The electro-magnet and its employment in ophthalmic surgery : with special reference to the detection and removal of fragments of steel or iron from the interior of the eye / by Simeon Snell.

THE ELECTRO-MAGNET

AND ITS

EMPLOYMENT IN OPHTHALMIC SURGERY

SNELL

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"Steel through opposing plates the Magnet draws,
And steelly atoms culls from dust and straws."

Crabbe.

THE

ELECTRO-MAGNET

AND ITS EMPLOYMENT IN

OPHTHALMIC SURGERY

WITH

SPECIAL REFERENCE TO THE DETECTION AND REMOVAL OF FRAGMENTS OF STEEL OR IRON FROM THE INTERIOR OF THE EYE

BY

SIMEON SNELL

OPHTHALMIC SURGEON TO THE SHEFFIELD GENERAL INFIRMARY AND TO THE INSTITUTION FOR THE BLIND; LECTURER ON DISEASES OF THE EYE AT THE SHEFFIELD SCHOOL OF MEDICINE

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PREFACE

This little volume was commenced with a view to its publication in one of the medical periodicals, and to form, as it were, a continuation of the Author's previous experience, recorded in the 'British Medical Journal,' vol. i, 1881. The full details of the cases, with the remarks they called forth, as well as those upon the use of the electro-magnet generally, extended, however, to greater length than could be conveniently published in such a manner. It was decided, therefore, to issue this monograph.

In addition to the writer's personal experience, towards the end of the volume have been added brief summaries of all the recorded cases which, after a diligent search in many British and Foreign periodicals, the author has been able to find. It is possible that others, in journals inaccessible, have escaped notice, but the published cases have been materially added to by those which various operators have been good enough to mention in private letters. To these gentlemen thanks are due for their courteous communications.

It is hoped that the experience collected in this little work may prove of assistance and value to some, may tend to encourage the wider adoption of the electro-magnet in ophthalmology, and may aid also in pointing out the mode of its employment and the class of cases in which its use is applicable.

Much information has been afforded, especially as to the early employment of the magnet, by the papers of Professor Hirschberg, of Berlin (which he has been good enough from time to time to send to the author), particularly the one "On the Extraction of Chips of Iron or Steel from the Interior of the Eye," in Knapp's 'Archives,' 1881.

The writer's thanks are due to Messrs. Cubley and Preston, the makers of the instrument described in the succeeding pages, for the manner in which they have at all times carried out his directions, and he would express his appreciation also of their many services, so courteously and willingly rendered.

SIMEON SNELL.

SHEFFIELD;
June 1*st*, 1883.

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THE ELECTRO-MAGNET

AND ITS

EMPLOYMENT IN OPHTHALMIC SURGERY

Accidents to the eye, from the unfortunate results frequently occasioned, always deserve consideration at the hands of the surgeon. Among these injuries none are more dangerous than those associated with the presence of a foreign body in the interior of the eye-ball; for if not immediately destructive to vision, by reason of the extent of the damage inflicted, it is not long, as a rule, before inflammatory changes ensue and impair the functions of the globe. Moreover, if to the injury to one organ is added the great danger in which its fellow is placed by the possibility of sympathetic ophthalmia, and this even in the class of cases where the foreign body has lain for some time inside the eye and perhaps become encapsuled, nothing need be further said as to the importance the treatment of these injuries acquires, nor of the attention which the subject merits, and, in fact, requires at our hands.

In the large industrial centres of England, with the extensive works of different kinds and the number of men employed in the various branches of trade, it is

fearful to contemplate the immense amount of ocular damage, or total loss of vision, that annually occurs. This remark applies to the dangers to which workers are exposed among minerals as well as among metals. It will, however, only here enter into the author's purpose to speak of injuries occasioned by some metallic substances, and indeed it is chiefly from these that the more grave accidents arise, but passing reference may be made to the want of protection afforded to, or even sought by, the employés in some of these dangerous pursuits.

Not long since, it was customary to associate together for treatment, foreign bodies in the eye, of whatever nature, and the course pursued differed but little, if the suspected fragment were one of the various metals, a mineral, or other substance. It has now, however, been rendered possible, by the application of principles of physics, to separate a class of these, and which has made them more amenable to treatment. It is the writer's purpose to speak in the succeeding pages, particularly of the fragments here alluded to, viz. those of steel or iron.

Within the last few years, a mode of treatment has been introduced and practised which has advantages over, and acquires results which were unknown under the older methods. Reference is made to the employment of magnetism—the magnet and electro-magnet. The idea, however, of thus employing the magnet, can perhaps scarcely be called new, but in by-gone days its use was only suggested and adopted by few

authorities. Fabricius Hildanus advocated as long ago as 1646 its employment, and used it apparently at the suggestion of his wife ; but he confined its application to the removal of splinters of iron from the cornea. The following quotation, also, which the writer recorded* some time since, will be here of interest. It is from 'Observations of Medicine and Surgery,' by Dr S. Milhes, published in 1745 :— "There was one in Salisbury, who had a piece of iron or steel stuck in the iris of the eye. The person was in very great pain and came to me. I endeavoured to push the iron out with a small spatula, but could not, and then applied a loadstone to it and immediately it jumped out." The situation of the fragment here, it may be inferred, was the cornea. Morgagni (1779) likewise endeavoured, unsuccessfully, to remove a splinter from a little corneal abscess with a magnet, and recommended it in similar cases. The other instances of the employment of the magnet in earlier times fall well within this century, and are those by Meyer of Minden in 1842, Dixon in 1858, and White Cooper in 1859. They are referred to fully among the recorded cases, further on in this little volume. It is, however, to McKeown, of Belfast, the credit is due of introducing afresh the employment of the magnet, and by recording in 1874† cases successfully treated by it of causing the stimulus which has led to its occupying an important position in the armamentaria

* 'Brit. Med. Journal,' 1880, vol. ii, p. 83.

† 'Brit. Med. Journal,' 1874, vol. i, p. 800.

of the ophthalmic surgeon. He, it must be remembered, used merely a simple permanent magnet, tapered at either end for introduction into the eye. Such an instrument as this, soon left in the rear, has had its place occupied by the electro-magnet, and it is with this latter, possessing evident and great advantages over the simple bar-magnet, that the greatest advances and the numerous successes in this field of ophthalmic surgery have been gained. Among the workers in this direction, advocating and adopting its employment may be mentioned, Hirschberg in Germany, Bradford in America, and McHardy and the writer in England. From the labours thus accomplished it is now well known on what principles any instrument designed for ocular purposes must be based.

Hirschberg of Berlin, probably, ranks as the first adopter of an electro-magnet for ophthalmic purposes, and suitable for introduction into the interior of the globe; his first instrument being manufactered in 1877.

In the 'British Medical Journal,' for 1881 (vol. i, p. 843), the writer described the instrument devised and used for some time by himself, and recorded also a series of cases in which he had successfully employed it. Extended experience has not only confirmed the belief then expressed, as to the adaptability of this instrument for the purposes for which it is intended, but that the method generally is a real and decided advance in the treatment of this class of cases.

A brief comparison of the older and the newer methods of removing foreign bodies from the interior of the eye, will at once demonstrate the advantages as to increased certainty of success and greater probability of preserving vision belonging to the latter. Formerly their extraction, and even now of necessity for those particles which are unaffected by the magnet, was attempted by forceps, curettes, or other means. Occasionally, by good fortune this kind of procedure was successful, but much more frequently not so, and this particularly in splinters completely hidden from view; and, indeed, if the fragment was secured and removed, it was too frequently done at the expense of sacrificed vision, as a consequence of the necessary manipulative efforts. A case of this character, occurring many years ago, and probably one of the first cases of the sort the writer had seen treated, well exemplifies the older method, and even then thoroughly impressed itself upon his attention. Through a sclerotic wound a fragment of steel had passed into the vitreous chamber, and though visible, eluded the grasp of the forceps, in the hands of a distinguished ophthalmic surgeon; enucleation immediately followed the failure to remove the foreign body. How differently with the electro-magnet such a case as this would have frequently terminated, will be seen in the course of the following pages. Indeed, the older plan might often, it seems, be not inaptly likened to the proverbial searching for a needle in a haystack, and frequently with as satisfactory a result. Now, however, the scene is

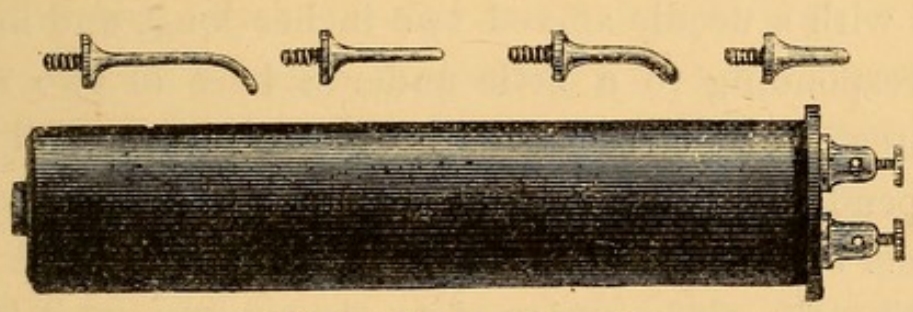
changed, for, with a properly constructed electro-magnet, the removal of a fragment of steel or iron, has, in many cases, attained something like certainty, and this especially in recent injuries. In instances in which the situation of the particle is visible, the electro-magnet is approached to it, either by means of the original wound, or by a fresh incision, and the fragment is readily extracted; in others, where the foreign body is hidden, removal is often more difficult, but is mostly effected, the amount of vision preserved depending upon the damage caused by the fragment, the length of time it has remained inside the eye, with the changes consequent thereon, and the manœuvres necessary to effect its extraction. Even applied to the surface of the globe, its action on the contained particle may sometimes render evident its character, or facilitate its subsequent removal.

The remarks in these pages have reference almost entirely to the electro-magnet. Before devising the instrument to which attention will presently be directed, various experiments were made with simple magnets of different sizes and kinds. The difficulty always presented itself of obtaining by this means a sufficiently small extremity for introduction into the eye, and yet at the same time to exert attractive force enough to make it of practical value in the majority of cases.

Gruening of New York, after various experiments, devised a magnet formed of a number of cylinders joined together and united with a cap at each end, and at one extremity he inserted a needle fifty-two milli-

metres long, one millimetre wide, and 0·3 thick. This instrument will support from the point a key weighing twenty-eight grammes (nearly one ounce). The attractive force of this magnet seems hardly greater than the simple bar-magnet used unsuccessfully in Case No. 18, and is, as will be noticed further on, very little compared to that of an electro-magnet; for the best devised simple-bar or other magnet is far inferior to a properly constructed electro-magnet, which readily fulfils the requirements necessary for our purpose.

Experience has not only confirmed the opinion formed as to the efficiency of the electro-magnet devised by the author and described in the 'British Medical Journal' in 1881, as before mentioned, but the success attained in the fiery ordeal of practice has



[Half Actual Size.]

demonstrated its value. Several ophthalmic surgeons have adopted it, and in other instruments its principle has been incorporated. As at present used it is somewhat less in size than the original instrument, but its efficiency has been maintained. Briefly described, the electro-magnet* consists of a core of soft iron around which core is placed the coil of insulated copper-wire,

* Made by Messrs. Cubley and Preston, High Street, Sheffield.

and this, again, is enclosed in an ebonite case. To one end of the instrument are attached the screws to receive the battery connections. At the other extremity the core of the magnet projects just beyond the ebonite jacket and is tapped, and into it screws a needle, which fits closely on the end of the instrument by a projecting cap. By this means it is possible to employ any kind of needle the operator may wish or the case require, either curved* or straight. A few such needles are supplied with the instrument, as appears in the woodcut, and the surgeon can readily use others as he may desire. Each sort of needle will perhaps be more adapted to a particular case. The suspensive force of this electro-magnet was thus given:—"Attached to a quart bichromate battery, and with a needle affixed two inches long, and in size corresponding to a little under a bore of two millimetres, the electro-magnet is able to pick up and hold suspended from the point a bunch of keys or other object equal to six ounces or 175 grammes." In estimating the given power of an electro-magnet it is important to bear in mind that the magnetic force decreases in rapid proportion according to the size of the extremity and the distance its point is from the

* Professor Hirschberg of Berlin, to whom at his request one of these electro-magnets was forwarded for comparison with his own instrument, remarks in his paper on the "Extraction of Chips of Iron or Steel from the Interior of the Eye" ('Knapp's Archiv,' 1881, p. 397), that he found it very powerful, but that he would have preferred bent needles, forgetting that in my original paper, and in private letters, I had mentioned their use.

coil. Thus, while the instrument with the needle attached mentioned above, viz. two inches long and two millimetres thick, raised only six ounces, in connection with the same battery (a bichromate cell) but armed with the polar extensions of five, four, three thirty-seconds of an inch in diameter and one half inch in length, it was found readily to suspend twenty, sixteen, and eleven ounces respectively, these being the weights which, with the same points, Bradford's electro-magnet (to be mentioned presently) is described as capable of lifting.

The tapping of the end of the core in the manner described appears a distinct advance in the construction of an electro magnet. The advantages derived from the ease with which one needle is substituted for another have been pointed out. In addition, in certain cases it is often of service, either as a means of diagnosis or as an aid to the removal of the fragments of metal, to be able to bring into close contact with the eyeball an electro-magnet of considerable power. The same instrument answers also this purpose, for by employing it with the needle unattached it is capable of lifting several pounds, and the necessity of a second electro-magnet is often thus obviated, which if the terminal were fixed would be required.

Usually the electro-magnet is employed attached to a quart bichromate element, and it answers the purpose well. It is, however, by no means convenient for carrying about, and whilst in every way suitable for the operating and consulting room, in other circum-

stances sometimes it might be desirable to have a battery more portable.

Dr Manchi, of Valetta, Malta, after reading the author's paper in the 'British Medical Journal,' kindly wrote suggesting the advantage of being provided with one more easily carried about, and for this purpose recommending a Trouvé's gutta-percha battery. These batteries are well known and Dr Manchi speaks favorably of them. They are always ready for use, and have only to be turned upside down when it is desired to employ them. They consist of zinc and carbon elements, and the solution used is one of bisulphate of mercury. One of these batteries certainly gives a fair force to the magnet, but the one the writer employs does not enable it to act so powerfully as with the bichromate cell.

Of the instruments designed by other operators, it may be mentioned that Hirschberg's* consists of a coil wound round a hollow cylindrical iron core, which is continued into two curved polar points, for introduction into the eye. One branch is about three quarters of a millimetre, the other about four fifths of a millimetre thick. The thinner branch bears more than fifty grammes. Recently he states that he employs thicker points, and the suspensive force is correspondingly increased.

Bradford's† is a powerful instrument, and is based

* 'Berlin Klin. Wochenschr.,' 1879, No. 46, and "Extraction of Chips of Iron or Steel from the Eye," 'Knapp's Archiv,' 1881, p. 376, and elsewhere.

† 'Boston Medical and Surgical Journal,' March 31st, 1881.

on the same principle as the author's, and possesses also the advantage of being tapped at one extremity to allow of various sizes of needles being inserted. Moreover, Bradford appears to have been experimenting at the same time and to have arrived at the instrument he employs almost simultaneously with the author. The magnet weighs about five ounces, and armed with polar extensions respectively five, four, and three thirty-seconds of an inch in diameter, and one half inch in length the suspensive power equals twenty, sixteen, and eleven ounces respectively, the battery employed being a single bichromate of potash cell, having eight square inches of negative surface.

McHardy, who had previously made use of electro-magnets for the removal of fragments of metal from the interior of the eye, exhibited before the Ophthalmological Society, on July 6, 1881,* an instrument made by Messrs. Coxeter. This electro-magnet was made after the plan of Bradford's and consequently after the description of the writer's instrument had appeared. The core resembled Bradford's and was in like manner tapped at one extremity; in bulk the instrument was reduced by the substitution of finer copper wire in the helix than had been used in the earlier electro-magnet. "This fineness of the wire," McHardy observes, "causes such resistance to the current and consequent heating, that the insulating material would be damaged if the instrument were used for long at a time. This disadvantage has to be

* 'Trans. Ophthal. Soc.,' vol. i, p. 220.

measured against the diminished bulk and weight of the instrument." It may be stated that it is not always that the employment of the electro-magnet is only necessary for a brief time. After the writer's earlier experiments, the finer copper wire was discarded on account of its manifest disadvantages, which, in his opinion, no great diminution of bulk can atone for; and in the instrument he has described, though the galvanic current has passed through it at different periods for a considerable time no heating has taken place. For these reasons concurrence would be given to a previous opinion* expressed by Mr McHardy, respecting Hirschberg's electro-magnet, viz. "whilst anxious not to be hypercritical about the apparatus, another apparent oversight suggests itself to me, viz. the very fine gauge of the insulated copper wire, which, it would seem, must be a source of undue resistance to the galvanic current." It may be mentioned that Hirschberg now employs larger sized copper wire than he was formerly in the habit of doing. Bradford's needles referred to as used with his instrument, are also too large for the majority of cases.

The author has records of sixteen cases in which he has successfully employed the electro-magnet, and two cases also in which its use was not attended with success, but the causes of failure in the latter admit of ready explanation; and further on, in their proper places, reference will be made in detail to each of them.

* 'Brit. Med. Journal,' March 26, 1881.

Another instance will be mentioned in which with a permanent bar-magnet failure resulted, making thus a total of nineteen cases in the writer's practice, where magnetism has been made use of for the removal of fragments of steel or iron. This number, however, is exclusive of instances in which, in doubtful cases, the electro-magnet has been employed as a probe, and which will be more fully referred to further on.*

A few of the nineteen cases mentioned have been already recorded in an earlier paper, but the great majority have as yet not been published.

In relating and discussing the individual cases, it will perhaps be convenient to arrange them, as far as practicable, in groups, and in this way to speak of the removal of fragments from the various regions of the eye.

Eyelids.—The first class of cases then to which reference will be made, as among those where the electro-magnet will be serviceable, indicates also, it is thought, that the method may find hereafter a wider field for employment in general surgery. Instances are meant, of fragments embedded in the lids or eyebrows. The following case is such an example:

1. Towards the close of 1881, a man applied at the Sheffield General Infirmary, stating that a few weeks previously he had been hit on the left eye by two or three

* Adding these "probing" cases, the total number would be brought up to twenty-six or twenty-seven.

pieces of metal. He feared that perhaps his eye had been injured.

Beyond, however, a slight nebula, there was no evidence of any ocular mischief; but an elevation in the upper lid was noticed. It was rounded, of firm feeling, and about the size of a pea, and on being questioned he asserted it had only existed since the time of the accident, though he had no distinct recollection of his eyelid having been injured. Thinking it very likely that a particle of iron was embedded in this little tumour, it was cut across with a scalpel, and as the electro-magnet was at hand, the needle was inserted into the wound and withdrawn immediately with the portion of metal attached.

This procedure, it may be added, has been repeated in other instances with varying success. These, however, need no further allusion, and are not included in the number given as that in which the electro-magnet was employed.

Cornea.—It is in connection with the removal of fragments from the cornea that the older instances of the employment of the magnet were associated. Reference has already been made to such cases recorded by Fabricius Hildanus, Milhes, and Morgagni. For the great majority of instances of chips embedded in the cornea the employment of the electro-magnet is, to say the least, unnecessary, and in this particular the writer agrees with McKeown and Hirschberg. The particles are mostly small, and while for this reason a magnet would have little practical effect on them, they are generally readily enough removed with a cataract needle or corneal spud. Often it happens that the

foreign body has flown from the surface of the metal (scale), and, having become chemically altered by oxidation, is but indifferently acted upon by the magnet. On the other hand, that there are cases in which the mode of treatment we are discussing will be found useful is certain. The author recollects no particular instance in which he has seen occasion to employ it, but his different infirmary assistants have told him that for fragments embedded in the cornea they have found the electro-magnet of use. Bradford* believes that for particles of appreciable size, and especially when employed before the wound is closed, the elctro-magnet will render good service. He records such an instance in which two thirds of the diameter of the foreign body projected into the anterior chamber; the wound was reopened, and the fragment immediately grasped by the electro-magnet. Dr Hill Griffiths† mentions also an interesting case where the chip had nearly been pushed through the cornea, and the electro-magnet, applied to the cornea without the needle effected its removal. The two above mentioned instances will be found among the recorded cases towards the end of this little volume, as well as one each by Joy Jeffries, and Hirschberg.

It may be mentioned that in large iron and steel factories the magnet has been for long in use for the removal of corneal splinters, and the author knows of

* 'Boston Medical and Surgical Journal' ("The Electro-Magnet in Ophthalmology"), March 31st, 1881.

† 'Ophthalmic Review,' 1882, p. 243.

one such place, at least, where the electro-magnet described in these pages is satisfactorily employed.

Conjunctiva and Sclerotic.—It must be seldom, if ever, that the electro-magnet can be of any service for the removal of particles embedded in the conjunctiva. The writer has never employed it in such a case, nor indeed seen one in which good seemed likely to accrue from its use, but, on the other hand, such particles appear unsuitable for the electro-magnet. They are generally readily removed by seizing with forceps the mesh of conjunctiva holding the foreign body and snipping it off with scissors. Their presence is not infrequently attended with no discomfort, and a particle removed some time since, the history left little doubt, had been embedded for thirty-six years. For fragments sticking in the sclerotic service may be rendered perhaps by the electro-magnet.

Aqueous Chamber.—For chips of steel or iron situated in the anterior chamber or embedded in the iris the electro-magnet may be expected to effect signal service. When free, on the surface of the iris for instance, the approach of the electro-magnet without the needle to the cornea will facilitate subsequent removal by attracting, it may be, the portion of metal to a more convenient situation. Thinking over cases, also, where formerly one removed a portion of iris, hoping to have the good fortune at the same time to withdraw the foreign body, it is easy to understand how, with the method now at our disposal, the operation would

have been simplified. Cases illustrating the value of the electro-magnet in these regions have been recorded by Hirschberg and by C. S. Williams, of Boston, and others. The following case is mentioned here, though perhaps properly falling under the next section, as being somewhat on the borderland between those fragments situated in the iris and those in the lens.

2. Robert K—, æt. 39, was first seen December 27th, 1881. A month previously, whilst engaged in cutting a file, a piece of metal had flown off, but whether from the chisel or the file he did not know. He felt it strike the eye, but thought nothing more about it until a week later, when he fancied there was "something over the sight;" his brother, whom he got to examine it, found it red-looking. After this time the sight became dimmer, but he experienced no pain except for one day. The lens was now found to be quite opaque; a very faint linear scar was visible in the cornea close to the upper border, and just below this in the iris was a dark mark. Light perception was perfect, and the pupil dilated moderately to atropine. The history of the case, the scar in the cornea, and the dark mark in the iris, led one to the conclusion that there was a foreign body in the globe and it was determined to remove the cataractous lens, and at the same time to use the electro-magnet for the detection and withdrawal of the fragment.

December 29th.—No anæsthetic was administered. A small shallow flap was made in the cornea at its upper part, and the lens capsule freely ruptured. There was a good deal of bleeding (iritic) which rather interfered with the view. The needle of the electro-magnet was, however next introduced, and withdrawn followed by a portion of iris. Examination of this latter disclosed a small frag-

ment of steel entangled in it; and it appeared probable that the particle had passed through the iris at the dark mark, and whilst perforating the lens capsule and occasioning the cataract, was in contact with, or in a measure entangled in, the iris posteriorly, from whence the electro-magnet had removed it. A portion of iris was excised, and the lens matter allowed to escape. For the rest it is sufficient to say that recovery was good.

January 18th, 1882, V + $\frac{1}{3}$ = $\frac{20}{70}$ and February 2nd, + $\frac{1}{3}$ = $\frac{20}{50}$. The fragment removed weighed nearly four milligrammes.

Lens.—We pass now to the consideration of fragments in connection with the crystalline lens. They may be situated merely on its surface or embedded in its substance, and the mode of application of the electro-magnet will differ in the two classes of cases. As to those located only on the lens capsule, Rothmund and McHardy have both succeeded in causing the fragment of steel to spring forwards, by bringing in close contact with the eye, a powerful electro-magnet. Removal was subsequently effected through a corneal section. In both cases cataract followed but ultimately vision was good.

In seven instances, including the one already related (Case 2), the author has succeeded in removing chips of steel or iron embedded in the substance of the lens.

3. C. S—, æt. 45, applied at the Sheffield General Infirmary on January 12th, 1881, in consequence of having lost the sight of the left eye. He stated that on the 21st of the preceding month (December), whilst engaged in turning a "cold chill roll," a piece of steel had flown off

and hit his left eye. The lens was now found to be opaque, a mark was noticed also in the cornea, as well as a corresponding one in the anterior chamber, through which doubtless the foreign body had passed; the eye was otherwise quiet, and the pupil dilated well under the influence of atropine. With careful examination by means of focal illumination, the fragment of steel was observed at the back part of the lens, on or in the posterior capsule. He was admitted into the Infirmary and operated upon in the following manner. No anæsthetic was administered. An incision with a Graefe's knife was made in the cornea, similar to the one the writer adopts* in extracting for cataract, by a shallow flap, and lower section; the puncture and counter puncture were made in the sclero-corneal junction and opposite the lower pupillary margin; and the knife was almost immediately turned forwards, the summit of the flap being midway between the margin of the pupil and the periphery of the iris. The lens capsule was next torn through with a cystotome and softened lens matter began immediately to escape. The electro-magnet needle was next introduced and withdrawn without having caught the foreign body; but on its being again passed in and a second time withdrawn the piece of steel was found attached to the needle. The remainder of the lens matter was then removed; a pad of wet lint was placed over the eye and a dry one over the sound organ, and a light bandage applied. The lint over the left eye was ordered to be kept moist with cold water, and the case was treated as an ordinary cataract extraction. The after progress was unexceptionally good. He remained in the Infirmary for about a fortnight.

* 'Brit. Med. Journal,' January 13th, 1883, "On Extraction of Cataract by a Shallow Lower Flap, with an Analysis and Record of 121 Cases."

On February 24th, 1881, the patient was shown to the members of the Sheffield Medico-Chirurgical Society, and it was at that time noted that the pupil was round and free and with $+3\frac{1}{2}$ V $= \frac{20}{40}$, and with a $2\frac{1}{2}$ inch lens he read J. 1 easily. The chip removed weighed $\frac{1}{2}$ a milligramme.

4. On March 17th, 1881, a little boy, H. A—, æt. 6, was brought to the author from the country under the following circumstances. Six weeks previously, whilst striking two hammers together, a "spark" had flown off one and hit the left eye. For a few days, it appeared a little bloodshot; his parents, however, paid little attention to it, until they noticed that the pupil was losing its normal appearance, and becoming occupied with a white substance, and which for the last two weeks had completely filled it. Vision was now reduced to shadows, and examination disclosed a faint linear scar in the cornea just below the pupil and on the inner side. The lens was opaque, and on the front, just below the pupillary margin, was a yellowish mark, not showing, however, a distinct reflex; and it was particularly noticeable when the pupil was dilated with atropine. Judging this mass of lymph to contain the piece of metal, its removal with the cataractous lens was suggested. It was not, however, until April 6th that he was brought into Sheffield with a view to operation. Attempts were made to ascertain the effect on the supposed fragment of powerful electro-magnets, and to endeavour to displace it forwards. With this object, a very strong horse-shoe electro-magnet was advanced to the cornea, and in the same way the writer's instrument was employed without the needle. No effect, however, was produced, except that the little patient complained of pain in the eye, indicating, it was thought, the presence of a fragment of steel or iron, and that it had become magnetised. Ether was now administered, and a small lower flap was

made in the cornea as in the last case, but not passing thoroughly across it; the capsule was next opened, and the needle of the electro-magnet inserted, and immediately withdrawn with the fragment of steel attached. The lens matter was then gently pressed out, with the mass of lymph which had enclosed the foreign body; a piece of iris which appeared inclined to remain entangled in the wound was excised. The case was treated in the same manner as the former one, and the little boy returned to his home in ten days. He was seen again later on, and it was ascertained that he possessed excellent vision. The fragment of steel was about as big as a fair sized pin's head, and it weighed $\frac{1}{3}$ milligramme.

5. Frank W—, æt. 21, a labourer in large iron and steel works, was admitted an in-patient at the Sheffield General Infirmary on June 13th, 1881. Two months previously, whilst cutting steel scraps with a pair of shears, a piece of steel had sprung off, striking the left eye. He was compelled to desist from work; the eye, he says, became inflamed, and continued in this condition for three weeks. Vision was soon materially affected; he fancied with the subsidence of the inflammation that it somewhat improved, but with the recurrence of some pain in the eye, and ocular congestion, sight had again become worse. The lens was, at the time of his coming to the Infirmary, opaque, and a fragment of steel was observed in the substance of the lens at its anterior part. The place of entrance of the foreign body was evidenced by a small linear scar in the outer and lower part of the cornea. Before proceeding to remove the fragment a very powerful horse-shoe electro-magnet was advanced close to the eye to test the possibility of withdrawing the chip into the anterior chamber. The experiment was not, however, successful, and neither was an attempt with the author's

own instrument applied without the needle to the cornea. Ether was accordingly given (June 13th); a small lower flap was made in the cornea as in the previous cases; the capsule was opened; the needle of the electro-magnet was inserted into the mass of broken-up lens, and withdrawn with the portion of steel attached. The remainder of the lens was let out, and a drop of eserine solution inserted into the eye. The after-treatment was similar to that pursued in the previously-mentioned cases.

November 25th.—It is noted that with a + glass V = $\frac{20}{50}$. The particle of steel removed weighed nearly one milligramme.

6. George U—, æt. 15, a grinder, first came to the Infirmary on August 4th, 1882. Three months before, whilst at his work grinding, a piece of metal from the object he had on the wheel had struck his right eye. At the upper and inner part of cornea, opposite the margin of pupil, was noticed a faint scar about a line in length. The lens was moderately opaque, and at its posterior part was a yellowish spot, which was thought to be lymph surrounding the foreign body. The pupil acted well to atropine, and there was no evidence of any further injury or affection of the eye.

11th. The patient having been brought under the influence of ether, a small lower corneal flap was made, and after the capsule was freely opened lens matter immediately commenced to escape, the removal of the fragment of steel being materially facilitated by the employment of the needle of the electro-magnet which was inserted into the lens space. The chip was, however, surrounded by lymph, and the attractive force of the magnet upon it was decidedly diminished.

On the 23rd he left the Infirmary, and on October 6th, 1882, it is stated that with + $3\frac{1}{2}$ V = $\frac{20}{40}$. The weight of the fragment was one milligramme.

7. Michael L—, æt. 44. On November 21st, 1882, he was occupied in taking out the "bed" of a machine used for cutting out forks. This "bed" having become worn and dull it was necessary to knock it out of its place, and this he accomplished by employing a steel-faced hammer. Whilst thus engaged a small chip of the "bed" (made of cast steel) flew off and hit the right eye. He says he felt blinded directly, and he went to a grinder,* who informed him that his eye was cut. He continued his work for a time, but was compelled to relinquish it in consequence of the pain he experienced. The next morning he was seen by the author and his admission into the Infirmary ordered. His condition then was as follows:—At the outer part of the cornea, corresponding to the pupillary edge, was a small vertical wound, not perfectly closed, and the underlying iris was also pierced at its pupillary edge. The lens was opaque, but in the anterior part the chip of steel was plainly seen, though somewhat under cover of the iris. The corneal wound was reopened and enlarged with a Graefe's knife, the capsule being lacerated as much as necessary at the same time. The needle of the electro-magnet was then introduced and immediately withdrawn with the chip clinging to it. As much of the opaque lens was removed as was possible. The chip extracted was about the size of a grain of pearl barley, and weighed six milligrammes.

The lens that remained underwent very slow absorption, and on January 22nd, 1883, through a fresh corneal section some more was removed. At the time of writing there is still some opaque matter occupying the pupil, but he is

* The class of workmen called grinders—scissors, fork, and so on—are locally famed for their skill in removing "motes" from their fellow-workmen's corneæ, and some are undoubtedly dexterous.

getting to see well, and with further absorption there can be no doubt that he will regain good vision.

The case next to be related is of particular interest on account of the presence of two pieces of metal in the same eye, and for the indications afforded also as to the presence of the particles by a suspended magnetic needle.

8. Joseph T—, æt. 36, whilst engaged at his occupation on April 13th 1883, was striking with a hammer a blade of a pair of shears, to hit it into position in a machine for cutting scraps. A piece flew off, he thinks from the shears' blade, and struck his right eye. Not much pain was suffered then or subsequently, but vision gradually became affected. On April 25th he first came under the writer's notice, and his condition may be thus described.

There was a small scar in the cornea, towards its centre; and one corresponding to it in the anterior lens capsule. The pupil dilated well with atropine. The lens was moderately opaque, especially at its posterior pole. A piece of steel was at once detected in the lens, at its outer and back part. This fragment was evident to the naked eye, but particularly so by the aid of focal illumination. A reflex with the ophthalmoscope was only evident at the edges of the lens. The eye was free from irritation. In addition to the presence of the foreign body just mentioned and before even it was looked for, the writer's attention was attracted to a mark on the iris, at its inner side, and midway between the pupillary margin and ciliary attachment. It was suspected to be a piece of metal. If the supposition were correct it had evidently lain there some time. The dilatation of the pupil was at this part in no way interfered with. At this time, the patient recollected no previous injury to the one he had come under treatment for.

The removal of the fragment in the lens was advised, and the patient's consent was given.

April 28th.—To-day without an anæsthetic the extraction of the particle was effected. A small section was made in the cornea above, and somewhat slanting, with the object of bringing the wound in such a position that the chip, if it were one, in the iris could be easily reached. The needle of the electro-magnet was then advanced up to this mark. It produced no attraction on it, and the writer's attention was drawn to the fact that one of the battery connections had become detached. Whilst this was being rectified, the piece of iris was withdrawn with forceps and excised. It was found to contain a small piece of steel. Attention was next directed to the fragment in the lens. The capsule was freely opened, and then the needle of the electro-magnet was inserted into the mass of lens substance. It was at once withdrawn with the particle of steel attached. The remainder of the lens was removed, and the eyes were closed with pads and a bandage.

The case is progressing favorably but at the time of writing it is too early to state the final result. It gives every prospect of a satisfactory recovery of vision. After the operation, the patient remembered twelve months or more previously having been struck on the eye. He had been knocking a "steel bed" (used for cutting saws) out with a hammer. He drew his brother's attention to the fact of the accident, but thought nothing more about it. The chip had been mistaken for one of the pigmented marks, which were several in number, in the iris of each eye.

The indications the magnetic needle afforded in this case, which were unmistakable, will be mentioned further on, when reference is made to the value of a suspended magnet for detecting the presence of particles of steel or iron in the eye.

The particles removed weighed respectively two and a half milligrammes and one-third milligramme.

It will have been noticed that each of these seven cases recovered good vision. Two obtained $\frac{20}{40}$, two $\frac{20}{50}$; one, a child, "excellent vision," and the last two give every prospect of making equally good recoveries. In six of these cases also the wound of entrance through the cornea had been small, and had closed before operation, and in these a fresh horizontal incision (shallow flap) was made in the cornea, in four cases by the lower section, and in two upwards. Once (No. 7) a larger wound than usual was present, and, being seen not long after the accident, had only imperfectly closed, and the operation was accomplished by enlarging it.

With regard to the removal of such fragments from the lens as have just been alluded to, it may be suggested that possibly the particles would have found their way out with the softened lens matter, and thus have rendered the employment of the needle of the electro-magnet unnecessary. The possibility of such an occurrence in some cases may be granted. In the cases mentioned, however, especially considering the smallness of most of the chips, it is far more probable they would not thus have found their way out, but would have passed beneath the iris, whence removal would have been difficult or impossible. It is not unlikely, moreover, that the efforts used would have resulted in pushing the fragment into the vitreous chamber. Extracting the lens in its capsule is a

possible but a hazardous procedure, and only applicable in those instances where the wound in the capsule has been small and has immediately closed. That, however, such a mode of treatment may be attended with success, the following case, occurring in the pre-magnetic days, witnesses.

Some years since (1876) a man, a fitter, came under observation for a "mote" in his eye. A chip at his work had struck the eye, and a piece of steel was readily noticed, especially with focal illumination, sticking in the lens, nearer its anterior than its posterior surface. The time he was first seen would be about ten days or a fortnight after the accident, and the lens had become a little opaque. It was decided to remove the lens entire in its capsule. It will suffice to say that this was accomplished through a lower corneal section, and that an iridectomy was performed. The patient recovered excellent vision. The fragment was found firmly sticking in the substance of the crystaline lens.

This case was thus successfully treated, but was more suitable for the plan pursued than any of those previously referred to, inasmuch as a free opening in the capsule would have precluded its performance. The employment of the electro-magnet compares favorably with such a procedure. The cases about to be related will illustrate the difficulties attending the removal of fragments from the lenticular space by other means than the electro-magnet.

Towards the close of 1881, an old man (æt. 76) came to the Sheffield General Infirmary from the country on

account of an injury to the right eye. A piece of cinder had struck the eye, and having passed through the cornea, was sticking in the lens, which was opaque ; part of the foreign body, however, remained in the aqueous chamber. To remove this an incision was made at the lower part of the cornea, and an effort was made to seize the piece of cinder with forceps, and it was only after repeated attempts with these and with a curette, that, after a large quantity of vitreous had been lost, its removal was effected.

How different the result had the cinder chanced instead to have been a piece of steel or iron !

A young man, æt. 22, was seen on January 8th, 1878. This was the day of the accident, and, indeed, he was admitted at the Infirmary a few hours after its occurrence. He had been engaged chipping a metal plate, and a piece of iron had sprung off and hit one of his eyes. The fragment was sticking in the lens, but projected also into the aqueous chamber. The lens was already opaque, and the capsule had been freely torn. The foreign body had entered through a wound in the cornea, situated below. This was enlarged, and the removal of the piece of metal attempted with forceps unsuccessfully, but subsequently it was effected by means of a curette. The softened lens was allowed to escape.

On February 14th, with a + glass he was stated to be able to read J. 8, and that later on vision was somewhat better.

This last case occurred at a time before we had an

electro-magnet, or even a simple magnet in regular use, and there need be little hesitation in asserting that the extraction of the fragment of iron would have been immediately effected with the needle of the electro-magnet, for in those instances where the particle is visible, the needle is advanced directly to it and its removal effected without difficulty.

Vitreous.—It is in the class of cases in which fragments are situated in the vitreous chamber that the electro-magnet evinces particularly its superiority over the older methods. It was in this class that the groping with forceps was undertaken; and as not infrequently the particles are entirely hidden from view, the advantage of employing an instrument capable not merely of *seeking* but of *attracting* such chips will be at once evident.

It may here be of interest to refer to the valuable paper of Knapp's on "The Removal of Foreign Bodies from the Interior of the Eye,"* and from the portion devoted to the consideration of those situated in the vitreous chamber the following extracts are taken:—After mentioning that numerous examples of foreign bodies in this region are to be found both in modern and earlier literature, he adds: "But the number of cases in which foreign bodies have been removed from the posterior part of the globe is very small," and "the cases of successful or only partially successful removal of foreign bodies from the vitreous chamber and its walls are so rare that they may be

* 'Archives of Ophthalmology,' vol. vii, p. 343.

considered almost as exceptions." His remark on the operative procedures sets forth well the older methods for the removal of foreign bodies from the vitreous. His words are: "I will first mention the two methods devised by A. Von Graefe, and especially practised for the removal of cysticerci, viz.: 1st, the extraction of the foreign body through the cornea, preceded by peripheric linear extraction of the lens; and 2nd, the extraction of the foreign body through an opening in the sclerotic by a circular section. Both methods involve great dangers. The first I consider admissible only when traumatic cataract is present. If, after the removal of the cataract, the foreign body cannot at once be seen with oblique illumination or the ophthalmoscope, three methods are at our disposal:—First, we may wait until the wound is healed and the eye cleared up, to determine the site of the foreign body with the ophthalmoscope, and either trust to its becoming encapsulated, or remove it through a scleral opening. Secondly, we may with a probe, or still better with a hook, search for the foreign body. This procedure, I think, is very hazardous, though it is supported by a successful operation (Schöler), the details of which I am unfortunately unable to look up. Thirdly, the immediate enucleation of the eyeball. This operation I would perform without delay in all cases in which symptoms of violent irritation indicate beginning panophthalmitis. The immediate enucleation—that is, without first extracting the lens—I consider the most advisable in

all cases in which we are sure the foreign body has passed through the lens. The danger of sympathetic affection is not counterbalanced by the slight chance of extracting the foreign body with preservation of a useful eye." The instruments he mentions for use are hollow transversely grooved hooks, and varieties of forceps.

Such, then, being the line of treatment advised by such a high authority in recent pre-magnetic days, we shall see in what way, and to what advantage, the electro-magnet is now used, bearing in mind, of course, the limit of its sphere, and the largeness of the one alluded to in Knapp's remarks. Many cases of removal of fragments with the electro-magnet from the vitreous will be found in the list of appended cases by different operators, and the rapidity with which the record of these cases has recently grown is worthy of note.

In *eight* instances the author has himself successfully extracted chips from the vitreous. The cases will be related in detail, as they present differences in character and in the exact line of treatment pursued.

9. James C—, æt. 33, whilst engaged on September 10th, 1880, in striking an iron plate with a hammer, was hit in the right eye by a piece of metal. This happened in the course of the forenoon, and he lost no time in applying at the Sheffield General Infirmary, where the writer happened to be, so that he saw him immediately. On the inner side of the sclerotic, at some little distance from the cornea, and in the middle line of the palpebral fissure, was a small horizontal wound. Examination with a fine probe at once

disclosed the fact that the greater portion of the foreign body was lying in the vitreous humour, but that it clung to the inner sclerotic wall sufficiently to enable one to detect it with the probe. The situation of this piece of steel was such that it appeared only too evident that any attempts to remove it with forceps or otherwise, would most probably result in its being pushed further into the interior of the globe. The only electro-magnet at hand was one which was too large to introduce into the wound, and therefore it was decided to place it at the surface of the wound, which, at the same time, was carefully enlarged a little in order to enable the fragment of metal to find a passage outwards more easily. After the electro-magnet had been applied a little time the foreign body was found to be fairly in the wound, and it was readily removed with a fine pair of forceps. The patient remained in the Infirmary for a few days, and the sclerotic wound healed immediately, and on a later date it was noted that vision was perfect ($\frac{6}{6}\frac{9}{9}$).

On February 24th, 1881, he was shown before the Sheffield Medico-Chirurgical Society, at which time sight remained good, and up to the present, thirty-two months since the operation, there is no reason to doubt its being still perfect. It may be added that with the ophthalmoscope a faint scar was visible corresponding to the wound in the ocular tunics. The chip removed was either lost or given to the patient, so that there is no record of its size and weight.

10. William C—, æt. 27, was admitted into the Infirmary on July 8th, 1881. About a week before, whilst following his employment, he was engaged in chipping a steel casting, and a portion flew off and hit his right eye. When seen on July 8th there was a small penetrating wound in the cornea, just below the pupil; in the iris also was a trian-

gular notch corresponding to the mark in the cornea; a wound in the anterior capsule was noticeable as well as one in the posterior capsule. This series of marks evidently pointed out the track of the foreign body, and as each one was on a higher level to the one superficial to it, it demonstrated also its upward direction. The lens was hazy and no particle could be distinctly observed, but it was judged to be lying at the posterior capsule, just where the wound was noticed, or in the vitreous immediately beyond. The eye had remained painful and congested after the accident for some days, and there now seemed to be some slight iritis, which did not, however, interfere with fair dilatation of the pupil with atropine.

July 10th. To-day the patient was operated upon in the following manner. No anæsthetic was administered, the patient preferring to have the operation performed without one. With a Graefe's knife a small shallow lower flap was made in the cornea, the capsule being next ruptured, and the needle of an electro-magnet inserted. It was passed freely through the softened lens matter towards the posterior capsule, and twice withdrawn without the particle one was in search of being attached. Inserted again, however, a third time, it was pushed upwards and inwards, towards and through if possible, the opening which had been observed in the posterior capsule; a "click" was now heard, and the needle was withdrawn with the chip attached, followed immediately by some escape of vitreous. Most of the softened lens had escaped during the introduction of the electro-magnet, and the eye was immediately closed to prevent any further loss of vitreous. Pads and a bandage were placed over the eyes, and the patient was removed to his bed.

Recovery was good and there is nothing further of importance to note. On January 17th, 1882, some opaque capsule was needled, and later on (July, 1882) it is noted

that V + $\frac{1}{3}$ = $\frac{20}{30}$. The particle removed weighed seven milligrammes.

11. Edwin H—, æt. 28. On December 9th, 1881, the patient was at his work, and near to him some other men were occupied in hammering a table-knife, when a portion of steel off their hammer struck him in the right eye. About an hour after the accident he came to the Infirmary. It was then noted that there was a perforating wound of the cornea, rather below its centre and in the outer part, and a wound also in the iris. No fragment of steel could be detected in the eye, either with focal illumination or with the ophthalmoscope; the capsule had been freely opened and the lens was somewhat opaque. Atropine, to be dropped into the eye, was prescribed.

During the next two or three days the eye continued irritable and painful, and, as ophthalmitis seemed threatening, it was decided to evacuate the lens and search with the electro-magnet for the fragment of steel, which, though looked for so soon after the accident, had escaped detection. For this purpose—no anæsthetic being administered—the original wound was enlarged and the needle of the electro-magnet inserted; the lens matter, which was soft and opaque, readily came away, and then vitreous presented at the wound, a small quantity escaping. Whilst the point of the electro-magnet was in the vitreous chamber, a "click" was heard, and on removing the instrument a large piece of steel was seen attached. The patient soon recovered, retaining only, however, light perception. He has not been seen for a very considerable time, so whether or not his condition admits of improvement cannot be stated. The weight of the fragment removed was forty-eight milligrammes.

12. Benjamin H—, æt. 34, was struck over the right eye with a piece of steel. A wound, oblique in direction, was

occasioned at the upper and outer border of the cornea. He suffered constant pain, and when first seen two or three days after the accident, suppuration was commencing. He was admitted into the General Infirmary, and on March 3rd, 1882, the original wound was re-opened and an incision made at right angles from it across the cornea; the needle of the electro-magnet was then passed into the vitreous chamber, and after searching for some time the fragment was found and withdrawn attached to the electro-magnet. A pad of salicylic silk was placed over the eye, and there is nothing to note about his after progress, except the freedom from pain experienced, and that eventually the globe shrank and atrophied. The chip removed weighed 190 milligrammes.

13. Robert B—, æt. 28, was admitted into the Sheffield General Infirmary on August 3rd, 1882. Whilst engaged on the night of July 21st, 1882, in holding a piece of red-hot iron which a fellow workman was striking, a chip sprang off and hit his left eye. He immediately went to a medical man, and remained under his care until coming to the Infirmary at the date before given. In the meantime he had suffered a great deal of pain and the eyeball had become inflamed.

On admission to the Infirmary his condition was as follows:—The surface of the eyeball was much inflamed and very vascular. The iris was dirty looking, the aqueous somewhat turbid, and the pupil dilated poorly and irregularly to atropine. On the outer side of the eyeball, in the palpebral fissure, and about the equator, was a dark, somewhat bulging elevation, suggesting the situation where the fragment had struck the sclerotic, the wound having subsequently become staphylomatous. He complained of pain as being constant and unbearable. Vision was reduced to light perception, and the media (especially

vitreous) were too turbid to allow of any reflex with the ophthalmoscope.

A consideration of this case made it appear only too probable that the chip of steel had penetrated the sclerotic at the staphylomatous spot described above, and was lodged in the interior of the globe. It was decided to attempt its removal with the electro-magnet.

On the day, therefore, of his admission into the Infirmary, August 3rd, *i.e.* thirteen days after the accident, he was taken into the operating theatre and the operation proceeded with. The conjunctiva was divided somewhat in front of the bulging sclerotic wound, and this having been dissected up, formed, as it were, a flap to cover the deeper incision. The bleeding was very copious and was checked with ice and iced water. The sclerotic wound was next enlarged, and the needle of the electro-magnet introduced into the interior of the globe. A quantity of discolored fluid immediately escaped and the needle was removed once without the fragment of steel. A larger needle was substituted, the instrument was again introduced and this time was withdrawn with a large chip attached to it. The eye was closed and covered in the usual way with a wet pad of lint. The relief to pain was immediate; the patient expressing the next day his sense of the comfort the operation had afforded him. On the sixth day after the operation he left the Infirmary.

The condition of the eyeball at the time he came under observation was such that it precluded any prospect of restoring vision, but the removal of the foreign body gave him a chance of preserving a presentable organ. When last seen, some time after the operation, the eyeball was quiet and the condition satisfactory. The chip removed weighed thirty milligrammes.

14. William F—, æt. 42. Early on the morning of

September 2nd, 1882, the patient was holding a "sett" which men were striking with the big hammer, to cut some scrap iron. A piece flew off, striking his left eye. He imagined the chip came from the "sett" in which case it would be steel. He was seen shortly afterwards by a medical man, but it was not until later that he came under the writer's observation. There was a wound of cornea running almost horizontally, being tailed, however, a little downwards and inwards; commencing a short distance from the centre of the cornea, it passed towards the sclero-corneal junction. Behind this wound the iris was severed, and the lens was opaque, the capsule having been freely opened.

The next day the eye appeared inflamed, and he suffered a good deal of pain. It was not, however, until the day following, September 4th, the third day after the accident, that one was enabled to make use of the electro-magnet. The conjunctiva was now much chemosed, the aqueous was turbid, and indeed there was lymph in the anterior chamber. The pain experienced was most intense, and, to use his own expression, he was "like a wild man." The situation of the fragment was not accurately made out; but it was surmised to have passed through the lens into the vitreous chamber. It was decided to operate without an anæsthetic. With a Graefe's knife the original corneal wound was re-opened and somewhat enlarged, and another was made, joining it at right angles. After searching in the vitreous in different directions, and the needle having been withdrawn without having caught the foreign body, it was passed downwards, more towards the ciliary processes, and a piece of steel, thin and flat, then attached itself to the electro-magnet. The patient asserted it had evidently been a chip from the "sett." The next night he was comfortable and free from suffering. The eyeball subsequently became

softened and somewhat shrunken. The chip weighed nineteen milligrammes.

15. Thomas W—, æt. 42, on November 1st, 1882, at 9 a.m., was chipping the rough ends off bars of iron, and whilst doing so a splinter struck his left eye. He immediately went to a medical man, who, suspecting the chip had penetrated the globe, advised his going to the Infirmary. He acted on this advice, and was accordingly admitted. The writer saw patient the same evening. There was then noticed a wound, commencing in the outer part of the cornea and running through the sclero-corneal junction into the ciliary region. The capsule of the lens had been freely opened, and the latter was somewhat opaque. With the ophthalmoscope, towards the background of the eye, the view of which, however, was a good deal obscured by the haziness of the media, was noticed a somewhat bright reflex at one part, which was considered likely to be the foreign body. Without an anæsthetic the original wound was enlarged towards the cornea, and the needle of the electro-magnet passed through the lens and into the vitreous. Now, however, it was found, after searching vainly for the particle for some time, that the attractive force of the electro-magnet, not the strongest at the outset, had become almost nil, but one hesitated to proceed further then, and did not therefore substitute a battery* in better working order. After this the patient suffered a good deal of pain, and suppuration appeared imminent.

On November 6th, consent having been given to the removal of the globe, if deemed necessary, he was again

* The author has learnt from experience, in order to insure when needed a battery in good order, the advisibility of keeping the bichromate solution separate from the zinc plates, and only putting it into the cell when the battery is required for use.

brought on to the operating table. He was got fully under the influence of ether, and feeling confident as to the presence of a piece of metal in the eyeball, the writer decided again to try the electro-magnet, which was now attached to a very efficient bichromate cell. With this object an incision was made in the sclerotic on the outer side, care being taken to adopt a conjunctival flap, as in a previous case (13), but which in this instance was more difficult in consequence of the swelling of the covering membrane. The sclerotic wound was joined at about its centre by another running for a short distance at right angles to it. The needle of the electro-magnet was then introduced into the vitreous cavity, one of the larger polar extensions being attached, and immediately it was withdrawn with the chip of metal adherent. The fragment was of a peculiar form—boat shaped—and weighed 240 milligrammes. Its removal, however, did not arrest the suppurative process which had already set in, and on November 27th the eyeball was enucleated.

The next case possesses some points of particular interest, not merely on account of the removal of the fragment, but for the presence of the particle, and the possibility of its extraction, being demonstrated by the electro-magnet.

16. John C—, æt. 23, came to the Infirmary on January 26th 1883, and stated that three weeks previously whilst pursuing his occupation he was punching holes in a knife "tang," when the punch broke and a portion of steel struck his right eye. A little bleeding resulted and he became very soon blind. He had been under treatment elsewhere before coming to the Infirmary on the date mentioned. On the sclerotic, on its outer side, and reaching from a little distance from the corneal junction, and run-

ning outwards for perhaps about a couple of lines, was a faint linear scar ; it was situated about midway in the palpebral fissure. Beyond this there was no external injury. The cornea, anterior chamber, and iris were unaffected and the pupil dilated fully to atropine. No reflex could, however, be obtained with the ophthalmoscope ; the vitreous was quite opaque, and the buffy tint seen just behind the lens suggested that the vitreous chamber was occupied with blood. The nature of the wound and the history of the case led to the supposition that the fragment of steel had penetrated the globe and lay inside it. As, however, the eye was perfectly quiet it was decided for the present to postpone operative interference, for it was thought that as the intra-ocular hæmorrhage cleared, as it was hoped it would, the location of the foreign body would be perhaps ascertained, and its removal facilitated. With this object in view he was kept under close observation. Atropine was employed to maintain dilatation of the pupil. Gradually the vitreous cleared (hæmorrhage), and at the latter end of the week preceding the operation a yellowish mass was observed in the back part of the eye, either with or without focal illumination, some little distance behind the lens. By February 12th this had become more distinct, and although the vitreous allowed a very imperfect reflex with the mirror, and that only at the upper part, the yellowish mass was found to be continuous by a track of lymph up to the sclerotic wound. Before proceeding to remove the fragment which it was felt confident was contained in this lymphoid collection, it seemed desirable as well as interesting to ascertain the effect upon this supposed particle of steel of the electro-magnet when approximated to the eyeball. Directly the instrument was brought close to or in contact with the sclerotic, it being used without the needle, the yellowish mass was seen to spring about in the vitreous and to follow the electro-

magnet from point to point. The movements were most evident, and were readily observed by the assistant and some students who chanced to be present. This experiment of course confirmed the diagnosis in a most decided and satisfactory manner. It taught, also, a no less useful or important lesson respecting operative interference in the case, viz. that in addition to the broken-down condition of the vitreous, which was to have been expected, that though the fragment had lain inside the globe for six weeks, the adhesions formed around it, if any, were so lax as to offer but little obstacle to its removal with the electro-magnet. These points, however, will be discussed more fully further on when referring to the value of the magnet in diagnosis.

The patient consented to an operation being undertaken for the removal of the foreign body, and he was accordingly admitted into the Infirmary. On February 13th the following procedure was adopted. Bearing in mind the situation of the particle of steel it was determined to make an incision in the sclerotic between the external and inferior recti muscles, it being thought that from this point the foreign body would be most readily reached. It was deemed, also, unadvisable to reopen and enlarge the old wound, partly from its being inconveniently situated and partly also as it involved the ciliary region. The patient decided to have the operation performed without an anæsthetic. After the introduction of a speculum the conjunctiva was divided some little distance in front of the intended sclerotic section, and separated carefully back to this point with scissors, in this manner forming a conjunctival flap. After all bleeding had been stayed with ice and iced water, the sclerotic was incised meridionally with a Graefe's knife, in the situation decided upon and towards the equator, in extent about two or three lines. The incision was joined by a cross cut at its centre, making it thus T shaped. Some yellowish-green fluid escaped, and

then the needle of the electro-magnet was introduced. The chip was seen (no click) to be attracted to the magnet, but on its withdrawal it was found not to have brought the piece with it. Again this happened, and the fragment with its surrounding lymph was no longer visible in the eye, and it was thought to have been stripped off at the wound and to be perhaps entangled there. The wound was therefore enlarged, and a shorter and thicker (more powerful) needle substituted for the one previously used. The fragment was now found at the wound; and though attaching itself to the electro-magnet, it was unable to pass until the lips of the wound were held apart by forceps, when it was readily withdrawn adherent to the needle. The particle was the size of a hemp seed, and from its shape and form appeared to have been a portion of steel which had been punched out of the knife "tang," instead of from the broken punch as the patient had supposed. Its weight was sixty-nine milligrammes. The conjunctival flap was closed over the sclerotic wound and united by one suture. A pad of lint soaked in cold water was applied, and atropine was ordered to be dropped into the eye once daily. On the third day the conjunctival suture was removed. The eye recovered without any inflammatory symptoms, and on February 19th he was allowed to leave the Infirmary. At the time of writing (end of March, 1883) the eye externally looks as well as its normal fellow; the vitreous has considerably cleared up, though as yet the details of fundus are not distinctly made out, and at the lower part is still a yellowish lymphoid track. Vision is only equal to good light perception.

It may be remarked respecting the eight cases here recorded, as those in which fragments of metal have been removed from the vitreous, that in two instances

good vision was recovered, whilst the others failed in that respect. Of the first group, No. 9 regained perfect sight $\frac{20}{20}$, whilst in No. 10 vision $=\frac{20}{50}$. The others it must be observed did not immediately come under notice, or the eyeball was already disorganised before the electro-magnet was enabled to be employed. Five (Nos. 11, 12, 13, 14, 16) out of the six retained presentable organs in, as far as is known, a quiescent state; in only one instance (No. 15) was enucleation resorted to. Five also, out of the eight cases, (Nos. 9, 11, 12, 13, 14) were operated upon by enlarging the original wound, but in the last two instances (Nos. 15 and 16) the fragment was satisfactorily removed through a fresh sclerotic incision, and in one (No. 10) by means of a new corneal flap. In only three of the instances referred to (Nos. 9, 13, and 16) had the fragments entered the vitreous through the sclerotic, the remaining five chips (Nos. 10, 11, 13, 14, and 15) had passed through the cornea before reaching the vitreous chamber.

Many points which have reference to the removal of chips from the vitreous will perhaps be better noticed after the record of the unsuccessful cases, and when dealing with the employment of the electro-magnet generally. It may, however, here be remarked that, whilst the electro-magnet renders efficient service in the removal of fragments from the vitreous, to be of use in preserving vision it must, at all events, in the great majority of cases, be employed early. This will have been evident from the foregoing

series of cases. Hirschberg has remarked respecting the use of the electro-magnet for the removal of chips of steel or iron from the region under consideration: "It celebrates real triumphs, when the foreign body is found within the vitreous, from which it generally cannot be extracted with the common instruments without severe damage to the eyeball."

Retina.—This region may be referred to as occasionally the seat of a metallic foreign body. It is known that sometimes the presence of such a particle appears harmless, the patient retaining good sight. The author* has recorded one such case, in which a piece of steel was situated close to the optic disc, with the preservation of perfect vision up to the time when patient was lost sight of (about two years); and he has since observed a case somewhat similar. Cases have also been recorded by other observers, and Knapp in his 'Archives' for 1882, collected a series of thirteen such cases from various sources, including the first recorded one of the author's. Knapp observes: "I would, in recent cases, try the removal of the foreign body, by curved hooks, forceps, or the magnet only if it could be seen." Considering the difficulty of removing such fragments, even with the electro-magnet, if they are at all imbedded, and bearing in mind also the wonderful tolerance of foreign bodies in this situation, a great deal may be urged against any such interference as is here suggested. If, however, in any case the needle of the electro-magnet

* 'Ophthalmic Hospital Reports,' vol. ix, p. 370.

be employed, the importance of using it whilst the injury is recent may be readily acquiesced in. Each case would appear to particularly require judgment on its individual characters. There is only one case, as far as the author knows, recorded of removal of a foreign body from the retina by the electro-magnet, and that a case by Galezowski is referred to towards the end of this little volume.

It may be convenient to group together the weights of the different fragments, removed in the foregoing cases. It will be recollected in one instance the fragment was lost.

	Grammes.	Grains.	Situation.
Case 1 ...	·0175 ...	·270 ...	Eyelid,
„ 2 ...	·0037 ...	0·570 ...	Lens.
„ 3 ...	·0005 ...	·0077 ...	„
„ 4 ...	·0003 ...	·0046 ...	„
„ 5 ...	·0009 ...	·0138 ...	„
„ 6 ...	·0009 ...	0·138 ...	„
„ 7 ...	·0060 ...	·0925 ...	„
„ 8 ...	·0023 ...	·0353 ...	„
„ 9 ...	Missing	...	Vitreous.
„ 10 ...	·0072 ...	·0111 ...	„
„ 11 ...	·0479 ...	·7391 ...	„
„ 12 ...	·1898 ...	2·928 ...	„
„ 13 ...	·0296 ...	·4567 ...	„
„ 14 ...	.0194 ...	·2993 ...	„
„ 15 ...	·2339 ...	3·609 ...	„
„ 16 ...	·0691 ...	1·066 ...	„

It will now be well to pass to the consideration of the unsuccessful cases, for in addition to those related as successful, there are two others in which the electro-magnet was employed, which must be classed as

failures, inasmuch as the instrument did not remove the fragments. Both of these cases admit, however, of such a ready explanation as to the reason of non-success that they but little depreciate the almost certain usefulness of the electro-magnet in suitable cases. Another case will here be mentioned in which, with a simple magnet, failure occurred. Each of these instances will now be given fully.

17. This case* was related at a meeting of the Ophthalmological Society in consequence of sympathetic ophthalmia occurring in the second eye thirty-two days after enucleation of the injured one, and as many of the particulars are reproduced here as are necessary.

"C. S—, æt. 26, a fitter, was engaged at his occupation on September 26th, 1881, and was chipping some steel when a portion flew off and struck his left eye. The accident happened early in the morning, and in the afternoon of the same day he was brought to me. There was a wound of the cornea, at the upper and inner part, of about a couple or three lines in length; externally it extended only to the sclero-corneal junction. There were some filmy opacities in the lens, but the pupil dilated well with atropine, and they did not offer any obstacle to a careful search of the interior of the globe with the ophthalmoscope for the presence of a foreign body. None, however, could be detected, and this corresponded with the patient's impression that the fragment had not remained within the eye. He was advised to become an in-patient at the Sheffield General Infirmary, and to this he consented. Atropine and cold water compress were ordered. The next day he complained of some pain, the lenticular opacity had increased, and there were signs of iritis. In

* 'Trans. Ophthalmological Soc.', vol. ii, p. 19 (1882).

another twenty-four hours the pain was aggravated, and there was lymph in the anterior chamber. An incision was made at the upper part of the cornea, and as much softened lens matter evacuated as could be readily done, and during this procedure a little vitreous was lost." Here it must be stated, but which was omitted when relating the case previously, as foreign to the object for which it was recorded, that the needle of the electro-magnet was passed well into the lenticular chamber and into the vitreous; the battery, however, was in such bad order that the magnet possessed only the faintest attractive power, and as the examination which was made so soon after the accident appeared so decidedly to negative the possibility of a foreign body being in the globe, it seemed unnecessary to substitute a bichromate cell in efficient order. The search with the electro-magnet was therefore quite of a summary character. "However, the next day he expressed himself as relieved, but his friends removed him to his home again. His subsequent progress was briefly as follows:—The injured eye suffered occasionally from pain, but the inflammatory symptoms gradually disappeared and the eyeball commenced to shrink. The sound eye was never more affected than by merely signs of 'irritation.' The removal of the injured globe was soon suggested. This, though urged at different times, was always rejected until December 9th, when consent was obtained, and enucleation was performed forthwith, eight weeks after the accident. Examination of the interior of the eye now disclosed a fragment of steel sticking in the lower and outer ciliary region, thus being out of the way of visual inspection. It is a matter of regret that the examination made so speedily after the injury appeared so conclusively to negative the presence of a foreign body in the interior of the eye. Had it not been so the electro-magnet, attached to a good battery, would have rendered

the removal of the fragment of metal almost a certainty."* To this statement must, however, be added the fact of the chip sticking somewhat in the tunics, an important point in connection with the feasibility of the removal of fragments as will be shown presently.

18. William C—, æt. 50, a steel melter, was employed at one of the large iron works at Newcastle-on-Tyne. It was whilst working there in one of the early days of August, 1882, that he sustained an injury to his left eye. A man near him was chipping a piece of steel and a fragment flying off had struck the patient's eye. Immediately after the accident he was examined by a medical man, who asserted there was no foreign body inside the globe. He could see nothing after the injury, but in a short time could distinguish shadows. It was not until about three weeks later (August 21st) that he came under observation at the Sheffield General Infirmary. There was then noticed a wound in the inner ciliary region. The lens was transparent, and in the background of the eye a yellowish mark was visible to the naked eye, but more so by the aid of focal illumination, but no reflex was obtainable from the fundus with the ophthalmoscope. Vision=fingers poorly. The opinion formed was that the fragment of steel had penetrated the eye, and was in fact now inside it surrounded by the mass of exudation to which allusion has been made. It was determined, therefore, to attempt its removal. Shortly after his admission, ether having been administered, a meridional incision was made in the sclerotic at its outer part and towards the equator, a conjunctival flap having first been formed as in previous cases. The needle of the electro-magnet which was in perfect order was then introduced and approached to the yellowish mass. It was,

* The remainder of this case will be found, as before stated, in the 'Trans. Ophthalmological Soc.', vol. ii.

however, withdrawn without bringing the fragment with it, although a movement was observed in the exudative portion, as if in some measure it had been attracted to the electro-magnet. No other result happened although the proceeding was several times repeated; the largest needle was attached and inserted, and still it seemed as if a slight movement had taken place, but no foreign body could be withdrawn. Feeling convinced that this was indeed the fragment, surrounded with exudation, attempts were made to seize and remove it with forceps, but with no better result. No permission to enucleate had been granted, nor, indeed, had it been solicited, as the prompt removal of the chip of steel had been counted upon; for the present therefore it was necessary to desist. Subsequently (Sept. 18th) consent was given and the eyeball was excised. On opening the globe a large fragment was at once noticed firmly embedded in the optic disc, and projecting into the vitreous humour.

From the relation of these two cases, it will have been noticed that the failure to remove in each the foreign body finds a ready explanation. In the first case, by reason of the insufficient force imparted by the battery to the electro-magnet, and the non-perseverance in the use of the latter, in consequence of a wrong impression as to the absence of a foreign body, gleaned from an early examination, and it must be added in some measure a certain fixity of the fragment. It is, however, questionable whether this latter circumstance would have materially influenced its removal, if the electro-magnet had been as powerful as usual, and had been employed, as it was, a few days only after the accident.

The want of success in the second instance depended alone upon the impaction of the chip into the posterior tunics, being there so firmly fixed as to render its removal impossible, one would imagine, by the aid of any electro-magnet that could be introduced into the interior of the eye. Similar cases have occurred in the practice of other operators, and those which have been noted by Hirschberg, Lloyd Owen, and others, will be noticed in the reference to recorded cases further on. Such a failure, indeed, as occurred in this last instance, the writer had from the first anticipated as likely to happen, and experience has only confirmed what early experiments and considerations rendered probable. The following passage, from the author's previous communication on the employment of the electro-magnet, may be here quoted:—"The cases (Nos. 3 and 9 in this series) I have related illustrate the services the electro-magnet may afford in removing fragments of steel or iron from the interior of the eye. They were cases in which the injury was recent; but in those where the foreign body has lodged for some time in the eye and become coated over, and especially when encapsuled and adherent to adjacent parts, such results are hardly to be expected. In some experiments made with portions of steel and iron coated with gelatine, it was found they were very readily attracted by the electro-magnet; and in other fragments which were enclosed in gelatine capsules, the electro-magnet still exerted considerable influence over the contained particles, if they were not too far from the surface.

Whatever effect the electro-magnet might have, therefore, on pieces of metal but slightly coated, it does not seem likely for sufficient attraction to be exerted to drag a particle away from its adhesions."

The conclusions then arrived at have proved correct in practice. It is possible for particles surrounded by lymph to be attracted by the electro-magnet, as has been abundantly shown; and even with a measure of impaction it is not impossible to attain success, in favorable conditions, such as being able to advance the needle (coarse) of the instrument or the magnet itself close up to the foreign body; but in those instances in which the particle is firmly fixed, experience, it would appear, proves the opposite.

One other unsuccessful case remains to be recorded. In this instance, occurring before the electro-magnet at present in use was devised, a simple bar magnet was unsuccessfully employed. Experiments had been made with various kinds of these instruments, and in this case, the magnet used consisted of a simple steel bar tapered at one end to a point, a line and a half wide and three quarters of a line thick. The length of bar was thirteen inches. This, for a simple permanent magnet was possessed of considerable power. The case in which it was employed is the following one.

19. A miner in one of the Derbyshire mines, was engaged (early part of 1880) in boring for the purpose of blasting, and a piece of the drilling instrument had flown off and struck one of his eyes. The medical man who saw him advised his coming to the Sheffield General Infirmary.

There was then a large wound in the cornea, the lens was opaque, and the foreign body appeared to have lodged in the vitreous humour. After the opaque and softened lens matter was removed, the magnet above mentioned was passed into the vitreous body but failed to detect the piece of steel, though the subsequent removal of the eyeball demonstrated the fragment lying at the fundus oculi.

The writer entertains little doubt that if the electro-magnet described in these pages had been employed in this case, the fragment of steel would have been removed. Reference has already been made to the fact that in his recorded cases, McKeown employed a simple bar magnet, and that Gruening of New York devised a more complex, yet still permanent magnet for ophthalmic use; but the superiority of a properly constructed electro-magnet over the best made permanent magnet cannot well be disputed.

There are points yet remaining with reference to the employment of the electro-magnet which may, perhaps, be conveniently noticed now. Firstly, then, as to the mode of introducing the instrument into the interior of the eye. This may be accomplished and the foreign body reached either through the original opening or by means of a fresh incision. Both of these methods find exemplification in the cases already related. If the accident is recent, and especially if the fragment is lodged in the anterior part of the eye, it will often be found prudent to make use of the original wound, enlarging it if necessary. On the other hand, if the wound is already closed, it will generally be preferable

to make a fresh incision, which will enable one, moreover, to select a situation the most convenient for reaching the foreign body. This last remark applies particularly to instances of chips in the vitreous, and even in recent cases advantage will often be derived by making a new sclerotic section. The importance of making the cut T-shaped, has been pointed out by Bradford, to obviate the stripping off of the fragment at the edges of the wound, which sometimes occurs. For this reason also, service may be rendered in some cases by holding the lips of the wound apart with forceps. It is hardly necessary to allude, perhaps, to the importance of any scleral incision being made posterior to the dangerous ciliary region; and a meridional direction, as Hirschberg also advises, will be found preferable. In making a sclerotic incision, it will be of advantage to separate the conjunctiva some little distance in front of the proposed point of section, forming in this manner a "conjunctival flap," which covers well the deeper wound, and which may be closed over by one or more sutures, and thus render, in the great majority of cases, their employment in the sclerotic unnecessary. Bleeding from the conjunctiva should be stayed with ice or iced water before incising the globe.

An important advantage belonging to the electro-magnet should not escape notice. Reference is here made to the way it allows, in instances where the foreign body is visible, the needle to be advanced directly up to the fragment of metal before the instrument is rendered magnetic.

As has before been mentioned, in several instances the needle attached to the electro-magnet has been employed as a probe. The cases in which it was so used, were generally those in which the injury was severe, and at all events, presented a possibility, however remote, of a fragment of steel or iron being in the interior of the eye. Many were cases in which from the size of the wound and other causes, it was deemed hardly likely that the searching of the interior of the globe with the needle, would aggravate the condition. Some manifestly demanded enucleation. In others in which the lens was broken up, it was thought well to remove it, and the instrument was employed and the lens space explored; and it will be understood from the earlier remarks that in some cases, the vitreous cavity was also searched. Employed, however, thus in these cases, as an aid to diagnosis and in some as an attempt to obviate the necessity for removal of the eye, in no instance did one succeed in finding a particle of metal. Nor, on the other hand, did subsequent enucleation, nor the after history of the cases, point out that a fragment had escaped one's exploration. If, however, this had been the case occasionally, it would hardly have been surprising, considering the more limited search one necessarily felt permitted to make, where the presence of a foreign body was, to say the least, doubtful, than where the diagnosis was more positive.

It must be remembered that the magnet offers this immense advantage over every other kind of probe,

that it not merely *seeks* the metal, but the metal *seeks* it.

Referring to the employment of the electro-magnet as an aid to diagnosis, mention may be made of the sense of discomfort experienced when the instrument is brought into close apposition with an eyeball containing a piece of steel or iron. This has been remarked upon by McHardy and other observers. The author perhaps has noticed this less, and undoubtedly in several instances it has been absent. Still one case in particular, a little boy (Case 4) complained of pain in the eye, when a powerful electro magnet was held in front of the cornea, and it then seemed to indicate though no movement of the foreign body was visible, its nature and that some measure of magnetic influence had been exerted upon it. Another patient also complained of the "dragging" experienced in the eye on the contact of the instrument. The writer has, however, only seen sufficient of it to regard it as an uncertain and by no means reliable aid to diagnosis.

In another manner the electro-magnet will often render conspicuous service in deciding as to the presence of a fragment of metal in the interior of the eye. McKeown called especial attention to this, describing* the lessons taught by watching the effects on a supposed fragment inside, of a magnet moved outside the eye. It must be mentioned that he employed a simple bar magnet. He mentions a case in which "the quivering of the body under the influence of the magnet afforded

* 'Dublin Journal of Medical Science,' 1876, p. 208.

proof beyond question of the presence of the metal and its nature and warranted him in undertaking the operation," for its extraction. Dr C. S. Williams of Boston, U.S.A. found the electro-magnet useful in deciding whether a foreign body lying in the iris was stone or steel; the action of the instrument proved it to be the latter and its removal was effected. A case of the writer's (No. 16) referred to already in detail has points of interest in this particular. It will be remembered that the mass of exudation, which was supposed to envelop the foreign body in the vitreous, on the approach of the electro-magnet without the needle, was observed to change its position and followed the instrument as it was moved to different parts of the sclerotic. These movements were of the freest kind and were most easily observed. The presence of a foreign body and its character, steel or iron, were completely thus set at rest. But in addition another interesting and important aid was afforded to the treatment of the case. The free mobility of the chip from point to point, not merely proved, what was before anticipated, that the consistence of the vitreous had become altered, but that the adhesions, if any, which had formed around the fragment of steel were of the loosest character and that notwithstanding the time (six weeks) it had remained inside the eye, its removal with the electro-magnet was feasible. The subsequent operation showed the accuracy of these anticipations.

The ease with which the ordinary steel instruments, knives, forceps, &c., are converted into permanent

magnets, by being brought into contact with an electro-magnet, is worthy of notice, for it enables an operator if he so desires, to substitute one of these instruments for the electro-magnet in any given case. They have in this manner been employed by different operators, and perhaps in some cases such a device may be useful. Particulars of such cases by McHardy and Hirschberg will be found among the recorded cases towards the end of this little volume. As far, however, as the writer himself is concerned, he has never employed such simple magnets, as with a variety of needles of different sizes for attachment to the electro-magnet their use has been rendered unnecessary, and he has been enabled to employ an extremity as fine as desired with a far greater amount of attractive force.

The "click," the sound with which it is accustomed to associate the adhesion of a fragment of steel or iron to a magnet, was by no means always heard in the cases reported in these pages. In some it was perfectly distinct, and unmistakably audible to bystanders as well as to the operator himself. In others, however, it was different, and the fact of the particle being adherent, was only ascertained on withdrawing the needle and its being seen attached.

In many cases the diagnosis of the presence of a particle of steel or iron in the interior of the globe is comparatively simple and easy, whilst frequently in others it is difficult. It does not enter into the scope allotted to this little volume to discuss the various modes and methods by which a satisfactory diagnosis

is facilitated, but reference may be made to experiments undertaken to ascertain, if in another way the properties possessed by the magnet could be utilised for the detection of such fragments inside the eye. It is to Dr T. R. Pooley*, of New York, we are indebted in the first instance for these experiments. They were based on the principle that if a fixed magnet attracts a movable piece of steel, a fixed piece of steel must attract a movable magnet.

It would seem that the employment of the magnetic needle as an aid to the precise location of a fragment of steel or iron is by no means new. Its use in general surgery has been more than once suggested. Dr Pooley states that as far as he can find out the first publication on the subject is by Mr Alfred Smee.† He employed a suspended needle, but, as the indications thus obtained were insufficient, he suggested that the enclosed piece of steel should be rendered a magnet, and this he stated could be done in two ways. First, by passing a galvanic current through it, and second by bringing near it an electro or permanent magnet. Dr James H. Aveling,‡ somewhat later, wrote a short article on the same subject, and an extract from it is here given as it shows the simplicity with which the method may be contrived. "A needle" he says "is

* Knapp's 'Archives,' 1880, p. 219 and 235.

† 'Med. Times and Gazette,' 1844. I have not been able to verify this reference. I imagine the name is *Smee*, and not Suree as mentioned in Pooley's paper.

‡ "On the detection by the aid of magnetism of needles embedded near the surface of the body." 'Lancet,' 1851, vol. i, p. 129.

to be magnetised by drawing a magnet along its surface for about fifty times; it is then to be suspended by a fibre of silk attached by a piece of sealing wax to the centre of the needle, so that neither the eye nor point may dip more than the other. This suspended magnet should be held over the suspected part, which should be shaved if very hairy; when this magnetic indicator arrives over the part, the needle will dip and adhere to the skin, showing the exact point under which the body lies. In two cases in which this mode of detection has been tried, the portion of needle sought for has been discovered and extracted, one of the needles having remained embedded for three months."

Dr T. R. Pooley refers to papers on this subject by Dr Bruce Jones, and by his brother (Dr J. H. Pooley), but omits any notice of the following record, which for its interest is given here somewhat fully.

"On October 24th, 1876, Sir B. C. Brodie* read a note before the Royal Medical and Chirurgical Society on 'The use of the Magnet in the Detection of a Needle Broken in the Leg.' On 24th June, 1873, the son, aged 11, of the author, accidentally ran a needle into the inner side of his left leg, where it broke off short, a part of the needle being left beneath the skin, a small black spot on the skin alone indicating its position. Mr Charles Hawkins saw the patient and advised non-interference. There was some pain over the seat of the needle, and subsequently some redness appeared on the skin. Sir B. Brodie then suggested

* 'Lancet,' 1876, vol. ii, p. 608.

submitting the needle to the action of a powerful magnet with a view of possibly dislodging the foreign body. Accordingly, on June 28th, at the Royal Institution, assisted by Messrs Hawkins, Prescott Hewitt, and Professor Tyndall, the author placed the affected part between the poles of a powerful electro-magnet, the indicator in connection with which oscillated violently over the spot where the broken needle was situated, but no dislodgment of the latter took place, and it was thought inadvisable to attempt its removal by other means, but to await its extraction by means of the movements of the muscles. From time to time Sir B. Brodie repeated the observation, and on July 27th the position of the needle was changed from what it was the day previously, viz. to the other side of the leg, where it could be felt and where its presence was also indicated by the magnetic needle on the 20th. The needle was close to the surface at the back of the leg, and the magnetic needle was much more violently affected by it than before. The next day the fragment of a large sewing needle was extracted by Mr Hawkins."

The references just given indicate clearly the value of the magnetic needle in fixing the location of a portion of steel or iron, and exemplify its use in general surgery. As has been said before, however, it is to Dr T. R. Pooley we are indebted for suggesting its application to the diagnosis of such fragments in the eye. He made numerous experiments on eyes recently removed and on eyes in live animals, in which particles of metal

were introduced, to ascertain their effect in deflecting a suspended magnet. As might be supposed, he found the effects greater in instances where the foreign bodies were previously magnetised, and this was accomplished either by passing a galvanic current through the eye or by induction by bringing in close proximity an electro or permanent magnet. From his experiments he drew the following conclusions:

1. The presence of a steel or iron foreign body in the eye, when of considerable size and situated near the surface, may be determined by testing for it with a suspended magnet.

2. The presence and position of such a foreign body may most surely be made out by rendering it a magnet by induction and then testing for it by a minute suspended magnet.

3. The probable depth of the enclosed foreign body may be inferred by the intensity of the action of the needle near the surface.

4. Any change from the primary position of the foreign body may be ascertained by carefully noting the changes indicated by the deflection of the needle.

He holds also that this method has a useful future before it in practical ophthalmology. The needles employed were sewing needles, magnetised and suspended by fine silk fibre, and other needles equally delicate. It must be mentioned that H. Pagenstecher*

* "Extraction of Splinters of Iron from the Vitreous," by Herman Pagenstecher, Knapp's 'Archives of Ophthalmology,' 1881, p. 145.

states after inquiries of his own, that "the results obtained by Pooley in his experiments, I can on the whole fully confirm." He says also, "beyond a doubt, the method succeeds in determining both the presence and situation of steel and iron particles, presupposing, however, that the intruding foreign body is not too small, and at the same time too far removed from the enclosing membranes." These conclusions are, it is only fair to add, like Pooley's results, obtained from experiments, and not verified by cases actually occurring in practice. On the other hand, Alexander, in the case of his mentioned further on, employed the magnetic needle with an absolutely negative result. McHardy, also, met with no better success in a case in which he used it, but as he states the chip was small and deeply placed, and the negative result corroborated Pooley's deduction that the magnetic needle would fail to indicate one of such size and situation.

The author hardly feels himself in a position to criticise any of the results summarised by Pooley and corroborated by Pagenstecher, or to express an opinion as to the ultimate use that may be derived from this procedure, as his experience is limited. He, however, has recognised the difficulty, as well as the importance, of avoiding extraneous causes of the oscillation of the suspended needles, such as currents of air, jars, &c. Gruening has, moreover, pointed out the necessity of counteracting the earth's magnetism, and suggested the desirability of reading off the deflections of the needle on a concave mirror a little distance off.

Dr Barrs of Leeds, very kindly had constructed for the writer, a needle suspended on the point of an upright stem. This little instrument allowed of free movement, but was certainly not of such delicacy as those needles referred to by Pooley in his experiments. With this needle trials were made on three eyes.

The first was an instance in which an injury had happened some weeks before, the eye was quiet, but the nature of the accident suggested the possibility of a foreign body (steel if any) being in the interior of the eye. The suspended magnet was employed with a negative result. Subsequently, also, after magnetising the fragment, if any, by induction, as well as by passing a galvanic current through the eye, no dipping of the needle was observed. The patient left the Infirmary and, as far as is known, there was no reason further to suspect the presence of a foreign body.

The second case was that of a boy, injured by a fragment flying off whilst at his work, and wounding the inner part of the right eye, just at the sclero-corneal junction; the iris was prolapsed and the eye filled with blood. No declination of the needle was observed. The subsequent progress of the case, the clearing away of the hæmorrhage, and allowing a full view of the interior of the globe, rendered it very improbable that there was a foreign body in the eye.

The third experiment was on case No. 16, in which it will be remembered the fragment of steel had lain in the eye six weeks at the time of its removal. When the

experiments with the magnetic needle were undertaken, the chip must have been inside the eye for five weeks. The needle yielded entirely negative results. It should, however, be added that no trial took place after the fragment was magnetised.

Of these cases, it may be remarked that in the first two, the negative results corresponded most probably with the absence of a foreign body in each. The third, however, can only be regarded as a failure, the presence of a piece of steel being subsequently so distinctly evidenced by its behaviour on the approach of the electro-magnet, and later on by its removal. If the fragment of steel had previously been magnetised, the result might have been different, as the writer's experience leads him to the decided conclusion as to the importance of this being effected.

These cases are recorded, as being in the opinion of the writer preferable to the relation of experiments on excised eyes. They may be considered perhaps not encouraging, but still it may be urged that the magnetic needle employed was not sufficiently delicate, and it can be well understood that with larger experience the method may prove more successful. Messrs. Cubley and Preston have now constructed for the writer fine needles, and also others pointed at the ends and perforated in the centre, as well as some ordinary sewing needles, all magnetised. These are without doubt more delicate than the suspended magnet employed in the recorded experiments. Trials on eyes excised with fragments of metal embedded have shown

decidedly, the advisability of the enclosed fragment being magnetised. In fact it would appear as if the use of the needle would be hardly likely to render much service in embedded fragments, other than those capable of retaining magnetism (steel).

In conclusion, the author would add that, bearing in mind the opinions of Pooley and Pagenstecher, over sanguine as those observers may be as to the real value of the employment of the magnetic needle, he should be disposed to continue its trial, hoping that with increased experience, and, it may be, with more conveniently made instruments, he may yet find in it a method at least useful in the diagnosis of some cases.

[Whilst this little work has been passing through the press two additional opportunities for testing the value of the magnetic needle for diagnosing the presence of particles of steel or iron have occurred. In one, the history of an injury twelve years before left little doubt as to there being a piece of steel inside the eye. After having been quiet for some years, the eye had lately become very painful. It was disorganised, and no view of the interior of the globe was possible. A magnetised sewing needle, and one or two other small suspended magnets, appeared to afford only a negative result. Subsequent removal of the globe disclosed a piece of steel, as large as a swan shot, in the sclerotic at the back part, more out than inside the eye.

It should be added that the experiments with the

needles were undertaken after inducing magnetism in the particle by the apposition of an electro-magnet.

In the second case the suspended magnet afforded unmistakable evidence as to the nature of the contained particle. The case is related under those fragments removed from the lens, No. 8. A sewing needle, magnetised and held suspended by a silk thread, on being brought close to the eye, and on reaching the cornea towards the outer side (over the situation of the fragment), very distinctly dipped, and testified by its movements that near at hand was some particle exerting attraction on it. At the time of the operation, also, the particle was magnetised by induction. This was accomplished by holding the electro-magnet, without the needle, in contact with the eye for a short time. Then, as might be expected, the dipping and movements of the needle were even more decided than in the previous experiment. The effects of the needle on both occasions were witnessed by others as well as the writer.]

II

In an earlier part of this little volume reference has been made to the mention of the magnet by the old worthies Fabricius Hildanus and Morgagni, and also by Dr Milhes. As far as the writer knows, the first, however, to make use of the magnet for the removal of a fragment from the interior of the eyeball was Dr Meyer* of Minden, in the year 1842. He succeeded with a magnet bearing thirty pounds in extracting a long narrow piece of steel which had entered the sclerotic behind the iris. The foregoing case is mentioned in the Ophthalmology of Dr Karl Himly,† Professor in Gottingen, in which work occurs the following passage, "you can try to extract, with the aid of a magnet, a piece of iron, having entered the aqueous chamber if projecting outward, but not sufficiently to be caught with forceps."

Mr James Dixon‡ records a case of a foreign body in the vitreous, the suspending filament of which allowing a certain degree of motion, suggested that

* Quoted from Hirschberg, "Extraction of Chips of Iron and Steel from the interior of the Eye," Knapp's 'Archives of Ophth.,' vol. x, p. 370.

† Vide Hirschberg also.

‡ 'Ophthalmic Hosp. Reports,' 1858, p. 282.

magnetic attraction might be employed to draw it nearer to the surface. "A powerful magnet was tried but its action on the foreign body, although very decided, was not available; for if drawn inward the body became hidden behind the iris, and if drawn outward it came into contact with the lens." Finally, the fragment was removed through a sclerotic section with forceps, and "the patient could read small print after three months."

On May 18, 1859, a girl aged fourteen was brought to Mr White Cooper,* at St Mary's Hospital, with a piece of iron sticking in the iris, about midway between its upper border and the pupil. Mr Cooper decided to try the effect of a magnet, thinking difficulty would arise in grasping the foreign body with forceps. The pupil was dilated with atropine, thus bringing the piece of iron nearer the corneal margin, chloroform was given, and an incision made in the cornea, close to the fragment, with a cataract knife, and a magnet applied to the wound. In an instant the chip attached itself to the magnet.

Professor Von Rothmund† in 1873 operated upon the following interesting case with success. "An iron chip had entered through the cornea, and its edge reached the anterior capsule of the lens, so that extraction seemed impossible without producing cataract. Prof. Von Rothmund made use of the enormous magnet

* 'Lancet,' 1859, i, p. 388. This account I cannot verify, as the reference given, as here stated, by Hirschberg is incorrect.

† 'Centralblatt f. Augenheilkunde,' 1880, p. 27, quoted from Hirschberg in Knapp's 'Archiv.,' 1881, p 371.

of the Munich Polytechnic Institute, combined with it a smaller one (probably an armature), touched the cornea and succeeded in removing the sharp edge of the chip from the capsule and in extracting the metal through a linear section." Cataract followed and was cured with good vision.

It is to Dr McKeown, however, that credit must be rendered, as previously mentioned, for in recent years having introduced the magnet and contributed to make it occupy a useful place in ocular surgery. He has published the following cases.*

1. A lad, æt. 15, first seen November 21st, 1873; injury the day previously; wound of cornea, passing from centre outwards; pupil cut at outer margin; no opacity of lens; deep in vitreous were opacities, one of which appeared to have a silvery streak. Next day under ether an incision was made in the sclerotic at its outer part, and two lines and a half from and parallel to the cornea. Forceps introduced failed to touch the foreign body. The pointed end of a magnet was pushed into the vitreous humour as far as its shape would allow. "The foreign body was felt to have become attached, but it was only at the third trial that he had the satisfaction of withdrawing the metal on the end of the magnet." The chip weighed a grain. The patient read later on Snellen's No. 2 at one foot.

The instrument employed here as in McKeown's other cases was a simple bar magnet about eight inches long, one inch broad, and one line thick, and tapered at each end to a blunt point.

* 'British Med. Journal,' 1874, vol. i, p. 800; 1878, vol. i, p. 644; 'Dublin Medical Journal,' 1876; 'Lancet,' 1871, vol. ii, p. 253.

2. September, 1875, patient æt. 30. Jagged wound of cornea and inner part of sclerotic, quarter of an inch long. Iris lacerated, and, sticking in wound, was excised. Magnet introduced into the vitreous, and metal detected by the click produced. Removed through enlarged wound. The globe atrophied, but enucleation was declined.

3. A dark body with bright margin, in a case of injury, was noticed in the vitreous. The nature of this body was set at rest by the "quivering" it underwent on the approach of a powerful magnet. Extraction was effected, but the eyeball became more inflamed, and was subsequently excised.

4. A suspicious body in the iris; on a magnet being applied to the cornea, and being moved about, the pupil changed its shape. The point of magnet was introduced through an incision at periphery of cornea. The portion of iris with the foreign body was immediately drawn out and excised.

5. D. B—, æt. 24, first seen January 16th, 1877. Injury three days before. Metallic body sticking at the outer margin of pupil, which was adherent by recent lymph. There was limited opacity of lens. Small section of cornea made, but the foreign body escaped forceps. Pointed magnet introduced, and immediately extracted metal.

6. A wheelwright, æt. 32, seen November 20th, 1877, three quarters of an hour after accident. Small wound in sclero-corneal junction. Magnet introduced into wound, and with care the fragment, a thin piece, was extracted.

Dr McKeown has been good enough to communicate to the writer the following cases, which have occurred in his practice since those previously published by him.

7. A man applied on January 19th, 1879, on account of an injury to the right eye by a piece of steel two weeks before; the eye was acutely inflamed; pupil adherent, with exudation; lens cataractous; small scar in cornea midway between centre and outer margin, and iris somewhat projecting forwards. The presence of a fragment of steel was suspected. A powerful permanent magnet was applied closely to, but not touching the cornea. In a little time Dr Mc Keown "had the gratification of observing that the iris was pushed forwards still more towards the cornea, and ultimately a sharp point appeared." A cut in the cornea over the part was made, and the end of fragment drawn into the wound by magnet, and removed by forceps. Subsequent extraction of cataract and iridectomy. Patient left before time for result to be ascertained.

8. D. H—, æt. 17, December, 1880. Injury about an hour previously to being seen. Wound in sclerotic one and a half lines in length, vertical, and two lines from outer corneal edge. Vitreous in wound; with ophthalmoscope no foreign body could be detected, because of effused blood. The end of magnet was introduced into the vitreous, without enlarging wound; the fragment at once became attached; by patience the end was brought into the wound and seized with forceps. Result almost perfect vision. The foreign body weighed four grains.

9. Patient æt. 18, first seen February 23rd, 1880. Left eye wounded by small piece of steel some time previously. A small foreign body presumed to be steel or iron, noticed on the iris about half a line from the margin of pupil at its outer side. Magnet held outside the eye, and "immediately the particle jumped to the posterior surface of the cornea, and was held there so long as the magnet was in position, but as soon as the magnet was withdrawn the particle fell into the niche between the iris and periphery

of cornea, the patient being in the upright position." A peripheral corneal section was made, and the magnet extracted the particle; it was like a mere pin's point. Patient recovered perfectly.

10. Joseph H—, æt. 16. Seen on January 20th, 1880, an hour after accident, by piece of steel from chisel, wounding left eye. Central wound of cornea, and bright piece of metal in front of iris, at lower part. Peripheral corneal section and fragment removed with magnet. Iris remained prolapsed and there was subsequent severe corneal inflammation; this subsided, but the lens, which was cataractous was not removed.

11. W. M—, æt. 58, applied 2nd March, 1880, three days after injury. The chip was projecting into anterior chamber and only slightly attached to posterior surface of cornea. The anterior chamber was opened, the foreign body then lay upon the iris. The magnet was introduced and extracted it. Patient recovered with perfect vision.

Respecting this last case Dr McKeown observes: "Although the magnet in ordinary cases of steel or iron in the cornea is useless, here it was invaluable."

Professor Hirschberg,* of Berlin, who has done much for this subject, written largely on it, and published several cases, first tried the magnet in 1875, employing a horse-shoe electro-magnet with an anchor-shaped forceps end. This proved a failure. In 1877 he adopted the instrument he now uses; it consists of a hollow cylinder of soft iron tapered at each end into a

* 'Berl. Klin. Wochenschr.,' 1879, No. 46; Langenbeck's 'Archiv,' Bd. xxvi, Heft 3; Knapp's 'Archives of Ophthalmology,' 1881, p. 371, "Extraction of Chips of Iron and Steel from the Interior of the Eye;" and private letters to the author.

branch which is to be introduced into the eye; around this cylinder is placed the coil of copper wire. He has recorded the following cases.

Cornea.—1. December 26th, 1882, piece of steel sticking through the cornea close to or into anterior chamber. He pushed aside the cornea in front and immediately extracted the chip; weight three milligrammes.

Anterior chamber.—2. Piece of steel in anterior chamber; lower corneal section made, removal unsuccessful with forceps, but extracted with magnet; weight twenty milligrammes.

In iris.—3. Foreign body near pupillary margin, with lymph lying in the floor of anterior chamber; seventy hours after the accident. Wound in cornea eight millimetres long. Attracted directly by the magnet. No subsequent opacity of lens. Perfect result.

In lens.—4. December 28th, 1882; left eye; foreign body just under anterior capsule; small corneal perforation; injury probably ten days previously. He magnetised cataract knife, made corneal section, and at same time opened lens capsule. The chip clung to the knife, and was readily extracted. Lens afterwards removed. Weight three quarters of a milligramme.

In vitreous.—5. Patient æt. 16. The chip was noticed in the vitreous behind the lens; electro-magnet introduced through a meridional scleral incision towards the equator, a conjunctival flap being formed; foreign body removed; recovered with normal sight, which was retained twenty months later, and even subsequently.

6. Patient æt. 18. Operation performed two days after injury (in sclerotic); hypopyon &c., had set in; foreign

body not visible, but it was removed through scleral section; subsequent wasting of globe and enucleation.

7. Operation same manner as last, but foreign body not discovered; eyeball remained painless.

8. Patient æt. 44, four and a half months after accident; the foreign body not removed; subsequent enucleation and iron splinter found in vitreous 6.3 mm. long.

Among recent accidents and cases of probing wounds, Hirschberg gives the following.

9. Æt. 39; seen three hours after accident; wound of cornea and cut in iris; electro-magnet introduced at first without result, then pushed deeper, "click" heard, and splinter, 15 mm. long, removed. Enucleation required four months later.

10. Æt 31; corneal wound, running into ciliary body; lens broken up; seen first at night a few hours after accident; next morning chemosis; electro-magnet introduced into corneal wound and splinter weighing 300 milligrammes extracted. Panophthalmitis and enucleation.

11. Large corneal wound; electro-magnet unsuccessful; enucleation; and large splinter discovered "firmly embedded in the coats of the eye" (ciliary region).

12. Foreign body implanted firmly in sclerotic and electro-magnet failed, as did also forceps, to extract it; with these latter it was impossible to remove it without cutting the sclerotic.

In addition to these published cases, Professor Hirschberg in a private letter to the author in March of this year (1883), refers to three other recent cases (still under observation), the first one of which for the length

of time (sixteen years) that the foreign body had lain inside the globe is of peculiar interest and value.

13. Right eye injured in 1867; subsequently extraction for cataract performed; recurrent attacks of inflammation; opaque capsule; partially occluded pupil; with ophthalmoscope "could detect a pigment alteration in the retina as it is often affected by a foreign body. The latter was presumed to have fallen into vitreous, and to have produced irritation." Magnet inserted into vitreous through lateral scleral wound and foreign body immediately caught.

14. Æt. 60; small scar in sclera; blood in vitreous; foreign body scarcely visible with reflected sunlight; the foreign body easily extracted; good visual result expected.

15. A man with commencing panophthalmitis; no perception of light; magnet tried for the satisfaction of patient, but in vain; enucleation a fortnight later; piece of iron embedded in coats of eye.

Mc Hardy has rendered valuable service in this field of ophthalmic surgery. The electro-magnet made for him by Coxeter has been referred to on an earlier page. He has recorded the following cases.*

1. Very similar to Rothmund's. In July 1877, patient æt. 31, fragment of metal upon the anterior surface of lens. In front of the cornea a powerful electro-bar-magnet was held "and one of its poles gradually approximated to the eye, until, when they were about four inches apart, the chip sprang from the lens to the inner surface of the cornea. Thereupon the magnet was withdrawn and the chip fell into the anterior chamber." The fragment was removed through a corneal section, a small piece of iris

* 'Clin. Soc. Trans.,' vol. ix; 'Brit. Med. Journal,' March 26th, 1881; 'Ophth. Soc. Trans.,' vol. i, p. 220.

being also excised. Cataract followed and underwent absorption. Result with + glass normal vision.

2. Patient, a blacksmith, æt. 53, was seen twenty-four hours after injury. Corneal wound; severe iritis and pupil blocked. Atropine freely used for twenty-four hours did not open pupil. North pole of electro-magnet brought before patient's eye, galvanic circuit completed and pain "unbearably augmented." This indicated the presence of a chip and its attraction towards the magnet. After applying for fifteen minutes the magnetic attraction, a metallic surface could be seen penetrating the iris, and becoming hidden in the track of the corneal wound. Five minutes later a projecting point was visible on the surface of the cornea, but on withdrawing the magnet to apply mechanical traction to the fragment, it was observed to immediately recede below the corneal surface. The administration of ether was commenced and when the patient was well under its influence the application of the magnet was steadily continued, and a fragment two by five millimetres and weighing ·0158 grammes, with sharp ends, passed through the track by which it had entered. Ocular congestion subsided, and the eye retained light perception and normal tension.

3. A bricklayer, struck with a chip whilst at work. Corneal surface disturbed at its centre; small opacity with metallic lustre posterior to the lens (in vitreous); twenty-four hours later lens had become slightly cloudy. The fragment was well magnetised, by induction, through the proximity of a large electro-magnet, and a lance-shaped cataract needle was also magnetised. This needle was passed through cornea and lens to the chip; withdrawn with the fragment clinging to it; left it, however, in the anterior chamber, and made another section with a non-magnetic bent knife, and chip was washed out by aqueous. The

lens became totally opaque. Weight of foreign body 1·2 milligrammes.

Dr. Bradford,* of Boston, U.S.A., has described an electro-magnet possessing the advantage the author claims for his own, of being enabled to substitute any needle desired, and to which instrument allusion has previously been made. It has been adopted by Drs Joy Jeffries and Williams, and others. Four cases are mentioned in Bradford's paper.

1. Machinist, æt. 24, injured from a chipping of steel; "piece penetrated cornea, and lodged in the substances of and posterior to the iris, with an exposure of only one point of one of its extremities upon it." Lens was opaque. Iridectomy attempted unsuccessfully, hæmorrhage ensued and the fragment disappeared; could neither be seen nor felt; electro-magnet passed in, and after second trial it was seen engaged at the wound and removed with forceps. Cataract afterwards removed and $V = \frac{6}{18}$.

2. Stone cutter, æt. 27; thin scale of steel had passed through cornea and projected nearly two-thirds its diameter into anterior chamber. Corneal wound healed over and attempted removal unsuccessful, until wound was re-opened with the knife, when the fragment was immediately grasped by the magnet and withdrawn.

The other two cases, occurring in the services of Drs Joy Jeffries and C. H. Williams, are mentioned by Bradford as recorded in the 'Boston Medical and Surgical Journal,' December 30th, 1880. One, however, is, it is thought, the following case, reported by Dr B. Joy

* 'Boston Medical and Surgical Journal,' March 31st, 1881.

Jeffries,* "at a recent meeting of the Suffolk County Medical Society ('Boston Medical and Surgical Journal')."

"No case of removal from the cornea had been hitherto reported. On September 29th, 1880, a man came to the Massachusetts Charitable Eye and Ear Infirmary with a piece of iron deep in the cornea at the outer angle, projecting into the anterior chamber just behind the sclero-corneal juncture. There was a cut towards the middle of the cornea, through which the metal might have passed. There also was no distinct tract through the cornea over the foreign body. As the metal could not be approached on the outer side in the blood-bearing tissue, it was decided to cut down upon it on the corneal side, and attempt to keep it in place or from falling into the anterior chamber by the constant and near presence of the strong electro-magnet of Dr Bradford's apparatus. On the approach of the magnet the foreign body was seen to move, and by applying it against the cornea the metal was drawn to it and removed."

At the meeting of the American Ophthalmological Society, held at Newport, R. I., July 27th–28th, 1881,† Dr H. Derby exhibited Bradford's electro-magnet, and several speakers stated their experience of the value of this method for the removal of chips of steel or iron from the eye. Dr Kipp referred to a case, where with this magnet (Bradford's) he had extracted an iron fragment from the vitreous. "The patient, a young man, felt something strike his eye while at

* 'Brit. Med. Journal,' vol. i, 1881, p. 149.

† Knapp's 'Archives of Ophthalmology,' 1881, p. 322.

work, and soon after his sight failed and the eye became painful. When first seen there was already traumatic cataract, and a yellowish reflex was noticed from the upper outer part of vitreous. The foreign body had passed through the cornea, iris, and lens. A meridional incision, about ten millimetres in length was made between inferior and external recti, commencing about eight millimetres from corneal margin. A bead of clear vitreous protruded. The magnet was introduced through the incision to the extent of about ten millimetres, and after a few moments withdrawn, without, however, bringing with it the foreign body. It was now again introduced to about the same length, but in a somewhat different direction, and immediately afterwards a distinct click was felt. On withdrawing the magnet, the piece of iron was found hanging to it. The wound healed without reaction. Some months later the eyeball was found to be slightly smaller than the other, but perception and projection were good."

Dr Charles S. Williams, of Boston, "mentioned several cases in which he had removed steel chips from the anterior chamber, by means of this magnet. In one case a foreign body was seen lying in the iris, but it was doubtful whether it was steel or stone. As soon, however, as the magnet was brought in contact with the cornea, the iris came forward, showing that the particle was metal. An incision was now made in the cornea, and the fragment of steel withdrawn with the magnet. Recovery perfect."

Continuing the report of American cases, Knapp has

recorded* two cases in the posterior part of the globe, one successful, the other unsuccessful.

1. Patient æt. 21, seen March 1st, 1880, seven months after being struck on right eye by chips from a hammer. Moderate circum-corneal injection; iris greenish-coloured and dilating insufficiently to atropia; globe free from pain and not tender; vitreous cloudy from diffuse and floating opacities, yet fundus could be seen; with oblique light a dark lustrous body was detected in the inner part of ciliary body.

March 6th.—Sclerotic section made four millimetres from cornea, at lower edge of inner rectus; grooved hook of flexible iron, attached to an electro-magnet connected with a Stöhrer's battery, introduced; moved in different directions with no result; foreign body still in situation, wound enlarged and grasped with forceps, and cut out together with the surrounding connective tissues; subsequent optico-ciliary neurectomy.

2. Machinist æt. 30. Seen May 19th, 1880, injury five days previously; S $\frac{1}{\infty}$; hypopyon; iris dirty greenish; pupil dilated somewhat with atropine; vitreous could not be illuminated; under oblique light its upper inner part looked intensely white in a round spot. Sclerotic incision between inner and lower recti and introduced a thin probe-like iron point attached to an electro-magnet into the vitreous. After third trial chip was found in wound, and removed with forceps. Panophthalmitis was threatened but subsided. Reported too early to state final result.

Dr Gruening,† of New York, introduced a permanent magnet, consisting of a number of cylinders joined by

* Knapp's 'Archives of Ophthalmology,' 1880, p. 207.

† Section of Ophthalmology, Otology, and Laryngology of American Medical Association, June 1st to 4th, 1880; reported in Knapp's 'Archives,' 1880, p. 349.

a cap at either end. This has been made use of in the cases which immediately follow. The instrument has been referred to in an earlier page. It is by no means very powerful.

S. B. St John of Hartford, Conn., reports* "Removal of a particle of iron from the lens by means of the magnet. Three months after the injury, the cataractous lens was extracted. After the section with a Graefe's knife, the point of a Grüning's magnet was introduced as far as to touch the superficially situated fragment of iron and brought it out. The cataract was then removed in the usual manner."

Lippincott also records† an unsuccessful case of a foreign body in the anterior chamber. "A fragment of steel, one third of an inch in length, was attached by one end to Descemet's membrane, while the other projected into the anterior chamber. Unsuccessful attempts at its removal were made with Grüning's magnet. It was removed by means of a fine pair of forceps."

Dr Oppenheimer‡ presented a patient at a meeting of the New York Society of German Physicians, from whom he had extracted a splinter by Gruening's magnet. The splinter had penetrated one millimetre to the right of and below the corneal margin. An in-

* American Ophthalmological Society, July 26th—27th, 1882; reported in Knapp's 'Archives,' 1882, p. 406.

† 'Pittsburgh Med. Journ., August, 1881; Knapp's 'Archives,' 1882, p. 126.

‡ 'New York Med. Journ.,' February, 1881, abstracted in Knapp's 'Archives of Ophth.,' 1881, p. 107.

cision was made on the opposite side near the rectus internus and the magnet was introduced. At the third introduction the splinter was drawn to the opening, whence it was easily removed. V = $\frac{20}{100}$ in good light."

In addition to the cases referred to previously as McKeown's and McHardy's, the succeeding ones have been recorded in British literature.

Dr Bronner and Dr Appleyard give * a case of a fragment sticking in the lens.

The patient, æt. 17, was injured on March 7th, 1881, but did not apply at the Bradford Eye Hospital until March 23rd; there was then noticed a transverse wound of cornea just below its centre; downwards and backwards through the lower part of pupil was seen a flat whitish plate, reaching and apparently perforating the capsule of the lens, which was cataractous. On 24th attempted removal through corneal wound which was trephined, by flat tapering end of electro-magnet worked by one potassic bichromate cell. Not successful. Next day, under ether, lower corneal section and iridectomy. Magnet introduced, and when in position circuit completed and fragment withdrawn.

The electro-magnet of Hess, Berlin, was employed.

Through the courtesy of Dr Appleyard, the author is enabled to add the following cases, communicated in a private letter. They were under the care of Dr Bronner and himself.

J. H—, æt. 26, admitted into the Bradford Eye and Ear Hospital on February 8th, 1883; the date of injury was two or three days earlier. A small wound was visible in

* 'Brit. Med. Journ.,' 1881, vol. i, p. 595.

the centre of cornea; eyeball congested and tender; a small dark looking body, which was believed to be a piece of steel, was noticed resting on the anterior surface of iris, at the lower part. Operation performed same day; incision made in cornea close to lower border; needle of electro-magnet introduced, and piece of steel extracted on first attempt. The chip was very small, and was lying loosely on the iris. When last seen recovery appeared perfect.

In another case, failure to remove a piece of steel from the vitreous occurred, and enucleation of eyeball was necessary. The steel chip was found involved in the ciliary body and processes. The electro-magnet of Hess, Berlin, was also employed in these cases.

Mr Lloyd Owen, of Birmingham, records * the removal of a fragment of iron from the vitreous. "The magnet employed," he states, "was similar in principle to that described in this Journal by Mr Snell."

Patient was æt. 16; horizontal wound, quarter of an inch in length, noticed on outer side of the eye just over sclero-corneal junction. Prolapsed iris was snipped off, and atropine used. Next day no pain or irritation. With the ophthalmoscope a bright glistening piece of steel seen suspended in vitreous, posterior and to the upper and outer side of the centre of the globe. Piece of steel was flat, square, and lying vertical. Magnet was attached to a thirty-cell Stöhrer's battery, and circuit was not completed until the point had reached the foreign body. Under ether an incision, posterior to the ciliary region and above external rectus, was made through the tunics. The

* 'Brit. Med. Journ.,' vol. i, 1881, p. 1001.

point of electro-magnet was introduced through this incision, and foreign body was at once removed. A week later (June 7th) V = $\frac{20}{xx}$.

In a private letter to the author, Mr Lloyd Owen mentions another case, which was unsuccessful, as others recorded in this volume have been, in consequence of the firm implanting of the foreign body in the ocular tunics.

"The piece of steel could be seen lying against the wall of the eyeball, directly upwards about midway between the equator and the ciliary processes. I put the magnet down on it two or three times through a puncture in the sclera, but could not seize it, the inference being that it was firmly embedded in the sclera." Suppuration took place, and enucleation was performed. "The piece of metal had a sharp ragged projection, which had so penetrated into the sclera that it was not easy to dislodge it when examining the globe after enucleation."

The same electro-magnet was employed in this as in the previous case.

Mr Henry Eales, of Birmingham, has kindly communicated, in a private letter, his experience with the electro-magnet. In four cases, each with a corneal wound, the needle of the instrument was employed as a probe and used for diagnostic purposes; in no instance was a foreign body extracted. In the following case, however, a fragment of iron was removed.

T. S—, æt. 26, admitted into the Birmingham Eye Hospital March 1st, 1883; two hours previously he was holding a "cold sett" which a fellow workman struck

with a sledge hammer, and he felt a severe blow on the left eye. A large vertical wound of cornea was found and traumatic cataract. Operation: a good deal of lens matter evacuated through original wound, and electro-magnet introduced, and on first withdrawal a piece of metal was removed. The magnet was not moved about in the vitreous, but simply put straight into it to about its centre and withdrawn with the foreign body attached. Result: puro-plastic irido-cyclitis, with hypopyon, for which eyeball was enucleated twenty-eight days after first operation.

The instrument employed in the first four cases was the one used also in Mr Lloyd Owen's cases; in the successful one it was Bradford's.

Two cases are reported* as occurring in the practice of Dr Little, at the Manchester Royal Eye Infirmary, by Dr A. Hill Griffith.

1. Patient seen first seven weeks after accident; shining scale of metal noticed in the deepest layers of right lens, the latter being nearly all opaque; the eye was quiet. The electro-magnet without the needle was applied to the cornea, and the chip immediately sprang forward, and, on withdrawing magnet, dropped into anterior chamber between iris and cornea. Extracted by incision with broad needle and inserting needle of magnet; small piece of iris was removed, and lens matter let out with curette. No reaction followed.

2. Before coming to hospital several unsuccessful attempts at removal had been made, and the chip had been nearly pushed through cornea. Directly the chip was touched with the spud the anterior chamber gave way.

* 'Ophthalmic Review,' 1882, p. 243.

Two days later the electro-magnet without the needle was applied to the cornea. After two attempts the little piece of steel was found adherent to the magnet. In a couple of days the eye looked perfectly quiet.

Besides these cases Dr Hill Griffith has been good enough to communicate the following additional ones, occurring at the Manchester Eye Hospital.

3. F. K—, a man under the care of Dr Little; small, sharp, angled chip of steel on iris, outer side of pupil, midway between ciliary attachment and pupil border. Small incision with broad needle made on outer side; no aqueous allowed to escape; needle of electro-magnet introduced, and chip came away easily; no prolapse of iris; perfect recovery.

4. T. W—, under the care of Dr Mules; large irregular piece of iron embedded in and behind iris; lens commencing to get opaque (one hour after accident); cut in cornea above, and also little laceration of iris. Eye fixed with speculum and forceps, and electro-magnet applied without the needle; in a second or two it had pulled the piece of metal straight through the iris and cornea, and was firmly fixed on the magnet. Good and rapid recovery.

It may be stated that the electro-magnet employed in these cases was very similar to the one described in these pages by the author.

Dr Reid* showed a patient from whose eyeball he had removed a large splinter of steel, by means of an electro-magnet, before the Glasgow Pathological and Clinical Society, on December 18th, 1881. The size of the fragment was $\frac{3}{4}$ in. in length and $\frac{1}{4}$ in. in breadth,

* 'Brit. Med. Journ.,' 1882, vol. i, p. 160; private letter to the author.

and about the thickness of a common hand saw, and it had entered the eyeball midway between the cornea and the equator, and lay across the eye close behind the lens. Two attempts at removal had been made before Dr Reid saw the case, and the patient had a long distance to travel. On passing the point of the magnet through the wound of sclerotic there was no sign of contact, but on withdrawing it, the thin edge of the fragment projected through the wound, and was removed with forceps. Subsequently shrinking of the eyeball occurred. On the recommendation of Sir W. Thomson he had tried a hollow conical needle, the magnet being connected to a quart chromate of potash battery.

Mr Wherry, of Cambridge, has reported the following interesting case.*

The patient, a carpenter, had a chip from his chisel in the left eye. The piece of steel could be seen in the anterior chamber, touching the iris in the lower outer quarter. An incision was made in the cornea, near the sclerotic junction. The pointed pole of the magnet was made to touch the lips of the incision, and the foreign body attached itself immediately and was extracted with the greatest ease. Very slight iritis followed, and the eye was well in seven days.

Mr Wherry observes: "The magnet used was the ordinary bar (with a coil round it), shaped like a small horse shoe by the ingenuity of Mr. Gordon, of the Cambridge Physical Laboratory. The poles were prolonged into sharp iron points, something like a

* 'Brit. Med. Journ.,' January 6th, 1883.

crab's claw, fixed about half an inch apart, one longer and sharper than the other. These points were movable, being screwed into the magnet-holes, and in no way spoiled the magnet. The battery used was five-celled Groves."

Dr Wolfe, of Glasgow, also informs the writer in a letter that in one instance he has removed a splinter of iron from the vitreous by means of Hirschberg's electro-magnet.

Passing now to German and French cases several still remain to be mentioned.

Dr G. Frankel,* of Chemnitz, gives the following case.

December 10th, 1879.—A machinist, æt. 17, in chiseling iron, was struck by a particle at the lower outer sclero-corneal junction. The wound, six mm. long was filled with iris which was cut off. Lens uninjured; no foreign body could be detected, blood occupying lower part of vitreous. The next week opacities of vitreous and detached retina in lower part were noted. A powerful magnet passed along the outside of sclerotic did not produce any movement of supposed foreign body inside; after trial with this magnet, however, twenty-four days after injury, a large splinter of iron was seen lying loose on lower part of retina. An incision (meridional) in sclerotic was made 10 mm. long between inferior and external recti; the foreign body did not escape nor could it be felt with forceps; wound made

* Hirschberg's 'Centralblatt,' February and January, 1880, p. 37; quoted by Hirschberg "Extraction of Chips of Iron or Steel from the Eye," Knapp's 'Archives,' 1881, p. 392; and Knapp, his 'Archives,' 1880, p. 209, "Removal of Fragments of iron from the Vitreous."

gaping and magnet passed along it, from before backwards, on reaching the posterior extremity the foreign body became firmly attached to it. Thirty-seven days later there was no detachment of retina, but striped opacities of vitreous over scar of operation S=$\frac{6}{18}$.

Hirschberg is able to add from a letter from Dr Frankel that in "September, 1880, no detachment, but an area of atrophy of pigment S=$\frac{1}{5}$; no irritation." The magnet, Janin's, used in this instance was a permanent one composed of steel strips bent in the shape of a horse-shoe, and united at the poles by steel shoes, and not suitable for introduction into the eye.

In the next two cases, Hirschberg's electro-magnet was employed and they are reported by Dr Samelsohn of Cologne.

1. A smith on August 20th, 1880,* had his right eye struck by a piece of steel chisel. Next day dimness of sight and pain. August 22nd, Dr Samelsohn found marked chemosis, hypopyon, and ciliary body very tender on pressure; recently closed horizontal wound of cornea, seven mm. in length; iris attached to a wound of anterior capsule, running transversely through the pupillary region. Fingers at one foot. Foreign body not visible. Without narcosis, electro-magnet was introduced through the wounds of cornea and capsule and a splinter of six mm. in length and two mm. in breadth easily extracted. Next day symptoms of cyclitis had subsided; the traumatic cataract took the usual course. Later V = $\frac{1}{3}$ is reported.

2. Seen the day after injury.† The fragment had pene-

* 'Berlin. Klin. Wochenschrift.' 1880, No. 44, and mentioned by Hirschberg in his paper "On Extraction of Chips, &c.," Knapp's 'Archives,' 1881, p. 392.

† 'Centralblatt f. Augenheilkunde,' June, 1881, abstracted in

trated the cornea and lens to the neighbourhood of the ciliary body. Extraction attempted by means of a meridional sclerotic wound, with the electro-magnet, unsuccessfully. Two days later, the pain became aggravated and the globe was excised. The metallic splinter was found between the retina and choroid, in a blood clot very near the sclerotic wound. He says the introduction between the lips of the wound is rendered difficult by the too considerable size of the pole of the instrument constructed by Dörffel (Hirschberg's).

Dr Burgl,* mentions a case interesting from the long period which had elapsed before removal was effected.

The left eye of a young locksmith was injured February, 1877, followed by inflammation for some weeks and then the pain subsided. November, 1878, Dr Burgl found a linear scar at upper edge of cornea, and behind it an oval hole in the iris; the pupil was normal, but iris discoloured; S = $\frac{1}{4}$. Floating bodies were noticed in the vitreous, and a bright splinter of metal was observed suspended by films from the superior wall of eyeball and oscillating on movements of globe. After a few weeks, pain, photophobia, circum-corneal injection, &c.; S = $\frac{1}{20}$; foreign body lying at the bottom of the eye, close behind ciliary processes. Conjunctivitis of other eye; enucleation refused. When the patient returned in February, 1880, the left eye was painful, with synechia and opacities in vitreous, the splinter

'Annales d'Oculistique,' 1881, vol. ii, p. 40, and mentioned by Hirschberg in same paper as last case.

* 'Berlin. Klin. Wochenschrift.' 1880, No. 44, quoted by Hirschberg in his paper on "Extraction of Chips of Iron and Steel from the Interior of the Eye," Knapp's 'Archives of Ophth.,' 1881, p. 369.

lying in the old place. Operation with electro-magnet made for the purpose. The splinter weighed thirteen milligrammes. The eyeball retained its size and shape and light-perception.

Fröhlich* has recorded an unsuccessful case, which was followed by amputation of the globe. The piece of iron was provided with serrations which harpooned the tissues at the moment of the retreat of the magnetic needle. He describes an electro-magnet, consisting of a cylinder of soft iron, surrounded by a coil of copper wire. Whether or not the needle attached at one end, however, is done so in such a manner as to allow of its ready exchange for another, or whether it is fixed, as in Hirschberg's and in other electro-magnets, the account accessible does not state.

Dr Max Knies,* of Zurich, gives the following case:

1. A fragment of iron had penetrated the eye at the lower border of the iris, without injuring the lens, and lodged in the neighbourhood of the ciliary body. There were posterior synechiæ, pupillary exudation and hypopyon. Knies with the aid of a very powerful electro-magnet (gramme machine attached to hydraulic motor,) drew it into the anterior chamber. Extraction was effected by a lower corneal section; hypopyon escaped; the piece of iron was seized with forceps; iridectomy. Later on the lens became opaque at the point of penetration. $V = \frac{6}{9}$.

2 and 3. The same operation in two other cases was tried without success.

* 'Klin. Monatsblattr. f. Augenheilkunde,' January, 1881, abstracted in 'Annales d'Oculistique,' 1881, vol. ii, p. 28.

Schiess Gemuseus* records two cases. In the first the subject of the accident was seen five days after the injury, in the second four days. In both the lens was already opaque and there existed purulent choroiditis. A notable remission followed the extraction in the first case, visual acuity remaining up to a certain point.

Alexander† gives the following successful case.

A fragment of iron had penetrated through the cornea into the vitreous, five months before, there were floating opacities in vitreous, neuro-retinitis, and foreign body was visible with ophthalmoscope; S=$\frac{17}{200}$. Extraction with electro-magnet by meridional sclerotic wound, behind ciliary body and between outer and lower recti; V = $\frac{17}{50}$. The fragment was 3·3 mm. long. The magnetic needle was tried in this case with an absolutely negative result.

Galezowski‡ has, as far as the writer knows, recorded the only instance of removal of a fragment of iron fixed in the retina. The particle passed through the cornea, iris, and lens, and lodged in the retina. It was discovered by the ophthalmoscope. An incision of the sclerotic was practised over the supposed situation of the chip and the foreign body searched for with a magnetic sound. The sclerotic wound was sutured and complete preservation of vision was noted the sixteenth day after the operation.

* 'Klin. Monatsblattr. f. Augen.,' 1881, p. 458, abstracted in 'Annales d'Oculistique,' 1881, vol. ii, p. 268.

† 'Centralblat. für Prak. Augen.,' 1881, p. 337, abstracted in 'Annales d'Oculistique,' 1882, vol. i, p. 71.

‡ Communicated to the Société de Chirurgie, 'Revue Générale d'Ophthalmologie,' 1882, p. 69.

Krenchel* relates three cases occurring at the clinique of Dr Hansen (Copenhagen). In two the employment of the electro-magnet was successful in removing particles of iron from the interior of the eye, and in the third the operation succeeded but the eye remained blind, though not painful.

Pagenstecher† in the following case employed Frohlich's sound, referred to previously, for the removal of a fragment from the vitreous.

The patient æt. 28, was injured about eight hours before he was first seen at night. There was a perforating wound of upper lid and small linear one near the inner corneal margin in the sclera; cornea, iris, and lens intact. Air bubbles noticed in vitreous, and also a considerable hæmorrhage. Foreign body not seen; V = $\frac{20}{30}$; eyeball painful. Atropine used until next day; then cornea was hazy, iris swollen, &c.; inspection of interior of eye impossible. On the third and fourth days the inflammatory symptoms had increased, and panophthalmitis seemed likely to ensue. Under chloroform small incision was made in sclerotic, opposite previously observed blood clot; through this the sound was introduced and moved about, a click was heard by the assistants. The first and second attempts failed to remove the foreign body, but when the wound was enlarged, it came away directly. Result phthisis bulbi.

Rheindorf has recorded a case with a similar result to that of Pagenstecher. Professor Hippel tried, without success, Hirschberg's electro-magnet for the removal of a piece of iron from the vitreous. After

* 'Revue Générale d'Ophthalmologie,' 1882, p. 453.

† "Extraction of Splinters from Vitreous," Knapp's 'Archives of Ophth.,' 1881, p. 145.

euucleation the fragment was found near the optic disc.

Dr J. F. Klein reports* a case of removal of a fragment from the vitreous, occurring at the clinic of Dr Jany, Breslau.

A chip of iron, two and a half mm. long and three and a half mm. in thickness had perforated the eye of a workman æt. 52. It had traversed the sclerotic and ciliary body, leaving a wound two and a half mm. long. With the ophthalmoscope a particle was visible moving freely in the vitreous body. The day after the accident, under chloroform the chip was extracted with Hirschberg's electro-magnet. A conjunctival flap was formed, and the sclerotic incised between internal and inferior recti muscles. The end of magnet was introduced, and at the second attempt it brought to the edges of the wound the piece of metal, which was then removed by forceps. Nine months after the operation, visual acuity equals 1.

* 'Annales d'Oculistique,' vol. i, 1833, p. 174 (Mars—Avril).

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