsequent retinal detachment. I did not detect retinal rupture by ophthalmoscopic examination though it was afterwards detected by microscopic examination. During the changes which were seen it must be admitted that a part of the fundus was obscured from view by the dense white opacity of the Vitreous. In those parts of the fundus which could be seen through the still clear Vitreous, no detachment could be detected for over a month after the change had begun in the Vitreous.

The beginning of the pathological change in
the Vitreous, and its course of development, throws considerable light on the question of cause and effect. The white opacity of the Vitreous which was seen, began between and around the particles of copper, which were lying together in a clump or mass about the centre of the Vitreous. Some particles lay at the upper part and were close to, and some on the retina at the point of introduction. At this point alone was the altered Vitreous observed to be in contact with the retina in the early stage, and for the reason mentioned.

The white opacity extended into the clear Vitreous from the mass of copper filings by steady advance.

No localized patches of opacity were observed to arise apart from the copper. Detachment did not come on till late in the process as before mentioned.

If, as Rähmann suggests, the fibrous change in the Vitreous was only in reciprocal relation to the detachment; it might reasonably have been expected that the detachment would have been observed earlier, and also that the morbid change in the Vitreous would have had a different course of development. That is to say, the altered appearance of the Vitreous would have first become visible not in immediate relation to the fragments of copper.
but nearer to those portions of detached retina which first impinged upon it.

The changes of the Vitreous are here clearly to be attributed to the direct action of the copper particles; and not to the indirect action through diffusion and retinal detachment, as Rahnmann states. The retinal detachment in these cases from its later occurrence and its site, as related to the altered Vitreous cannot be regarded as other than a change secondary to, and caused by, the altered Vitreous.

In the microscopic examination of one of the eyes above referred to, the retina was much degenerated, as can be seen from the accompanying photographs. Detachment had taken place to such an extent that the bulk of the debris of copper filings and altered Vitreous was found to be behind the retina, having found its way through the rupture from the Vitreous cavity to the subretinal space.

The cause of rupture in this case, and the reason why the debris was found to have passed into the subretinal space, is a question of considerable interest here. That the change of position in the debris, above mentioned, took place post mortem and during the hardening process is more than probable, as it was not detected with the ophthalmoscope.

In any case the force at work in producing detachment, in causing rupture, and in so markedly altering
the position of the retina, as is shown in the photograph (p.19), must have been acting from in front of the retina.

The alteration of position in the mass of debris lying behind the retina, is comparatively small, if we consider its general relations to the sclera. The change in the position of the retina is very remarkable, and it is to this change that the altered relations are chiefly due.

It is obvious that fluid pressure acting behind the retina, having once caused rupture and so gained free communication with the Vitreous cavity, would then cease from any further positive pressure on the retina.

We cannot regard a subretinal fluid pressure as simultaneously causing rupture and receiving a large addition to its bulk. We must therefore turn to the action of the contracting Vitreous as the only explanation left.

The action of the contracting Vitreous, pulling upon the retina from the front, would at once offer an explanation for the remarkable position of the retina, its degeneration, its rupture, and its having been pulled forwards over the mass of debris in the Vitreous.

We have now considered the points in the pathology which specially relate to rupture.
It is evident that rupture may occur in a variety of ways, and that no one given cause is sufficient to explain all the cases which are met with.

Firstly, pressure from the choroidal side may cause retinal rupture where the Vitreous has not become altered, as in Cases (H) and (F. p. ).

Secondly, rupture may occur as in the copper filings case, as a result of fibrous contraction of the Vitreous, combined with degeneration of the retinal tissue.

Thirdly, it may occur as has been shown by Elsching and by Collins, by an adhesion between the retina and the choroid which is co-existent with an advancing condition of detachment. From the cases shown by Collins together with the microscopic appearances in some cases which I have observed, the presumption is strongly in favour of the view that the point of rupture has frequently been the site of a degenerative process before rupture occurred, and that the site of rupture may often be determined by the previous thinning and weakening of the retinal tissue. Thus a comparatively slight pressure of subretinal fluid or quite a feeble traction of fibrillated Vitreous, might suffice as the immediate cause.
The comparison of some other experiments of a different nature may perhaps throw farther light on this subject. The same plan of operation as that described later, under the artificial production of retinal detachment, was in the following case employed.

About six drops of the fluid sterile horse plasma - which was not treated to bring about clotting - were, under ophthalmoscopic control, injected behind the retina of a rabbit, (See Case V. p./27) The fact that no breach of continuity or puncture of the retinal membrane was made, was not only observed at the time of operation, but was repeatedly confirmed afterwards.

On the day following operation, a well-marked detachment at the lower part of the fundus was observed. The undetached parts of the fundus were normal.

The detachment was generally of a triangular form, having its base towards the equatorial region below, and its apex about the centre of the fundus, beneath the transverse band of opaque nerve fibres.

On examination two days later a marked increase of the detachment was observed, this increase continued for about seventeen days. At the end of a month the detached area was slightly lessened, though still covering nearly half the fundus.
The area covered by the detachment when it was first seen, would correspond to \( \frac{2}{3} \) of the fundus at its lower part. That covered by it at the end of seventeen days, would correspond to more than half the extent of the entire fundus, at the lower and anterior part.

The chief extension being forwards and upwards.

In the periodical observations made, certain interesting phenomena were observed.

The general appearance of the detached area altered to a more opaque white. Small blister like patches of detached retina were seen to form near the larger area; some becoming included in the larger, and others disappearing.

The extension upwards of the anterior part, contrasts strikingly with the "phenomenon of sinking" as described by Rählmann.

The fact that in this case (see Case V p.) we find the injection of a small amount of albuminous fluid behind the retina, producing an increasing detachment which at the end of a month is about three times its original extent, points strongly in favour of the theory of diffusion.

In another case by the same method and on the same date five minims (or 6) of a sterile 20% solution of glucose, were injected behind the retina. (See Case U. p. 126).
The retina appeared uninjured by the operation. Detachment was produced to about the same extent as in the last case. Three days later it had not increased, and five days later it disappeared. The retina had become reapplied to the choroid. There remained at the part where detachment had taken place an irregular pigmentary mottling, which was still present at the end of a month. The crystalloid diffusible nature of glucose more than counterbalanced its osmotic tendencies, and so it became absorbed in a few days without increasing detachment.

In the cases in which detachment was produced by injecting sterile normal salt solution behind the retina, (see case J. p. 94-) reapposition of the retina took place slowly. In one instance where complete detachment had been produced in this way, the retina became gradually reapplied to the choroid and was completely restored to its original position at the end of five weeks.

The same pigmentary changes were observed afterwards as in the glucose case.

In still another class in which the animal's own Vitreous was injected behind the retina, (see E. Right, p. 91) the detachment produced followed the same course of healing as that caused by salt solution.
Another form of experiment consisted in passing a flat, curved, blunt-pointed needle between the retina and the sclerotic. (E Left, p.///) The choroid being injured extensively by the movements of the needle. In this case extensive haemorrhage was at first seen. Detachment could not be made out at first.

After a few days the Vitreous became much clouded by haemorrhage into it, so that the changes in the fundus could not be seen.

At the end of a month the condition of the fundus could be clearly seen, though the Vitreous still showed some areas of opacity.

Extensive detachment could be seen which continued to increase for about a fortnight.

At the end of two months extensive detachment still existed. The opacity of the Vitreous in this case was an unfortunate circumstance, as it prevented notes being made of the course of events throughout.

The fact that detachment was still increasing during the 5th, 6th and 7th weeks after the Vitreous had partially cleared up, though it cannot be regarded as direct evidence, points to the effect of haemorrhage into the Vitreous as the most likely cause.

In many of the experiments sub-retinal
haemorrhage was observed, sometimes at the margin of an artificially produced detachment, and at other times over large areas of the fundus.

In no case were such retinal haemorrhages followed by detachment. This observation supports the statement made by Nordenson, in the concluding remarks of his work, that retinal haemorrhage does not cause detachment. Nordenson states at the same time that haemorrhages which extend not only into the retina, but also into the Vitreous, have been followed by detachment.

This latter statement of Nordenson's is, I believe, the explanation which probably underlies the course of events as described in the last mentioned experiment.
From the foregoing text we have seen that many points can be adduced to show that Vitreous contraction may under certain conditions, act as a cause of retinal detachment. Thus the slow inflammatory change set up by the introduction of copper filings into the Vitreous, was shown to have caused detachment in this way.

Again in case (E. Left) where an extensive haemorrhage into the Vitreous as well as into the retina was produced, retinal detachment followed.

It is not possible, however, to convince one's self, either from carefully reviewing the writings of those who supported the theory of Vitreous contraction; or by the comparison of various experiments, that this explanation can be accepted. The theory as originally advanced by Leber, cannot be reconciled with the acknowledged composition of the post-retinal fluid, nor with the fact that rupture does not appear in a large number of cases.

The work by Erik Nordenson cannot be accepted as a demonstration of the theory. The eyes examined by Nordenson were from oldstanding cases of detachment. The pathological changes which were found to have taken place in these eyes were of long standing, and were probably secondary to the original or primary morbid condition.

Lastly, it seems difficult to believe, that
with safety we can accept an explanation of the pathogenesis, which is largely founded upon the investigation of oldstanding cases.

In this view of the theory advanced by Leber and Nordenson, we have, it would appear, the increasing support of the more recent observers.

H. Schmidt Rimpler (12) refers to the points above mentioned in connection with the composition of the subretinal fluid, and the frequent absence of rupture, as proofs against Leber's theory. Although in certain cases, probably in very few, Vitreous fibrillation and retraction may be the true explanation of some cases of idiopathic detachment of the retina, I am of opinion that this theory can only be regarded as of rare occurrence.

The explanation of the pathogenesis, which to my mind is the only adequate one, is that to be found in a combination of choroidal transudation and Vitreous diffusion.

This view must now receive our careful attention, by which I hope to show sound reasons for adopting it.

The chief points in the process of the diffusion of fluids, have already been touched upon in the short account given of Rählmann's position and

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(12) D. Med. Wochenschrift, 1897 No. 44.
arguments, in support of his theory of diffusion.

It will however be necessary here to enter farther into the question of diffusion.

The work of Ernest H. Starling (13) is of especial interest to us in this connection. In his paper entitled, "The physiological factors involved in the causation of dropsy", he points out how the transudation of the fluid contents of the capillaries, is regulated not only by fluid pressure but also by osmotic pressure.

He shows how a process of diffusion taking place between the fluid contents of the lymph spaces and that within the capillaries is a factor of the highest importance in preserving the continual physiological exchange between substances in solution. Thus the lymph spaces while they are supplied with lymph which contains a sufficiency of the substances required for nutrition, are not overloaded with fluid.

Injections of indigo carmin into the lymph spaces appear in the urine in five minutes, while in the lymph stream they do not appear for, from twenty minutes to two hours. We thus see that absorption by the blood-vessels is much more rapid

(13) Paper read before The Royal College of Surgeons of London, 1896.
than that by way of the lymphatics. The contents of the capillaries being richer in proteids, than that contained in the lymph spaces, exerts a higher osmotic pressure and thus promotes diffusion.

The permeability of the capillary walls to proteid materials differs in different parts of the body in health. Thus according to Starling the lymph of the limbs, the filtrate of the comparatively impermeable limb capillaries, only contains 2% to 3% of proteids; that of the intestinal capillaries 4% to 6%; while that from the permeable liver capillaries contains 6% to 8%. These facts illustrate that in health, there is considerable variety in the amount of proteid material found in the transuded lymph from blood-vessels in various parts of the body.

The experiments performed by Wooldridge (14), have shown that ligature of the femoral vein, with an injection of fibrinogen, causing artificial thrombosis, is followed by dropsy of the limb. Simple ligature of the femoral vein is not followed by dropsy of the limb as is well known.

Wooldridge attributes this circumstance to the disturbed relationship between the blood and the vascular wall.

(14) See Starling's paper.
Halliburton has shown that the fluid effused from the pleura in cases of inflammatory pleurisy, contains a much higher per centage of proteid material than does fluid effused as a result of pressure. The fact that various forms of inflammation are accompanied by an excessive transudation of fluid from the blood-vessels is sufficiently well known. How far the altered permeability of the vascular walls to proteids, may account for this phenomenon, it is impossible to state in the present state of our information.

The facts just referred to, as ascertained by Halliburton and Wooldridge, are in this connection highly suggestive, that the fluid transuded from vessels in certain conditions of inflammation, is not only excessive in amount, but is richer in proteids than in health. In this way the altered osmotic relationship between the fluid in the lymph spaces and that in the blood-vessels, will tend to lessen the return of fluid into the blood-vessels by diffusion and so to the continued distension of the lymph spaces.

We may now turn to the consideration of the physical conditions of the fluids contained within the sclerotic tunic of the eyeball, so far as they are related to the retina.

The Vitreous Body lies in close relation to the
anterior surface of the retina; it is surrounded by the Hyaloidia, which forms a distinct limiting membrane.

In chemical composition the Vitreous substance consists almost entirely of water.

According to Berzelius, Frerichs and Lohmeyer, as quoted by Oliver and Norris, 98.40% to 98.64% of water is found in the Vitreous substance. The remaining small proportion of solids, is composed of Salts and extractives, with traces of proteids and nucleo-albumin.

Between the retina and the sclerotic we have the "Vein sheath" or choroid. "The retinal blood-vessels do not penetrate beyond the Ganglion Retinae. The stratum of visual cells being nourished by the fluids conveyed by the dense capillary network, within the choroid coat, constituting the chorio-capillaris which lies in close proximity to the outer pigment cells and the underlying percipient elements. The lymphatics of the retina are represented chiefly by the perivascular lymph channels which surround the veins and capillaries and freely communicate with the subpial lymph spaces of the optic nerve.

Injections of the subpial space not infrequently pass between the retina and the pigmented epithelium as well as between the Hyaloid membrane and the
limitans retina, which extensions of the injected fluid have been regarded by Schwalbe as indicating the presence of lymph spaces in these positions. (15). By thus glancing over the distribution of blood-vessels and lymph channels, connected with retinal nutrition, we are enabled to throw further light upon our considerations of the pathology.

Unfortunately it is not possible to find any statement or reliable information as to the percentage of proteids which normally exists in the contents of the lymph-spaces and lymph-channels of the retina.

According to the analysis of Dr Scherl, before referred to, the post-retinal fluid in retinal detachment is found to be highly albuminous.

In the second case analysed by Scherl, the albumen present, amounted to 8.9969 per cent. If we now compare this with the percentage of proteid found in the lymph of other parts of the body, as stated by Starling, we find the proportion of proteid to be about three times that found in the lymph of the healthy limbs, and even greater than that normally transuded from the liver capillaries which are regarded as the most permeable to those proteid substances.

We are therefore justified in regarding the

(15) Oliver and Norris.
percentage of proteid as found by Scherl's analyses in this instance, as probably much greater than that which exists normally in the fluid transuded from the vessels nourishing the retina.

That the postretinal fluid in detachment is derived partly from the blood-vessels is evident from its albuminous nature.

That a collection of albuminous fluid behind the retina, tends to set up a morbid process of diffusion, which results in the increase of detachment, partly by diffusion of fluid from the Vitreous, is shown by (experimental case, s. p. ) which has been referred to already, and is further detailed later on. The question which now presents itself is, what pathological conditions could account for the beginning of such a collection of fluid as is found in the deeper part of the retina in cases of detachment. The statements already made from Halliburton and from Wooldridge are sufficient at once to direct our attention to some inflammatory condition affecting blood-vessels, as the probable cause for such serous effusion as are unusually rich in proteids.

Nordenson has stated in his work that in the cases of idiopathic detachment of the retina observed by him, choroidal disease was almost invariably present.
The remarkable frequency with which the myopic state of refraction is associated on the one hand with disease of the choroid, and on the other hand with idiopathic detachment of the retina is worthy of note in this connection.

Stedmann Bull (16) states that out of 30 cases of spontaneous retinal detachment observed by him, Myopia existed in 22 and in 22 atrophic changes of the choroid were found.

Galezowski (17) found in 1158 cases of retinal detachment observed by him, that Myopia existed in 918.

Horner (18) out of 1378 Myopes, observed 11% to have inflammatory conditions of the choroid.

S.D. Risley (19) observed choroidal atrophies and inflammations in 60% of eyes with myopic-astigmatism, and 87% with various forms of choroidal disease.

Eresmann (20) in his studies in the schools of St Petersburg, observed that out of 1245 myopic pupils only 5% were free from pathological conditions of the choroid.

(16) Transactions American Ophthalmal Society 13th meeting.
(17) Receuil d'Ophth. page 385.
(18) Oliver and Norris.
(19) Oliver and Norris.
(20) Oliver and Norris.
The above statistical notes afford examples of the experience of some well known observers in this connection.

The earlier stages of a patch of choroidal inflammation which might escape ophthalmoscopic detection, because structural changes had not yet come on, would nevertheless be liable to those changes in function, which we have seen take place under similar conditions in other parts of the body. In this way an excessive transudation of highly albuminous serum might be deposited in the tissues around the affected blood-vessels.

As we have already noted the deeper part of the retina - that is - the "pigment layer and the layer of Visual Cells" is supplied with nourishment by the normal transudation of lymph from the choroidal vessels.

The pathological transudation which we have supposed as starting from the choroidal vessels, would in the first instance find its way in the normal course to those layers of the retina which are in health nourished from this source. The loose structure of the retinal tissue at this level would further favour accumulation of fluid. The higher osmotic pressure exercised by a collection of such fluid would, in addition to the continued choroidal transudation, tend to augment its volume.
by diffusion with the more watery fluids around.

Thus through the retina the subhyaloid fluid would be attracted and then the saline fluid of the Vitreous Body.

In this way we can explain the origin of detachment. In this way we can explain the origin and composition of the post-retinal fluid, and the mode of its increase; and also the reasons why the plane of cleavage is through the layer of pigment cells close to the rodes and cones.

We have now to consider how it is that we can have an accumulation of albuminous fluid behind the retina without an increase of ocular tension. That fluid passes away from the Vitreous is proved by the fact that the forward movement of the retina is not accompanied by a rise of ocular tension, but rather the reverse.

The removal of fluid from the Vitreous by way of the angle of filtration and aqueous chambers is quite inadequate.

Removal of fluid from the Vitreous through diffusion, by way of the post-retinal space into the blood-vessels, is the only explanation which can suffice.

The factors which supply fluid to the post-retinal space are two.

1st. The choroidal transudation.
2nd. The diffusion of fluid from the Vitreous.

The removal of fluid from the post-retinal space, is carried on chiefly by the choroidal blood-vessels, and partly by the lymphatics.

The absorption by the choroidal vessels is carried on by diffusion; which acts by abstracting the more saline and diffusible fluids from the sub-retinal space into the vessels in the manner before discussed.

The recovery of those choroidal blood-vessels which give rise to morbid transudation, and the consequent cessation of such transudation, would soon favour the complete absorption of the post-retinal fluid by the choroidal blood-vessels.

In this way the more gradual cases of spontaneous cure can be explained.
Some recorded cases and farther points in Etiology.

In connection with the Etiology of retinal detachment some interesting theories and cases have been recorded.

Galezowski (21) does not consider the retinal rupture or liquefaction of the Vitreous to be factors of much frequency in the production of detachment.

He regards the most usual cause to be a lymph infiltration which is produced between the choroid and the retina. This infiltrating fluid is at first transparent and later becomes citron yellow. Galezowski compares the choroidal epithelium in this connection with that of the synovias which secrete a normal synovial fluid in health; but which may become morbid and secrete an excessive quantity of morbid fluid.

He considers that these morbid secretions set up an inflammatory condition in the subretinal tissues and so detachment from collecting fluid.

The cause of such deprived secretion may be local as traumatism, or general, as rheumatism, gout, arthritis, syphilis.

Pignatari (22) observed in a case of retinal detachment a number of centres of exudation, which spread from the papilla in a horizontal line to the Ora Serrata. He regards detachment as always due to serous inflammation of the choroid.

Dahrenstatt (23) observed a somewhat rare case of detachment which came on in a boy after a fall on the face. The detachment was of an annular and circumvallate form and situated round the optic nerve.

Many cases have been recorded from direct injury to the eyeball.

Schmidt records (24) a case from a gunshot wound of the temple with extensive haemorrhage into the Aqueous and Vitreous chambers.

Drausart (25) records a case of detachment following upon a knock upon the rim of a pitcher. Sublunation of the lens and detachment were caused.

Ohlemann (26) gives notes of a case of detachment which came on suddenly in a man sixty years of age, while he was carrying some bags of wheat weighing 60 to 65 Kilos each. The man claimed insurance

(22) Recueil d'ophth. page 656.
(23) Centralblatt für praktische Augenheil. March 1892, page 70.
(24) Jaresbericht 1893, page 482.
(25) Jaresbericht 1893, page 531.
(26) Klin monalshl, March 1895. pages 85 – 89.
which he had made against accident. The claim was sustained by an Arbitrator and thus the diagnoses confirmed.

Teillais (27) gives a case of double detachment in a child of two years of age. The Vitreous of both eyes showed signs as if the result of an old haemorrhage. The child had recently had a severe attack of whooping-cough, and had during the illness suffered from haemorrhages under the conjunctiva and skin, from the nose and ear.

The cause was put down to haemorrhage of the retina and vitreous, from the strain of prolonged fits of coughing.

The case noted under spontaneous cure as described by Armaignoc is interesting as an example of the good results which sometimes follow traumatic detachment when associated with haemorrhage. It has been observed by Mr George Berry, that in those cases of traumatic detachment, in which haemorrhage occurs from the accident, in the vicinity of the detached retina: the prognosis is more favourable than in other forms. That haemorrhage into the subretinal tissue causes a temporary separation of the retina from the choroid cannot be denied, but that a progressive detachment is thereby produced there is no proof. The facts of

(27) Reports French Society of Ophthalm: May 1895.
clinical experience point in the other direction, as Nordenson has observed. In the production of artificial detachment in animals, I observed sub-retinal haemorrhage to be of frequent occurrence, but never observed that detachment developed over the haemorrhagic area.

In some of the cases just noted, we observe that detachment of the retina has followed upon injury, without haemorrhage having been observed.

The theory which I have supported meets these cases, for it is the partial injury to blood vessels short of haemorrhage which gives rise to morbid transudation of serous fluid. Haemorrhage relieves the hyperaemia of such injured vessels, and tends in that way to favour their earlier recovery, so lessening the period during which pathological transudation of serum goes on.

Again, haemorrhage is of comparatively short duration, because coagulation soon brings about the natural arrest of haemorrhage. Coagulation has also a favourable effect in preventing detachment, because the fibrine threads tend to draw together, and so prevent farther separation of the tissues with which they are entangled. It is the continued transudation of noncoagulating albuminous fluid, which tends to the production of progressive detachment of the retina; not the rapid and brief flow of coagulating blood.
Sphylis has been stated as a cause of retinal detachment.

Galezowski (28) reports that he believes a syphilitic form of retinal detachment to exist, which he states can be cured by daily enunction with mercurial ointment.

Hirschberg (29) relates a case sent to him by Lasser. The patient had a strongly marked syphilitic eruption on the face. A delicate central detachment was made out, which rapidly yielded to appropriate syphilitic treatment. Information as to the way in which syphilis operates in this connection has not come under my notice. The cases are, it would appear, rare, and if diagnosed by other evidences of specific disease, are easily treated.

Bright's disease is given as a cause of retinal detachment by some writers. Mr J. Collens (30) produced a case at the Society's meeting, and gave some notes on it.

In Mr Berry's textbook on diseases of the eye an interesting note occurs on this subject.

He says, "In some rare cases the detachment occurs where there is inflammation of the retina itself, as in albuminuric retinitis." He continues that though such cases are described as detachment of the retina, "Probably the appearances in most, if not in all, are due to excessive infiltration of the retina itself, so that its inner surface comes to occupy a position which causes it to appear detached."

The results of some experiments performed by me on the eyes of dead sheep, show some interesting results in this connection.

The experiments were performed with a view to estimating the effect produced, by the introduction of various fluid substances behind the retina. The quantity of fluid introduced was in each case ten minims.

The method of injection which was employed is described in detail (as method ii) under artificial

detachment of the retina, later on. (see p. )

The eyes were operated on within an hour after their removal from the animals' heads. The superficial tissues, including the ocular muscles were removed, the sclera being laid bare all round, except where the optic nerve, and muscle tendons join it. The eye-balls thus dissected, were dipped in 1 in 1,000 corrosive sublimate solution, operated on, and placed in a moist, sealed chamber for three days, at the end of which time, they were removed, frozen and cut with a razor.

**No. I.** behind the retina of which sterile normal salt solution had been injected, showed some slight detachment which was just discernible to the naked eye.

**No. II.** which had received an injection of a sterile twenty percent solution of glucose, showed on examination the same appearances to the naked eye, as in the first case.

**No. III.** into which an injection was made of sterile blood plasma, which was not treated to bring about coagulation. The sterility of this plasma was proved by cultures made from it.

On examination the amount of detachment of the retina was to the naked eye the same as in Cases I, and II.
The retina, though not much detached, was very much thickened at and around the part where the injected fluid had been lodged. The amount of thickening was remarkable, and can best be indicated by referring to the drawing. (on the next page.)

Unfortunately no register of the ophthalmoscopic appearances could be made in this case.

It is obvious, however, from the drawing, (which is a true and approximately accurate representation, of the appearances as seen upon the cut surface of the frozen eye-ball), that the anterior surface of the retina in this case would have presented the appearances of detachment to ophthalmoscopic examination. The amount of detachment is so insignificant as compared with the remarkable thickening of the retina, that the ophthalmoscopic appearances would have been in a case such as this quite deceptive.

This experimental evidence supports the view above referred to, that in certain cases, the ophthalmoscopic appearances of true retinal detachment, may be simulated by excessive infiltration of the retinal substance.

No. IV. in which the same fluid was injected as in No.III, presented the same remarkable thickening of the retina as in No.III, and is of value as a confirmatory evidence.
SPONTANEOUS CURE

The question of spontaneous cure from its relation to the pathology may now be shortly touched upon.

Wood, of Chicago, (31) has stated the frequency of spontaneous cure at about 10% of all cases of retinal detachment. This phenomenon sometimes occurs suddenly.

"Alajmo-Marchetti (32) gives the facts of a case, in which detachment had spread at the end of four days over ¾ of the fundus, and had reduced vision to the mere perception of light. No treatment was in this case employed. At the end of three months vision was suddenly restored, apparently by a sudden movement of the head. Vision gradually improved till at the end of three months more it was stated to be of its former strength—which is not recorded. At the end of eight months a greyish scar was observable on the fundus, which was regarded as the remains of a retinal rupture."

Cases of sudden spontaneous cure only occur when rupture of the retina is present; and are

(31) Paper read before Section of Ophthalmology at the "American Medical Association Atlanta 1896."
explained, by an accidental cause, like movement, in the fluid contents of the vitreous cavity, and post-retinal space, which in such cases freely communicate.

Other cases of spontaneous cure are reported by many observers. Kamocki, (33); Fraenche1, (34); Gourfinkel, (35); Nalauzon, (36); Armaignoe, (37); may be referred to, for interesting examples of the more gradual forms of spontaneous cure.

The case recorded by the last mentioned writer, may be noted here as an interesting example of spontaneous cure in traumatic detachment with haemorrhage.

"The patient aged 9 years received a scleral wound from the wooden arrow of a playfellow.

A large haemorrhage into the anterior chamber and vitreous was produced. The wound which for two days discharged vitreous, healed rapidly. The haemorrhage cleared up, and vision was restored except for a large scotoma which corresponded to a detachment at the level of the wound.

(33) Jahresbericht 1892 p. 386.
(35) Westnik Ophthalmologii Nov. and Dec. 1894.
(36) Congress of Russian Doctors - from the French
At the end of three weeks the scotoma still persisted $V = \frac{1}{5}$.

At the end of six weeks, that is three weeks after the last observation - no trace of detachment seen $V = \frac{5}{5}$.

The cure had lasted eight months at the time report was made.

Spontaneous cure occurs most frequently in traumatic cases, and for two reasons. Firstly because in these cases the eye is usually healthy to begin with, and secondly because these cases are more frequently associated with haemorrhage than the idiopathic forms are.

As we have before noted haemorrhage has been observed to have a salutary influence.
The prognosis in retinal detachment is, as we have seen, always bad; the traumatic cases, for reasons already stated, being the most hopeful.

Boucheron of Paris (38) directs attention to the seriousness of macular detachment. He states that if the macula lutea is detached, restoration of central vision becomes impossible. He regards the recovery of vision, which is sometimes stated to take place after macular detachment, as only partial and never a recovery of true central vision.

Baduel (39) strongly emphasises the necessity for distinguishing between the idiopathic forms and those secondary to other conditions, and regards the latter class as much the more hopeful as a rule.

Galezowski (40) remarks that a rupture at the superior part of the fundus, which permits the passage of the subretinal fluid into the Vitreous, is a favourable prognostic. He still further believes in the prognostic value of exudation stains, as he

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(39) Jahresbericht, 1892, p.387.

believes the stains to be formed by plastic material which leads to the final adhesion of the retina and choroid.

Masselon (41) regards the exudation stains mentioned by Galezowski as marking the termination of the healing process and consequently not of prognostic value.

Adamuck (42) considers a favourable result as by no means rare in recent cases.

Lagetschnikow (43) attacks this remark, and states as the result of his experience that cure of detachment is of very rare occurrence.

The tendency which a comparatively small detachment has to pass downwards or to "sink" has led to the view that macular detachment is more likely to follow when the original site of detachment is above the macula. The prognoses would therefore be more favourable in cases in which detachment had appeared at a point lower than the macula.

Cases of long standing and of a high degree of myopia are of the worst prognoses. The best that can be hoped is that re-attachment may, if effected in time, prevent extension over a wider area or to the macular region.

(42) Jaresbericht, 1892, p.388.
(43) Jaresbericht, 1892, p.388.
TREATMENT.

The treatment of detachment of the retina has of late years, engaged much attention, and a variety of active measures have been tried, and with what measure of success we shall better determine as we proceed.

The older method of treatment, which by some is still considered as effectual as any, consisted in prolonged rest in bed; the patient for some weeks lying on the back. It was customary to accompany this with injections of pilocarpine, or with other therapeutic measures which were regarded as promoters of absorption.

Drainage.

As we have already seen the evacuation of the post-retinal fluid, was the earliest form of treatment of which we have any distinct record as proving successful in this connection. This treatment has been practised by many and has been the subject of a variety of modifications.

Wolff, of Glasgow, has employed a long incision (six to ten mm.) carried through the sclera. The conjunctiva being held back by hooks, so that constant and free drainage was kept up. This
treatment met with some measure of success, but on account of the dangers of sepsis, which attend the employment of so large a wound, and some unfortunate results, this treatment has not gained ground.

Galezowski (44) reports, that he performed posterior dissection of the eye in severe cases. He operated with a scythe-shaped knife, with needle-shaped point, and made a puncture and counter-puncture at the site of detachment.

Out of seven cases, he had five unsuccessful, inflammation having followed. In two, the results were considered as strikingly successful. The details have been given.

Parinaud (45) regards posterior sclerotomy as the safer method, and considers the results as equal to those recorded as following upon electrolysis or other methods.

De Wecker (46) regards the principle of electrolysis as nothing more than drainage, and regards its advantages as due to the fact, that the wound remains open longer.

Alajmo (47) records the results of

(44) Receuil d'Ophth. page 385.
(47) Jaresbericht, 1893.
Angelucci's experiences, which would appear strongly to favour the principle of drainage. The method which he prefers is that of scleral incision, with subsequent cauterization of the edges of the wound with the electro-cautery.

Bucheron (48) would appear to have held this view, for he records favourably on the use of the electro-cautery as a means of keeping the edges of the scleral wound from healing, and of preserving continued drainage.

Further individual instances of success might be given as resulting from the practice of this method. But, as before stated, it is recognised that the results shown by this method of treatment, though comparatively good, are far from finally satisfactory.

Scleral punctures.

Pagenstecher according to Scheffeld (49) has obtained a good effect by producing adhesive choroiditis as a result of scleral punctures.

Sutphen (50) gives two cases, one of complete cure, and one of partial cure, as a result of this method.

(48) Jahresbericht, 1893, p.349.

(49) Jahresbericht, 1894, p.415.

E. Praun (51) also notes a successful case which seems well authenticated.

**Iodine Injection.**

This method of treatment brought into notice and strongly supported by Schoeler, has excited much notice during the past nine years.

It has been made the subject of experiment on animals, and has also been applied clinically by some of the more enterprising ophthalmic surgeons.

An experimental research was carried on by Wolff (52) with a view to throwing farther light upon the method of injecting Iodine as supported by Schoeler. The animals used were dogs.

Iodine was injected into twelve eyes. Observations were made clinically, and afterwards an anatomical examination was carried on.

The points of chief interest may briefly be stated as follows.

1st. With two exceptions, there occurred in all cases, detachment of the retina to a greater or less extent, as a consequence of the Iodine injection.

2nd. In the two exceptional cases there was

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(51) French Ophthalm. Society December, 1893.

(52) Von Grafe's Archives für Ophthalm. XLII p.63, seen in Jaresbericht 1894, pp. 366, 367.
not sufficient time given and very little Iodine had penetrated the Vitreous.

3rd. Among the ten cases in which detachment occurred, in four detachment was complete; in four the retina was evidently pushed forward by choroidal exudation; in one case of the last four by haemorrhage. Detachment in the remaining two cases of the ten, was apparently caused by shrinkage of the Vitreous.

In five cases the Vitreous body had become entirely liquid.

In two cases considerable rupture of the retina was observed.

Inflammation occurred once in the form of Irido-choroiditis, and twice as Irido-cyclitis.

The term of observation varied from two to seventy-two days. The general absence of inflammatory reaction was considered remarkable. Wolff thinks the Vitreous body quite unable to stand the action of Iodine, under any circumstances.

The experiments of Henry M. Chasseaud, (53) performed on Rabbits, also show that Iodine is an unsuitable agent for intra-ocular use.

Schoeler (54) emphasises the point that the

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(53) The reports of the Laboratory of the College of Physicians of Edinburgh.

(54) Jahresbericht, 1894.
injection should be made into the subhyaloid space.

He gives also further reports on the five cases treated by his method, and communicated in 1889. (55)

1st. Case observed for four years, result remains good.

2nd. Operated on two years ago for cataract. Vision was better than after injection.

3rd. A cataract was developed but the fundus can still be seen with the ophthalmoscope, and a progressive retinal atrophy can be observed.

4th. A cataract has developed.

5th. The patient has not appeared for four years, but even then a cataract existed.

This report certainly appears very unfavourable, though the facts of the individual cases might modify the view if known in detail.

Wood, of Chicago, (56) says although much was expected of Schoeler's Iodine treatment, and though cures have followed its use, the evidence is, on the whole, against it. He admits that many eyes have been lost through the employment of this method of treatment.

(55) This report from French.

(56) Paper read before the section of Ophthalmology at the 47th annual meeting of the American Medical Association, Atlanta May, 1896.
He does not consider its use justifiable even in a modified form. It seems evident that the employment of Iodine as recommended by Schoeler cannot be regarded as a sufficiently safe therapeutic agent.

Its reaction would appear to be uncertain and often dangerous.

Abadie (57) has abandoned the injection of Iodine and now employs electrolysis.

Galezowski, (58) it would appear, in 1872 injected Iodine between the retina and the choroid; but failed to promote adhesion between them.

(58) Archives d'Ophthalmologie, 1872.
THE GALVANO-CAUTERY.

This method of treatment has been practised with a measure of success by some.

Dor, of Lyons (59) stated that he obtained remarkable results by combining this method with the application of leeches. Dor made repeated applications with the cautery points upon the sclera at the level of the detachment.

Motaïs (60) states that in 11 cases of recent detachment, he obtained three improvements and two cures by the use of the galvano-cautery point.

He regards this as equal to the good effect of any other form of treatment.

ELECTROLYSIS.

The use of electrolysis has received considerable notice in recent years.

Gillet de Grandmont has been credited with the first application of electrolysis to the post-retinal fluid.

(60) Reports French Society of Ophthal. May, 1895.
It is difficult satisfactorily to review a subject such as this from the records of individual cases which one meets with.

The just estimate of how far any one method of treatment can be credited with the good results which may follow upon its use, is a matter which always involves the most careful scrutiny.

The records we often find, give no account of the state of vision before treatment, or if they do, it is in general and vague terms. If the acuteness of vision were given in figures, and the field of vision by a drawing, both before treatment; and then at suitable periods after treatment, valuable and interesting information could be collected from the study of individual cases.

In a paper by Terson of Toulouse (61) we find an interesting account of the application of electricity in this connection. From this paper, and from other notes, we may here give a short account of this subject.

Various methods of applying Electricity have been used. Some, following the principle formerly applied to the treatment of Hydrocele, have employed bi-polar Electrolysis - (Schoeler) -

Others, as in the cure of Aneurisms and Naevi

(61) Anals. d'Oculistigue, July, 1895.
penetrate the eye with a single needle bound to the positive pole, as in the positive Electrolysis of Abadi and Gillet de Grandmont.

Finally, others have used the needle bound to the negative pole, as in the negative Electrolysis of Van Moll.

Terson, thinks the positive pole is the proper one to use, as by its use we obtain the most rapid occlusion of the wound and thereby prevent the escape of the Vitreous which might take place to an unfavourable extent.

This view is strongly opposed to the opinion expressed by De Wecker, who regards the benefits of Electrolysis as due to the drainage thereby established.

The Electrodes employed must be unassailable by the products of Electrolysis, and sufficiently rigid to penetrate the sclera. Iridium platinum best serves this purpose, and is also capable of being sterilized by heat.

It is very important to measure the strength of current during the period of application. A sensitive galvanometer, which must be free from oscillating movement, should be employed.

Terson of Toulouse states that he has been able to give a constant current of five and a half milliamperes during the whole time of application.
which did not exceed one minute. As Terson would appear to be an authority on the use of Electrolysis we may here give some of his results, as given in the Reports of the French Ophthalmological Society, Paris, May, 1895.

Terson states that from July 1894 to May 1895 he treated 100,000 patients of which 17 were cases of retinal detachment: of these 12 were observed long enough to be recorded, and were all of serious nature.

In 1 case of three years standing, aggravation was observed to follow the treatment.

In 2 cases, no beneficial results.

In 3 passing improvement.

In 5 Improvement persisted in an encouraging manner.

In 1 case, immediate cure followed and had lasted for nine months at the time of Report.

The strikingly good result observed in the last case, was attributed entirely to the treatment by Terson.

By a glance at the above results we can see that electrolysis as applied by Terson does not offer much ground of expectation.
Schoeler (62) here gives a case of cure by the use of the constant current. The case, one of shallow detachment at one side of the fundus, in a young man and had lasted for eight days when the treatment was used.

On the fourth day, when the dressings were first removed, the retina was attached all round and the field of vision normal.

Abadie (63) obtained results much the same as those recorded by Terson. He states that in outstanding detachments, results are nil, and he abandons this class of case.

The more recent cases and those in which the degree of Myopia is not high, are by him regarded as decidedly hopeful for this form of treatment.

Gillet de Grandmont (64) gives details of a case, in which, after a second application of Electrolysis the retina became re-attached and vision was improved from the mere perception of light, to the counting of fingers at 1 mètre.

Three months later the detachment had not reappeared, and the author takes cure for granted.

(64) Archives d'Ophth: June 1894.
This conclusion is somewhat hasty as detachment sometimes re-appears at a later period than this. Semi (65) gives some account of his experiences of this treatment, but states that he cannot flatter himself upon the results he has obtained.

Montgomery and Bettmann of Chicago (66) employed positive electricity (after Terson) in four cases without any good result. All the cases were extensive detachment; one was recent.

The patients complained of pain at the time of operation. In one case inflammatory glaucoma followed.

Simon Snell (66a) employed Terson's method, using five milliamperes for one minute.

He found that five milliamperes gave considerable pain while two to three did not give pain.

He thinks that, kept well within Terson's limits, it is quite harmless, but cannot say that the results in his hands have proved better than other methods. He, on the whole supports drainage.

Dr Pechin (67) in discussing the use of electrolysis, gives as his opinion that this form of treatment has received more attention and credit

(65) Bulletins d'Oculistica an XVIII., No.3.
(66) See Wood's paper before quoted.
(66a)
than the results warrant.

He quotes some interesting cases in this connection, which tend to support the view that electrolysis has not been proved superior to other methods.

Though this treatment has been widely tried, its use has not resulted in any advance of the therapeutics of this subject.

Deutschmann's Treatment.

Deutschmann (68) introduces two entirely new and striking methods of operative treatment.

He bases his treatment on the theory of fibrillation and contraction of the Vitreous.

The first operative procedure, which he terms 'debridement' is carried out in conjunction with drainage. The procedure is shortly as follows:

An aperture for the evacuation of the post-retinal fluid having been established, a narrow two-edged, straight knife is introduced into the Vitreous, and its fibrillated strands are cut across. In this way the retina is set free from its acquired Vitreous attachments, and thus is permitted to become approximated to the choroid as the fluid behind it is removed.

In connection with this operation of debridement, incisions are made in the retina and choroid with the point of the knife, with a view to obtaining the beneficial adhesive effects of haemorrhage.

The second operative procedure which he has termed "transplantation" consists in the injection into the Vitreous of the diseased eye, of a preparation made by macerating the Vitreous of a young rabbit with sterilized normal salt solution.

The transplantation method is practised in connection with debridement and drainage; or alone, in cases where the others have proved insufficient.

Deutschmann details eleven cases shewing striking results after the debridement and drainage procedure; and six after the combined transplantation operation. He proceeds to explain how the salutary effects of this treatment come about; and gives reassuring statements as to the safety of his method.

There is no doubt this plan is radical and bold and of a highly interesting nature. I have not yet, however, been able to discover any confirmatory evidence of the benefits derived from this plan of treatment.
SUTURING.

Galezowski (69), in 1880 used Catgut Suture, and obtained some good results; but on account of subsequent failures, abandoned this method.

Weckler's gold suture also proved ineffectual.

MASSAGE.

Granedigo (70) reports six cases of good result. Hirschberg (71) also details similar successful results.

In the practice of this method, Granedigo applies massage to the eyeball, by means of his thumbs, three times a day for four minutes.

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(69) French Society of Ophthalm: May, 1889.
(70) Jahresbericht, 1894, p. 44.
(71) International Medical Congress at Rome, 1894.
IRIDECTOMY.

This operation has been recommended by some. Boucheron (72) refers to this operation, as one suitable to the relief of detachment.

SUBCONJUNCTIVAL INJECTION OF SALT SOLUTION.

Dianoux (73) states that the injection of a saturated solution of Sodium Chloride under the Conjunctiva, to the level of the detachment has given him good results.

In reviewing the foregoing notes of the various methods of treatment, one is impressed by the fact that all alike seem inefficient. The evidence of good results from any of the methods, even if regarded as quite reliable, is very small.

The fact that spontaneous cure is stated as occurring in about ten per cent of cases, is an additional reason for throwing doubt upon the meagre benefits attributed to treatment.

In the Central Blatt für die Medicinischen Wissenschaften, März 12th 1898, I observed an interesting note by H. Schmidt Pimpler, with which I

(72) Archives d'ophthal: XIII, page 80.
(73) Ophthalmic Society Paris 1895.
thoroughly concur. He is opposed to the theory of Leber and Nordenson, and to those therapeutic measures, which, founded upon that theory, are directed to the Vitreous body as the subject of treatment.

The irritating nature of Iodine is such, that its use as an intra-ocular injection, cannot be employed without great risk. Of the benefits of this procedure (as given by Deutschmann) the evidence is as yet insufficient.

"Debridement" could only be beneficially applied in those cases where Vitreous contraction has been ascertained.

The application of 'transplantation' has only been employed in aggravated cases, and would not be justifiable in the treatment of early, partial detachment.

That no form of treatment in present use is adequate, can hardly demand further emphasis here.

The cases which are the most hopeful for treatment, are recent cases in which the detachment has not extended into the Macula lutea. If at this stage some prompt measures could be employed to bring about the replacement of the retina, and its adhesion to the choroid, we might hope to obviate further separation, and so to preserve central vision; as also to prevent the more disastrous
consequences of total detachment.

The lines of treatment which appear to me as most likely to yield the desired results, should be directed to the area of detachment, and applied through the sclera to the subretinal space. The removal of the post-retinal fluid, and its replacement with a substance which would promote plastic adhesion between the retina and choroid, would best serve these indications.

The observation made by Mr George Berry, that haemorrhage would appear favourably to modify the prognoses, when associated with the occurrence of detachment; and which is supported by some facts in our text, led him to suggest to me, the use of fibrinogen as a therapeutic agent.

The practical application of this suggestion could only be carried out through the channel of experimental research.
EXPERIMENTAL.

The experimental work in connection with this research, divides itself into four parts, and can best be described in this form.

First. Experiments relative to Pathology.
Second. Artificial detachment in animals.
Third. Blood plasma as the vehicle of fibrinogen.
Fourth. Means devised for its application to the eye.

To begin with a few preliminary remarks which are applicable to the operative part as a whole, may here be introduced.

The animals employed were rabbits. At the time of operation each animal was thoroughly anaesthetized and placed conveniently in the prone position. The operations were carried on under ophthalmoscopic control, and were therefore performed in a dark room, by the properly directed light of a suitable lamp.

The direct method was used in following the procedure with the ophthalmoscope, so that one hand remained free to direct the needle, or other instrument, when applied to the animal's eye. A sufficient dilatation of the pupil was always obtained before the Anaesthetic was given.
The Anti-septics used were Lysol for instruments in addition to the wet method of sterilization for Syringes. Corrosive sublimate solution - 1 in 5000 - to wash the conjunctival sac before operation, and boracic acid solution for douching during operation.

The assistance of a trained laboratory boy was always obtained. The subsequent ophthalmoscopic examinations were made chiefly by the direct method, dilatation of the pupil being artificially produced when necessary. For these observations no general anaesthetic was used, the animal being placed in an oblong box with a sloping board arranged for it to sit upon.

The sloping board was so arranged that the animal's head could be fixed to the upper projecting end of it, if required.

The Instruments used were, in part, those in ordinary use in an eye surgery; as scissors, fixation forceps, Graefe's knife, etc. The others were specially devised by me for use in this research, of them photographs are furnished. The instruments have also been forwarded for inspection.

THE NORMAL FUNDUS OF THE RABBIT.

The ophthalmoscopic appearances of the fundus of the rabbit vary in colour according to that of the animal. In the black rabbit it is chocolate. In
In the Albino it is of a bright red hue, the choroidal vessels being visible all over the fundus, except where the band of opaque nerve fibres obscure it. In the grey rabbit, the fundus is somewhat darker than that of the albino, the choroidal vessels being only partially seen through the retina.

Taking this latter as the normal type (Drawing A, Page 74) shows the appearances as seen directly by ophthalmoscopic examination. The drawing is from the left eye of a grey rabbit, the image not being inverted.

The optic nerve pierces the sclera above the horizontal meridian and towards the temporal side of the eyeball. On entering the eyeball, its fibres are distributed in a remarkable manner. The fibres at first, retaining their myeline sheaths, spread out upon the fundus in the form of a white opaque band, extending across the fundus obliquely, the long axis forming an angle of 30° to the horizontal. The extremity directed to the nasal side of the fundus being the higher. From the margins of this band the fibres radiate in all directions, and losing their opaque character disappear from view.

The subhyaloid blood-vessels are seen coursing upon the band of opaque nerve fibres, and are lost to ophthalmoscopic view, after leaving them.

The first division, that of experiments relative to pathology, will here require some details as to the method used, and a few supplementary notes
Direct Ophthalmoscopic View of normal Fundus of Grey Rabbit.
to those already given in the pathology.

**Case C.** in which copper filings were introduced into the Vitreous of both eyes.

The filings were prepared from a piece of copper wire, which had been sterilized by heat.

The file used, and the receptacle for the filings were also rendered sterile.

The method of introducing the copper filings into the Vitreous, were as follows.

The needle of a hypodermic syringe of average size, was furnished with a clearing wire, which fitted exactly, both in thickness and length the bore of the needle. The clearing wire was looped at one end, which served to prevent it from being passed too far into the needle, and formed a convenient handle.

The clearing wire being introduced to within a sixteenth of an inch of the end of the bore, at the sharp end of the needle; the copper filings were introduced into that part of the needle bore which was unoccupied by the wire.

The filings were throughout carefully guarded from dust settling upon them. The animal having been prepared for the operation, the conjunctiva was reflected from the upper part of the eye-ball, and the sclera punctured with the point of a Graefe's knife. The needle was then introduced, very carefully, to
prevent the filings from falling out before reaching the Vitreous. When the point of the needle was seen with the ophthalmoscope, to be approximately at the centre of the Vitreous, the clearing wire was gently pushed home by the assistant. The filings were observed to protrude from the point of the needle in a rounded mass, which remained in position on removal of the needle.

The colour and metallic lustre of the copper could be clearly seen. A small amount of Vitreous fluid escaped when the needle was withdrawn.

The same procedure was carried out in both eyes, though in the right eye no particles of copper were seen to leave the needle point in the Vitreous on pushing home the clearing wire.

The filings had in the case of the right eye, fallen out from the point of the needle before its introduction. A few were afterwards observed by the white opacity which they produced in the Vitreous, close to the point where the retina had been punctured.

This operation was performed on January 6th 1898. The changes which appeared in the Vitreous at first around and between the filings, and which spread towards the fundus, have been sufficiently dwelt upon in the pathology. The important points observed were:
First, that the change which took place slowly, was of the nature of fibrosis, appearing at first opalescent and pearly, later of a dense white and finally becoming visibly vascular. It caused a shrinkage of the eye-ball to nearly one third of its normal size.

Second. No sign or symptom of any supplicative change was detected throughout.

About the end of the 5th week the dense white opacity of the Vitreous had spread so widely that little of the fundus could be seen; but detachment could be detected to have taken place. The animal was killed on February 24th and the eyes hardened for examination.

In Case D the same method of operation was carried out.

In the left eye copper filings were introduced, and the results were observed to correspond to those in (C Left); though on account of the filings being larger, the effects were more slowly produced.

In the right eye a piece of copper wire, of nearly \( \frac{1}{8} \) inch in length, was introduced into the Vitreous in the same manner as the filings, but by means of a larger size of needle.

The effect of this, though similar to that produced by the filings was very much less. The white opacity gradually forming close to the surface of
the wire and extending downward and horizontally from its point.

The remarkable appearance, and slow increase of a small collection of gas, in the form of a bubble, at the lower extremity of the wire which lay about the centre of the Vitreous, was observed. In this case also, no symptom or appearance of purulent inflammation was seen.

The animal was killed on February 17th.
Two photographs under (D, Left, p.129) show some interesting microscopic appearances of the pathological changes which have been indicated in the text. In the high power photograph it is especially interesting to observe how the altered inflammatory tissue of the vitreous has become incorporated with the anterior surface of the degenerated detached retina. We can see how by the formation of such connections, the inflammatory tissue in the vitreous, by its contraction, would bring about detachment. These cases serve to show that progressive inflammatory changes in the vitreous may be a cause of detachment.

Professor Leber of Heidelberg (73) in speaking of the action of copper in the vitreous, says, "The perforating injuries of the eye by morsels of copper are of peculiar character. This metal is capable of causing purulent inflammation merely by its chemical action, so that without the aid of microbes, hypopyon, or purulent inflammation of the vitreous may occur."

As already noted no such effect was produced by copper in my experiments. The observations of Leber which led to this statement must have been made on the action of particles of copper which were not sterile.

(73) Transactions of the 8th International Ophthalmological Congress, Edinburgh, 1894.
The second division of our subject, that of the artificial detachment must now be described.

The objects served by this procedure are, first to establish a reliable method by which detachment can be produced in animals; and afterwards to record the course of events which follow the employment of various substances for this purpose.

Two methods by the injection of fluid behind the retina were employed, both suitable for producing detachment, with a view to the subsequent trial of therapeutic measures.

A third method referred to under (E. Left p. ///) is not of value from this point of view.

The necessity for having the movements of this eye-ball under complete control led to a special pair of forceps being devised for this purpose.

The blades of this forceps are detachable, so that they can be applied separately, and afterwards locked like a pair of midwifery forceps. By means of a spring and screw, the grasp of the blades can be regulated. The blades are applied laterally, with the handles underneath. (see photograph, p./32)

The fluid injected behind the retina was introduced by a specially modified Liston's Hypodermic Syringe. The modifications consist in the use of a large sized needle with a special curve upon it, made to suit the size of the animal's eye. The
eye of the needle appears near the end, and upon
the concave side. The piston is moved by elastic
pressure and the Liston's screw. (See Photograph,
p. 133).

Method I. The upper eyelid is reflected - the
superior rectus muscle cut, and the sclera cleared
at a point behind the equator. The eyeball is
then tilted forwards, and the incision made through
the sclera obliquely, into the vitreous, with the
point of a Graefe's knife.

The hypodermic syringe before being introduced
is adjusted as follows. The end of the needle
being placed in sterilized normal salt solution,
the piston is withdrawn to about \( \frac{1}{3} \), by advancing
the screw. The loops of the elastic attached to
the barrel are then pulled over the end of the
piston.

The syringe thus adjusted and carefully freed
from contained air, is introduced into the vitreous
through the puncture already made.

The point of the needle is now located by means
of the ophthalmoscope. A small quantity of vit-
reous fluid (from 3 to 8 minims) is then slowly as-
pirated by advancing the screw of the piston. The
needle is then tilted and pushed backwards until
the point is seen to impinge upon the retina,
through which it is now pushed.
The aperture at the end of the needle now lies behind the retina, the obliquity of its introduction enabling this to be effected. The aspirated vitreous fluid is now injected behind the retina by reversing the screw upon the piston rod, and thus permitting the steady elastic pressure to affect the injection.

Method II. This method differs from the one just described in several important points. The upper eyelid is not here reflected. The incision in the sclera is in front of the equator: the needle, when introduced, does not penetrate the retina, but remains between it and the sclera during the entire operation. An additional puncture is made directly through the sclera at another part, to permit a slight escape of vitreous when the injection is made. The fluid injected can thus be varied as desired.

This method has proved the more valuable of the two. A point requiring special emphasis must not be omitted. The incision which we have seen is made in front of the equator; at the upper part of the eye-ball, should be carried out in a direct line behind the tendon of the superior rectus. It should be made in a very oblique manner and of such size, that the needle is firmly grasped by its margins on introduction. If this precaution be
neglected, the injected fluid will return through the wound, alongside the needle, and the detachment will not be effected.

The two following cases will severally illustrate these methods.
Case E. right, illustrates Method I. In this instance a partial detachment was produced at the lower part of the fundus, by the injection of the animal's own Vitreous. The drawing (E. I. page 92) shews the appearances presented a few days after the operation. During the course of five weeks of observation, the detachment had almost entirely healed. (See drawing E. 2. page 93.)

The reapposition of the retina, which was permitted to proceed without interference for the sake of observation, was completed at the end of six weeks. The pigmentary changes of the fundus, which usually are seen after the recovery of detached retina, and are shown in other drawings, are, in this case, not obvious, owing to the dark appearance of the fundus in the case of a black rabbit.
View of detachment in Black Rabbit
Drawing E ii

Showing Scalings of Detachment
The chief facts of Case J. Left, as illustrative of method II, we shall now indicate.

On February 2nd, by this method, five minims of sterilized normal salt solution were injected behind the retina. On account of the fact that the solution of corrosive sublimate to wash the eye was too strong, the view of the fundus was obscured for a few days after the operation, by opacity of the cornea. The presence of detachment was, however, detected at once, as the alteration in the position of the retina could be observed with the ophthalmoscope while injection was being made.

On the eighth day after operation, drawing J. I. page 96, was made, by reference to which the extensive nature of the detachment can be appreciated.

The process of reattachment in this case was rather more rapid than in the last. Twelve days after the operation, drawing J. II page 97, was made which shows the advance of healing.

On March 1st the retina had become entirely re-attached. Drawing J. III page 98, shews the appearance at this stage. The characteristic pigmentary changes being well marked. Also a scar remained representing the site of rupture. The extremities of the subhyaloid vessels as seen upon the band of opaque nerve fibres, shewed a very unusual appearance.

Having established a method for the production
of detachment, by the injection of salt solution or Vitreous fluid behind the retina, it is of importance to know the subsequent course of events, in order to estimate, correctly, the value of any therapeutic measures which might be used.

The two cases given serve this purpose by demonstrating the course of spontaneous cure.

Before leaving the consideration of artificial detachment, reference must be made to two further cases, in which detachment was produced by the second method described. In both instances the animals were killed before recovering from the anaesthetic. The eyes were then frozen, and cut. Drawings were made from the first case, shewing the appearance of detachment as seen upon the cut surface of the frozen eye-ball. (See drawings O. page 99.)

In the second case a large and well marked detachment was found on cutting the left eye, which has been photographed. (See photograph P. page 100.)
Partial healing

Needle introduced here

Glands of retina

Subhyaloid vessels

Seen in part only

Cords of opaque band

of nerve fibers

Shows extensive detachment.
Drawing I

Shewing progress in reattachment
Showing altered appearance of fundus after reattachment has occurred
Drawings from Case 0

Showing appearance of detachment as seen on frozen section of rabbit eye.
Photograph from case P

Showing large artificial detachment of retina as seen on frozen section.
BLOOD PLASMA
THE VEHICLE OF FIBRINOGEN

In approaching this subject, one of the first things to be determined was a suitable method by which to obtain and preserve fibrinogen for use.

The difficulties entailed in the process of separating from the blood a proteid substance such as fibrinogen, in its pure form, are under ordinary circumstances very considerable. When, however, the carrying out of this process is complicated by the precautions necessary to the preservation of absolute sterility, the problem becomes more serious. In addition the insoluble nature of these pure proteid substances renders them difficult to manage.

From these considerations I decided to use blood plasma preserved in a fluid state as the vehicle for the practical application of the fibrinogen which it contains.

The blood plasma was obtained sterile, and preserved fluid in the following way.

A clean two-litre glass jar was obtained, in which was placed (50 cc.) of a solution composed of 2 per cent of oxalate of potash, and 4 per cent of normal salt solution. The jar was then carefully covered with two layers of parchment paper, which had been dipped in Lysol solution and was sterilized.
by moist heat and kept ready for use. When a convenient opportunity arose, two litres of blood drawn sterile from the jugular vein of a horse were obtained. By means of a canula, which can be made to conduct the blood directly from the horse's jugular to the jar, the risks of contamination can be reduced to a minimum.

After sufficient time has been allowed for the sinking of the blood cells, the plasma can be conducted into a sterilized flask from which it can be obtained from time to time as required for use.

As a means of additional convenience for after use, small quantities may also be taken up in glass tubes, made to contain 4 c.c.s. each. These tubes are prepared from a piece of soft glass tubing, of a suitable size, which is heated and drawn out so as to leave a chamber of the desired capacity in the centre. The extremities are drawn to a smaller size so that they can be sealed by heat, and thus sterility is ensured. (See photo page 135)
The next point to be determined was the most convenient way in which coagulation of the plasma could be brought about.

For this purpose calcium chloride was selected as the most suitable salt, with which to neutralize the potassium oxalate, which by its free presence in the plasma preserves fluidity, and prevents coagulation. By a series of experiments it was found that a 20% solution of calcium chloride was the most suitable strength to use.

It was also demonstrated by experiment that by employing the above solution the following relative quantities gave the best results.

In the ordinary room temperature (0.03 of 1 cc.) of the calcium chloride solution was added to (4 cc.) of the prepared plasma, and well mixed by gentle agitation. After the lapse of three to four minutes the mixture was removed to an incubator, in which the temperature was kept between 99° and 100° F.

The time was carefully taken from the mixing of the calcium chloride solution with the plasma, till the completion of coagulation. On several repetitions of the experiment, it was found that from 12 to 15 minutes elapsed before coagulation was completed under these conditions.

The coagulum produced in this way was of an
opaque yellow appearance, was firm and tough, and contracted with the effusion of serum in the ordinary way.

Throughout all the details of these experiments as in their practical application the strictest precautions against organismal contamination were observed.
The means for the introduction of the prepared substance into the eye, must now be considered.

In dealing with the eye in which there is already free fluid behind the detached retina, we have to consider the removal of such fluid, in addition to the introduction of our therapeutic agent.

In addition we have to remember that the injection of fluid into the post-retinal space, must be regulated in amount by the size of that space.

If we throw in too much, we produce an increase of detachment.

Again, if we allow the post-retinal fluid to escape, and then attempt to pass the point of an injecting apparatus, we have difficulty in assuring ourselves that the instrument has found its way to the proper place.

For these reasons, it was necessary to devise a means by which, at one introduction of the instrument into the eyeball, the removal of the post-retinal fluid and its substitution by another fluid could be effected at one time.

The instrument devised for this purpose is shown by two photographs. One shewing it when fitted together; (see page /36), and a second shewing some of the separate parts. (Page /34).

This apparatus is arranged as follows:-

Two small sized hypodermic syringes (of
Liston's pattern are attached, side by side, by spring catches, to a single metal plate. One of these syringes is intended to aspirate with, while the other is meant for injecting.

One double-channelled needle is connected by small pieces of india-rubber tubing to the syringes. The connection is made in such a way as to insure firmness and to facilitate cleaning.

Fresh tubing can be easily applied when thought advisable.

One syringe, marked with a little sealing-wax on the handle of the piston, is always used for injecting, and the other always used for aspirating.

The aspiration is effected by advancing the screw upon the piston rod. In this way we can guard against any jerking movement, and by noting the graduating upon the piston rod, we determine the exact amount of fluid removed.

The latter point is of great importance; for it enables us safely, to regulate the amount of the injection which may be given, which should never be more than the fluid removed.

The injection is carried out by elastic pressure and the retraction of the piston screw, as in the method for producing detachment.

In carrying out the operation for replacing the post-retinal fluid with coagulating blood plasma,
it is necessary to have an assistant who can be relied upon to carry out the management of the plasma, exactly as arranged.

The proper quantity being ready for use; the calcium chloride solution, and a properly graduated sterilized pipette are placed in readiness. The animal is then anaesthetized in the usual way with ether, having had the pupil dilated if necessary. The site of the detachment is then located by means of the ophthalmoscope, and the sclera is then exposed over the area corresponding.

The needle with the pieces of tubing attached having been previously filled with normal salt solution, two small clips are placed one on each tube to prevent the fluid from leaving the channels of the needle and rubber tubes during manipulation. The needle is introduced with its tubing intact first, and then the connection is made with the syringes.

A small incision is made through that part of the sclera which has been laid bare, and the needle is directed as nearly as possible to the point of greatest detachment and is located there by means of the ophthalmoscope, before the operation is proceeded with.

While the needle is thus being introduced, the assistant, when the indication is given, adds to the plasma the calcium chloride solution and then fills
the injecting syringe.

The connection is then made, and the operation concluded, as has been before indicated.
It is evident from the account of my experiments that the introduction of blood plasma, whether caused to coagulate or not, has tended to the extension of detachment. The temporary inflammatory reaction produced, may be regarded as favourable, and would, I believe, under slightly different conditions, prove of salutary influence.

It is the fluid which collects after the plasma has been injected, which requires to be further dealt with. This fluid whether the result of choroidal transudation from the irritation of the foreign substance introduced, or from whatever source, is the cause of the increase of detachment.

The addition of a puncture made with the electrocautery, through the sclera, which would permit of the escape of fluid, would serve this purpose. This additional puncture made after the introduced plasma had coagulated, would I believe modify the result favourably.

It is important to note that no serious effects were produced on the Vitreous by the presence of a mass of fibrine. No acute inflammatory process was set up; but only a mild temporary inflammation which is an additional reason why we may hope for good results from the application of this form of treatment.

It was my hope and intention to have carried
into effect the modification which I have suggested, and to have made clinical application of this treatment.

I was prevented from further progress by a peptonizing change which took place in the plasma with which I was working, and by the delay which was occasioned by the difficulty of procuring a fresh supply.

As shewn by the slow absorption of salt solution and other diffusible fluids injected behind the retina, the absorptive power of the choroidal vessels would appear to be feeble. It is striking that a solution of glucose as in the case recounted, is so rapidly absorbed, and suggests the use of this substance as a possible therapeutic agent.
Case E. Left. In this case a large sized, flat, slightly curved, surgical needle, with the point removed was employed. (See photo page 133)

The preliminary preparations as usual.

Oblique incision made through sclera at equator directly behind superior rectus tendon.

The eye-ball being held with forceps, the above mentioned needle was introduced between the retina and the sclera, its position being obvious to ophthalmoscopic view, through the retina. The needle was moved from side to side, always being held in close relation to the inner surface of the sclera, in order to prevent penetration of the retina or Vitreous. By this means large areas of the choroid were injured or destroyed. On the day of operation, extensive subretinal haemorrhage was seen. On the day following operation, large haemorrhages all over the upper and central parts of the fundus, both subretinal and into the Vitreous. The Vitreous rapidly becoming clouded from haemorrhage the condition of the fundus became entirely obscured.

The points of interest in the subsequent course of this case have been mentioned on page 32.
Case F. January 18th. Operation by Method II. Detachment produced in both eyes by the injection of vitreous fluid from another animal.

Day following, operation, January 19th.

Right eye - Extensive subhyaloid haemorrhage with detachment and rupture of the retina.

On January 20th the Right eye showed large detachment with laceration of the retina, the torn margins being distinctly seen.

Left eye - On day following operation.

January 19th. At the upper part of the fundus to the nasal side, appearance resembling detachment was seen, with retinal haemorrhages.

January 20th. Detachment more evident.

January 31st. Detachment extended downwards at nasal side of fundus.

February 4th. The post-retinal fluid replaced by coagulating blood plasma by the method described.

Points of interest in further course of this case noted on page 19 and after.

The drawings show the appearances presented at certain periods.

(Drawing F 1 page //4) shows the appearance of the elongated mass of fibrine presenting through the ruptured retina, January 10th, six days after its introduction.

(Drawing F 2 page //5) shows the appearances on March 16th, six days later.
(Drawing F 3 page //6) shows the appearances on March 1st which differ in the important particular that the retinal detachment which has healed at the nasal side of the fundus appears at the lower part of the fundus more markedly than before, and extends toward the centre of the fundus. By the 6th of March the fibrine mass had become smaller and the detachment much decreased. Also on March 11th no trace of detachment could be seen. The fibrine mass still remaining in position at the upper part of the fundus.

Some patches of choroidal atrophy were all that remained to shew the original site of detachment.

The Vitreous remained clear throughout a period of over six weeks during which the mass of fibrine remained in it.

The animal was killed on March 20th.
Drawing F I

Band of opaque nerve fibres not here represented.

Fibrin Mass as seen through retinal minima.
Band of opaque nerve fibers not shown here.
Drawing F iii

Atrophy of choroid

Altered mass of fibrin

Particles of fibrous tissue

Appearance of temporary detachment of lower part of fundus

Band of opaque nerve fibres not shown
Case H. February 2nd. Operation as described under Method II. was performed.

The Right eye does not present any points of sufficient interest to be detailed here.

In the Left eye (referred to on page 19 and after) coagulating plasma was injected by above method.

The drawings show the appearances of chief interest.

Drawing (H. 1 page //8) made on February 3rd shows detachment as a result of the material injected behind the retina.

February 4th. The mass of fibrine is seen lying in the Vitreous having come through the retina during the night of February 3rd.

February 10th. Drawing (H. 2 page //9) was made shewing the large mass of fibrine in the Vitreous.

On the 14th February the animal was killed.

During the ten days in which this mass of fibrine lay in the Vitreous, no signs of inflammation could be detected with the ophthalmoscope. The Vitreous remained clear throughout.
Drawing H I

Detachment as seen here produced by injection of coagulable plasma beneath retina.

Fibrous in vitreo

Subretinal haemorrhage

End of band of opaque fibres with vessels

Large detachment

Upper part of fibrous mass seen, and changed appearance of retina.
Drawing H IV

Shewing large fibrous mass in vitreous.
Case M. Having obtained a suitable detachment in the Left eye by Method II. (see drawing M I page 122) Coagulating plasma was introduced behind the retina at the area of detachment by the method described.

The coagulating plasma was introduced on February 23rd.

February 24th. The detachment has a more irregular surface and is slightly yellow in colour.

February 25th. No change in appearances noted.

February 26th. Fibrine very clearly seen through the retina. The general fundus does not show any notable change.

February 27th. Fibrine seen through the retina as before at the upper part of the fundus. The general fundus is reddened with the formation of greenish stripes upon the fundus, which appear like extending detachment.

February 28th. The detachment has extended over a large part of the fundus, passing downwards at the periphery both on nasal and temporal sides. A bright red inflammatory appearance characterizes the undetached parts of the fundus (see drawing M 2 page 123)

March 1st. Detachment still increasing though the inflammatory appearance of the retina has subsided considerably (see drawing M 3 page 124) made on this day.
March 2nd. Detachment increased. Inflammation passing away.

March 3rd. No further increase of detachment. Inflammatory appearance gone.

March 4th. Condition improving.

March 6th. The fundus shows no inflammatory reddening now present.

Detachment much reduced but still present at the upper part and towards the periphery at the lateral parts of the fundus.

The further notes show the disappearance of all inflammation, but the persistence of the extended detachment of the retina.
Drawing M1

Opaque nerve fibres not represented.
Drawing M II

Fibrin as seen through retina

Extended detachment

Inflammatory reaction and partial detachment seen as folds.

Showing extended detachment and inflammatory reaction as seen five days after introduction of coagulating plasma.
Drawing M iii

Shewing some further increase of detachment and marked subsidence of inflammation.
Case S. Having obtained a sufficient detachment by Method II., the following modification of the coagulating plasma operation was carried out.

The same plasma as that used for Case (M) was employed, diluted by the addition of four parts of sterilized normal salt solution to one of plasma.

The object of this dilution was to render the fluid less active in the hope that by so doing its effect might be improved.

The observations made upon Case S. after the application of this modified fluid, showed much less inflammatory reaction but no marked improvement in the detachment.
Case U. which has been referred to on page 30 requires a short note.

March 6th. The Right eye was injected with Vitreous fluid but did not shew any points of interest.

The Left eye injected with a 20% solution of glucose as before noted shewed interesting results which have been already described.
Case V. March 6th as described on page 29 blood plasma which was not treated to bring about coagulation was here injected behind the retina.

Method II. was employed.

The Left eye detachment was not effected because the fluid returned through the wound alongside the needle.

In the Right eye detachment was produced. The subsequent extension of this detachment has been detailed on page 29.

The animal was killed on April 22nd.
Photograph showing
Low power view of normal retina of rabbit
Showing bundles of opaque nerve fibres
on transverse section.

High power view of part of same section
of normal retina of rabbit.
(Low power) photograph from Case D left page 84.
See also text page 26

Inflammatory tissue of vitreous
Degenerated retina.

(High power) Photograph shows
Degeneration of retina also the incorporation
of inflammatory tissue formed in vitreous
Photograph of specimen sent showing opaque nerve fibres of Rabbit's fundus.
Photograph of eye-ball fixation forceps described on page 87, showing blades fixed in position.

The same showing blades detached as before. Their attachment to the eye-ball.
Photograph showing modified hypodermic needle used for artificial production of retinal detachments (see pgs. 57-58).

The photograph shows the syringe in position for injecting with the elastic sheen stretching over the tip of the handle of the piston, and the screw pulled down on the graduated shaft.
A shows double channelled needle with rubber tubing attached, and fittings, to connect with syringes or plungers. Two small clamps, also shown in position on rubber tubes.

B Y-shaped needle with single channel and stops for connecting through rubber tubes to syringes, used for some operation.

C another pattern of double channelled needle.

D Large needle of hypodermic with cleaning wire used for introducing rubber tubing into vitreous.
Photograph showing glass tube for preserving plasma for use.

Photograph showing apparatus for the withdrawing of the posterior fluid, with fluid therapeutic agents.