The New Photography.

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THE New Photography is more than two years old. At the beginning of the year 1894 Lenard, at Bonn, showed that it was possible to obtain "shadows" of objects through optically opaque substances, and to produce an impress of these "shadows" on photographic plates which could afterwards be developed and fixed by ordinary photographic processes.

So modestly was the fact announced in the midst of other and more striking statements, that even those who read his paper upon its publication had well-nigh forgotten that such photographs had been obtained by him, when their attention was called afresh to the subject by the announcement (in January of this year) of a much more sensational fact by Professor Röntgen, of Würzburg—viz., that by similar means it is possible to photograph the skeleton of an animal while it is still alive. Professor Röntgen's publication —pregnant as it was with the possibility of important practical applications—was the herald of an enormous amount of activity in the physico-medical world; while certain paradoxical properties (announced at the same time) of the agent by which the photographs are obtained, afforded a rare stimulus to experimental work by physicists in the exercise of their true function as inquirers into the secrets of Nature.

It is not possible in this place to narrate all the scientific details connected with this subject; but to make the process plain to you a few brief semi-scientific paragraphs are indispensable.

Take an ordinary medical or "shocking" coil, with its electric battery, and imagine both made so much larger that the apparatus is no longer convenient for producing comfortable shocks. If the terminals which you usually catch hold of (in the smaller coils) are brought very close together, you will probably see a small spark passing between them; and even with only moderately large coils it is easy in this way to obtain electric sparks (miniature lightning flashes) several inches long. A spark 3in. long is very good for our purpose. This spark is produced by the electric current tearing its way through the intermediate air.

Now imagine the coil terminals imbedded in the ends of a glass tube from which the air can be gradually withdrawn by means of an air-pump. As the exhaustion proceeds, a series of remarkable changes is passed through. At a particular stage the spark has lost its sharp, lightning-like character, and a reddish glow of light spreads through almost the whole extent of the tube. Near one terminal (called the negative terminal) a non-luminous space is seen, while the terminal itself is coated with a blue, velvet-like glow. As the amount of air present becomes still less, a stage is at last reached when the red light disappears, and in the meantime the appearances near the negative terminal have become increasingly prominent. From this terminal a very faint glow of blue light may be seen spreading. It has been shown to represent the path of a stream of particles of gas which dart away with prodigious velocity in a direction always perpendicular to the negative pole. This is the famous negative stream. If a solid

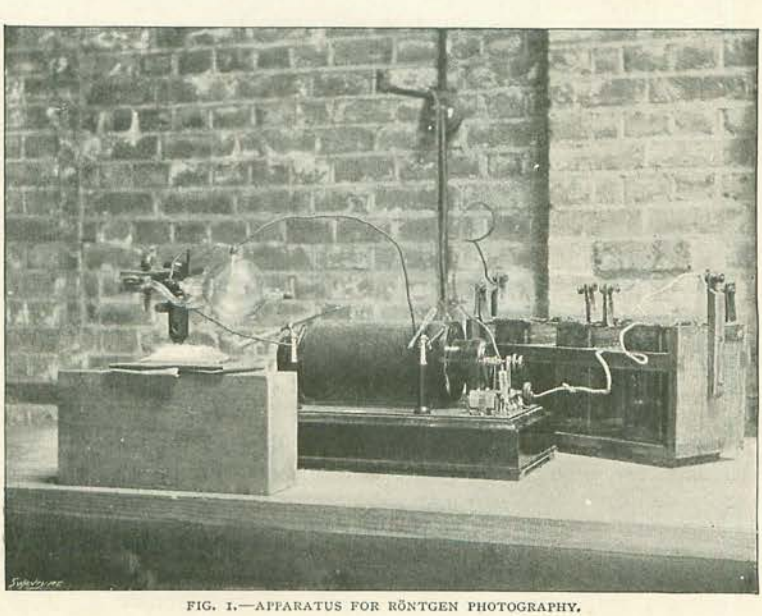


FIG. 1.—APPARATUS FOR RÖNTGEN PHOTOGRAPHY.

object is placed in the path of this stream, several things may happen: 1st, it may get hot; 2nd, it may get bright—shining with a green or blue glow, according to the material of which it is made; 3rd, it may become the seat of the production of that which is the instrument in the hands of the "New" photographer, and which is variously known as Röntgen radiation or X-radiation. At the solid object the new radiation springs into being, and then travels away from it in all directions, in very much the same way that ordinary light would do.

Tubes in which this new phenomenon may arise have been in use in all physical laboratories for nearly twenty-five years. In the majority of them the negative stream first strikes against the glass walls, and these walls constitute the source of the active rays. But a far more efficient form has been used by a few experimentalists from the beginning, and now—since it has been put on the market—is used by every worker in Great Britain. In this tube (it is a *spherical tube*, by the way, and we shall henceforth call it a bulb) the negative terminal is made of a saucer-shape, and the paths of the stream of particles starting from it all meet at a point near the centre of the bulb. At this point a disc of platinum is placed, and this serves both as the second terminal and as the source of the new rays. The bulb is called a "focus-tube." Amongst those who recognised the great superiority of this form of bulb were Professor Hicks, F.R.S., of Sheffield; Mr. Herbert Jackson, of King's College, London; and myself. The first to show in public a bulb of this character was, I believe, myself, viz., in a lecture delivered at University College, on January 29th; and on February 13th, in a discussion at the Royal Society, I first described the bulb in connection with an experiment demonstrating that a point on the platinum disc acted as the source of the radiation.

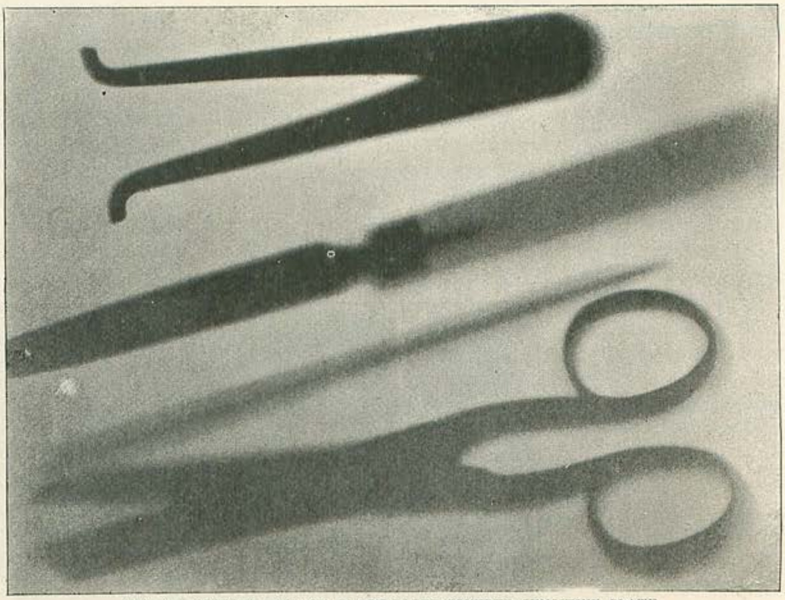


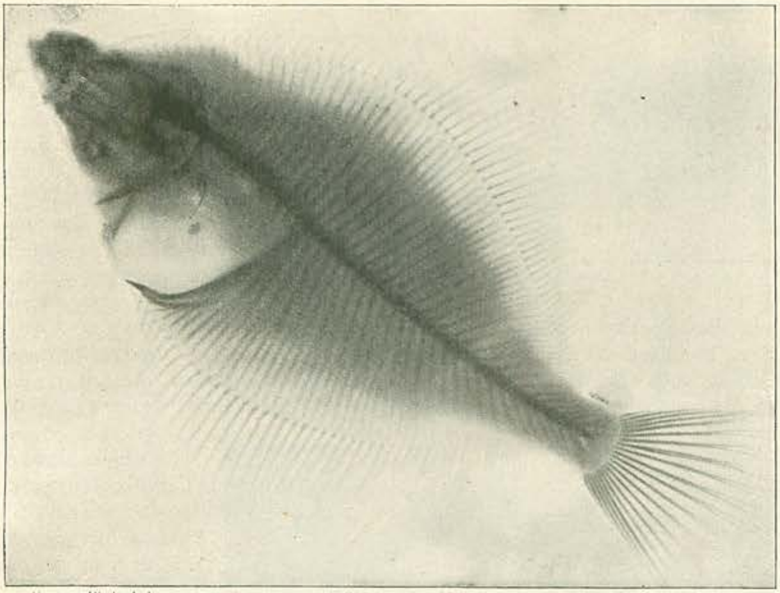
FIG. 2.—OBJECTS LAID ON BLACK-PAPER-COVERED SENSITIVE PLATE.
From a Photo. by Mr. Spiers.

In what manner is this radiation employed in the New Photography?

If we hold a lighted taper above a sheet of paper, rays stream out in every direction, and where they strike the paper illuminate it. Now interpose an opaque object between the taper and paper screen: it will prevent the light from falling on certain portions of the paper, which will, therefore, remain dark—*i.e.*, the object casts a shadow. This shadow has sharper edges the smaller the source of light is and the nearer the object is to the paper.

Replace the taper by the platinum disc of the active bulb. Radiation (of the new kind) streams from it in every direction *on one side of the disc*, and if the interposed object be opaque to the rays it will again cast a shadow on a screen which is placed in their path; but in this case it is usually an *invisible* shadow, for the new radiation cannot be seen by the eye.

Two ways are known of showing that the shadow is there. If a screen coated with crystals of potassium platino cyanide receives the rays, it glows blue *wherever the rays fall.* Such a screen then will reveal the presence of the shadow, for it will glow least where fewest rays fall. It is called a *fluorescent screen.* The other mode is the photographic one. The X-rays, like light-rays, possess the property of affecting an ordinary photo-



From a Photo. by] FIG. 3.—PLAICE. [*Mr. Swinton.*

graphic plate, so that where most rays fall a black deposit will be formed on subsequently treating the plate chemically (developing it), as is done in ordinary photography—where no rays fall no deposit is formed, the plate is then transparent when finished. If a series of objects of various degrees of transparency are permitted to cast shadows, we obtain a series of visible images of different degrees of darkness on the developed photographic plate. We obtain, in fine, a New Photograph.

The disposition of the apparatus as used by me throughout is represented in Fig. 1. The photographic plate is there shown wrapped in black paper (so that one may work in ordinary daylight); upon it lies the object (a white rat), whose shadow is being "taken," and above it the acting bulb. Behind these stands the induction coil, and in the background is the battery which serves to excite the coil.

And what will be the appearance of the image of the rat when taken? If its shadow had been cast by ordinary light, we would obtain merely an ungraded shadow, bounded by the outline of its body; because the whole body is opaque to rays of light. But optical opacity is no guarantee of opacity to the new rays. To these flesh is very tolerably transparent—the rays get through several inches of it without considerable loss. Bone, on the other hand, is very opaque—a shower of rays falling on even slender bones is to a large extent stopped. The bones will therefore cast a more complete shadow than the rest of the body. We might compare the result with that which would be obtained optically from a glass rat with translucent porcelain bones.

Let us prepare now to look at some of these *radiographs* (as we call them) obtained by various experimentalists in England. They represent the productions of two periods. First, the pioneer period, when every man used the tube and other apparatus which was right in his own eyes; secondly, the present period in which the focus-tube has proved itself to be king over all tubes, and the rest of the apparatus adopted is identical in character with that figured above. For the work produced by Professor Hicks, and also

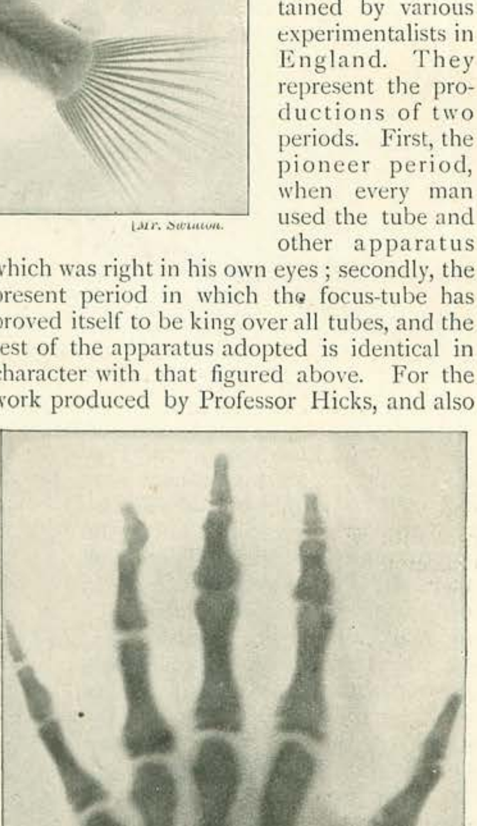
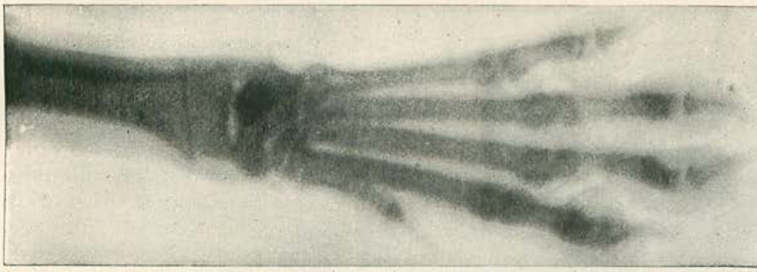


FIG. 4.—INJURED HAND.
From a Photo. by Prof. S. P. Thompson, F.R.S.



From a Photo. by] FIG. 5a.—DOG'S PAW (NO ANÆSTHETIC USED). [Mr. Gifford.

for that done by myself, both periods merge into one; for each of us has used the same character of apparatus and bulb throughout. Further, with regard to my own work, I must say that, with the exception of Figs. 7, 13, and 21, all shown here were obtained by means of the *identical bulb* with which my first successful radiograph was taken. I mention this latter fact in order to assist in dissipating the impression created by the first reports of English work, viz., that the radiographs could only be obtained at the expense of an immeasurable number of bulbs. We heard (in imagination) crash after crash as successive bulbs succumbed. But these crashes did not occur in our own laboratory.

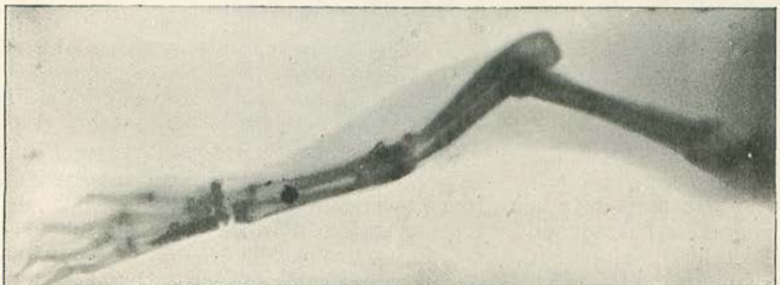


FIG. 5b.—RABBIT'S PAW (SHOWING SHOT IMBEDDED IN FRACTURED BONE).
From a Photo. by Mr. Gifford.

We must hasten to our first-period photographs. Fig. 2 is an example of Lenard photography by Mr. C. W. Spiers, working in the laboratory of Professor Ayrton, F.R.S. It is interesting, because it was taken with a 2in. coil, at a time when very much huger and more complicated apparatus was declared to be necessary for the process. Fig. 3 is by Mr. A. C. Swinton, to whom the credit is due of being the first to obtain a Röntgen radiograph in Great Britain. It represents a clearly defined shadow cast by the body-clothed skeleton of a plaice.

In Fig. 4 we have a glimpse of a possible practical application of the process. The revelation of the bones in a living subject at once opened up the power of the process in investigating the nature of internal injuries without the need of surgical probing. The figure represents an injured hand, taken by Professor Sylvanus Thompson, F.R.S. The definition, however, in this case is not good enough to enable one to make out more than the general positions of the bones.

The illustrations,

FIG. 6.—FOOT TAKEN WITH THE SOCK ON.
From a Photo. by Porter & Duckham.

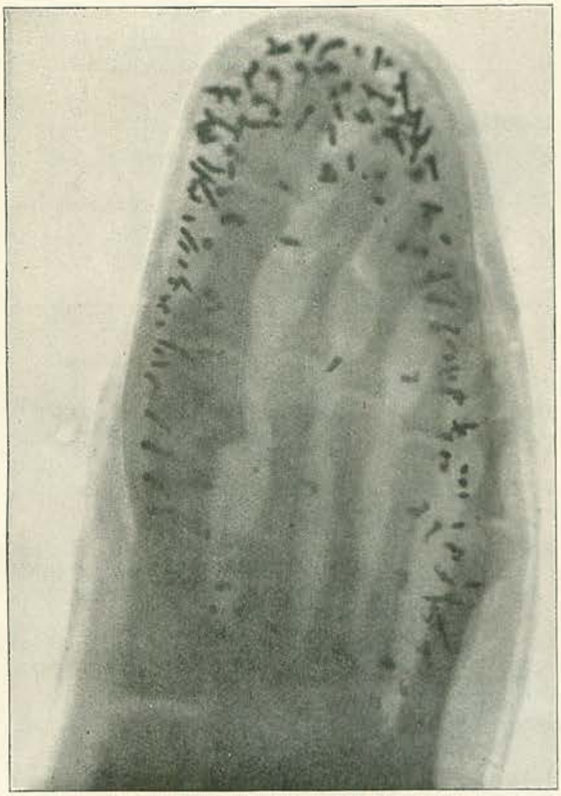


FIG. 7.—BOOT CONTAINING SOCK AND FOOT.
From a Photo. by A. W. Porter.

Figs. 5*a* and 5*b*, were radiographed by Mr. J. W. Gifford, of Chard, one of the first whose names became familiar to us in connection with the subject. Fig. 5*b* was taken with a practical object. The heavier metals are very opaque to the X-rays; hence the presence of a lead bullet in a limb should at once manifest itself. There is no need to put a bullet in one's hand to test the point. Mr. Gifford has utilized the paw of a shot rabbit, in the fractured bone of which the shot is embedded. The fur was on the paw, but the radiation went through it as easily as you go through an open door; hence it does not appear on the print.

We will deal with the actual surgical cases later on: but this is the place to say that, in the first public demonstration of the new process given in Great Britain (given by me on January 29th), I took, with an exposure of 3¾ min., a radiograph of a finger containing a lead pellet, which showed most clearly the presence of the pellet. Short exposures, such as that just mentioned, were all that were required (at any rate in my case) for such slender things as fingers.

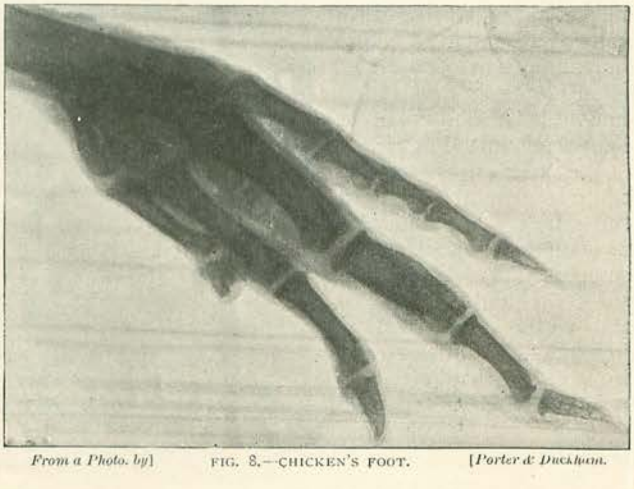
In passing from these to thicker objects, such exposures were found to be insufficient. It has to be borne in mind that each inch of substance passed through cuts off a certain percentage of the incident rays, and in order that the same quantity of rays shall reach the sensitive plate, a longer exposure must be given for thick objects than for thin.

This is exemplified in Fig. 6, which was taken with the assistance of Mr. Alec Duckham. Six minutes' exposure was given, although for a hand four minutes would have been ample. The sock was visible optically, almost invisible Röntgenically, though its outline shows faintly along one side.

The same point is exemplified still better by Fig. 7 (taken at a much later date), representing a foot taken with both sock and boot on—a sample curious for its revelation of the structure (partly metallic) of the boot, and quite ghastly in its portrayal of the bones inside. We willingly turn to some less gruesome specimens.

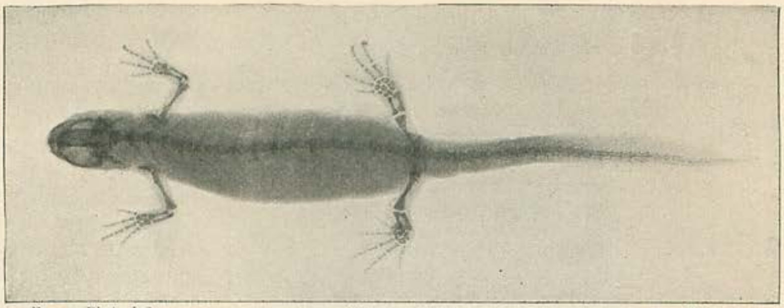
Fig. 8 is a chicken's foot, which was laid on the sensitive plate placed at the bottom of a cardboard box packed up to the lid with corrugated paper (such as is used for packing bottles), the lid put on, and the whole radiographed. The result is of unsurpassed sharpness.

In Fig. 9, the water-newt, or common triton, proudly exposes his wrists and ankles to view; and very pretty they are, too.



From a Photo. by] FIG. 8.—CHICKEN'S FOOT. [*Porter & Duckham.*

But for magnificence nothing can compare with the common frog (Fig. 10). *He was made for the process.* His skeleton is strong but graceful: built up of innumerable small bones, each of which is so fine that the radiation partly penetrating it reveals its internal structure, and yet it stands boldly out in the midst of its almost spiritual covering of flesh. The radiograph kindly hides the fact that he had been dead several days when this last memorial of his earthly career was obtained. The only indication of the fact is the abnormally expanded lung, which shows of a light shade in the figure.



From a Photo. by] FIG. 9.—NEWT. [*A. W. Porter.*

We turn now to the severely practical side of the subject—the utility of the process as an aid to the surgeon. This aspect of the subject is more suited to the pages of a medical journal — we prefer not to look on ghastly things. A few illustrations will serve to emphasize its vast importance.

Fig. 11 is by Professor Hicks, of Sheffield. (We must remark that all the examples by Professor Hicks which we have seen are of remarkable sharpness and distinctness, and we would have been glad of examples from him on a *variety* of subjects.) This figure served to locate a needle which had become embedded in the ball of a thumb.

Fig. 12 (*a* and *b*) is another similar instance where the needle is in a more difficult position. It illustrates how entangled such an intruder can become in the

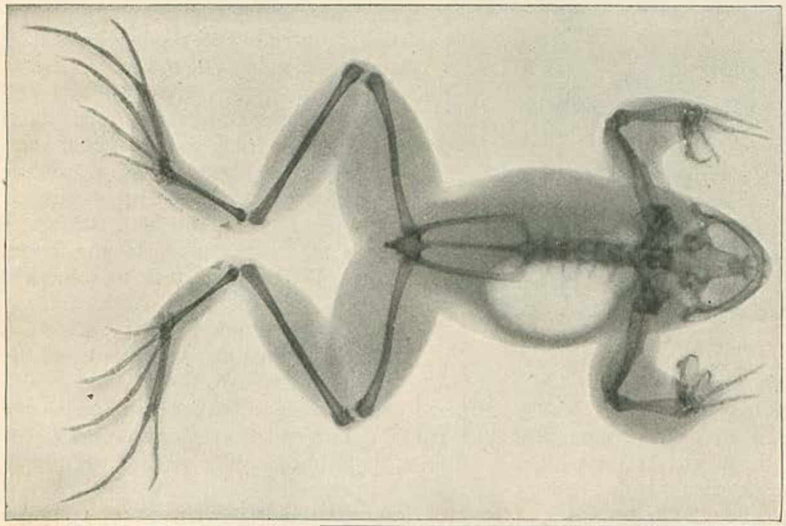
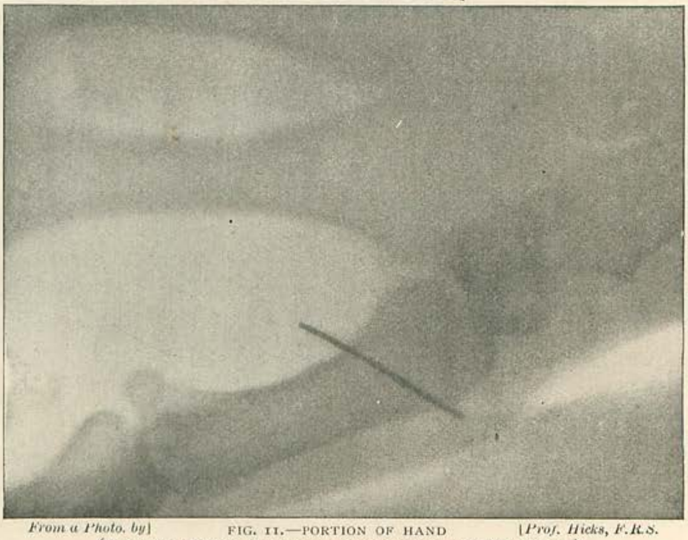


FIG. 10.—GERMAN FROG.
From a Photo. by A. W. Porter.



From a Photo. by] FIG. 11.—PORTION OF HAND [*Prof. Hicks, F.R.S.*
(SHOWING NEEDLE EMBEDDED IN THE BALL OF THE THUMB).

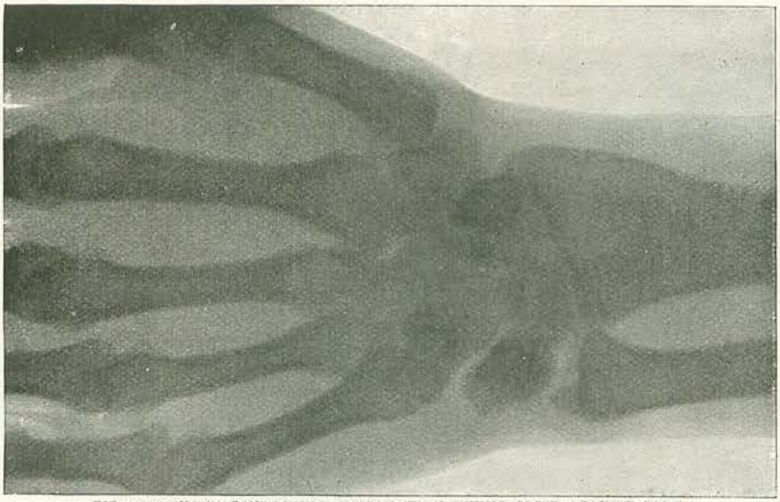


FIG. 12*a*.—HAND CONTAINING NEEDLE WITH THUMB CLOSE AGAINST PALM.
From a Photo. by Porter & Allan Hair.

to the animal and mineral kingdom. I am not aware that any attempt has been made outside our own college to extend its range of application to the vegetable kingdom. But the different parts of a plant are of different degrees of transparency, and therefore will be differentiated from one another if a radiograph be taken. The inside of a growing plant can

tissues into which it works its way. The only difference between Fig. 12*a* and Fig. 12*b* is that in the former the thumb is close against the palm, while in the latter it is stretched as far from it as possible; yet this slight movement of the thumb has shifted the shadow of the needle through nearly a right angle.

In both Professor Hicks's case and the latter the needle was successfully removed. A specially interesting fact with regard to the latter is that the doctor who had initially treated the case was confident (in spite of the swelling and pain) that *no needle was present.*

We will glance, as we take the path away from this part of the subject, at a malformation of the hand (Fig. 13). The process is here seen to be valuable, as affording interesting information where no resort to the surgeon's knife is intended. The hand lacks the normal number of fingers: there are only three bones in the palm instead of five; and one of the wrist bones is wanting.

The process has been applied almost exclusively

then be revealed without destroying the life of the plant. As an illustration take Fig. 14 (*a* and *b*), which shows (*a*) the outside of a black tropical pod taken by ordinary photography; (*b*) its internal structure revealed by the new method. These were obtained by Mr. W. Grant, of this college. We do not scruple to tear a plant to pieces, and this will generally be the easiest way of finding out what is inside, but there may occur cases in botanical investigation in which the new process will be of some slight use.

A means which is so capable of disclosing

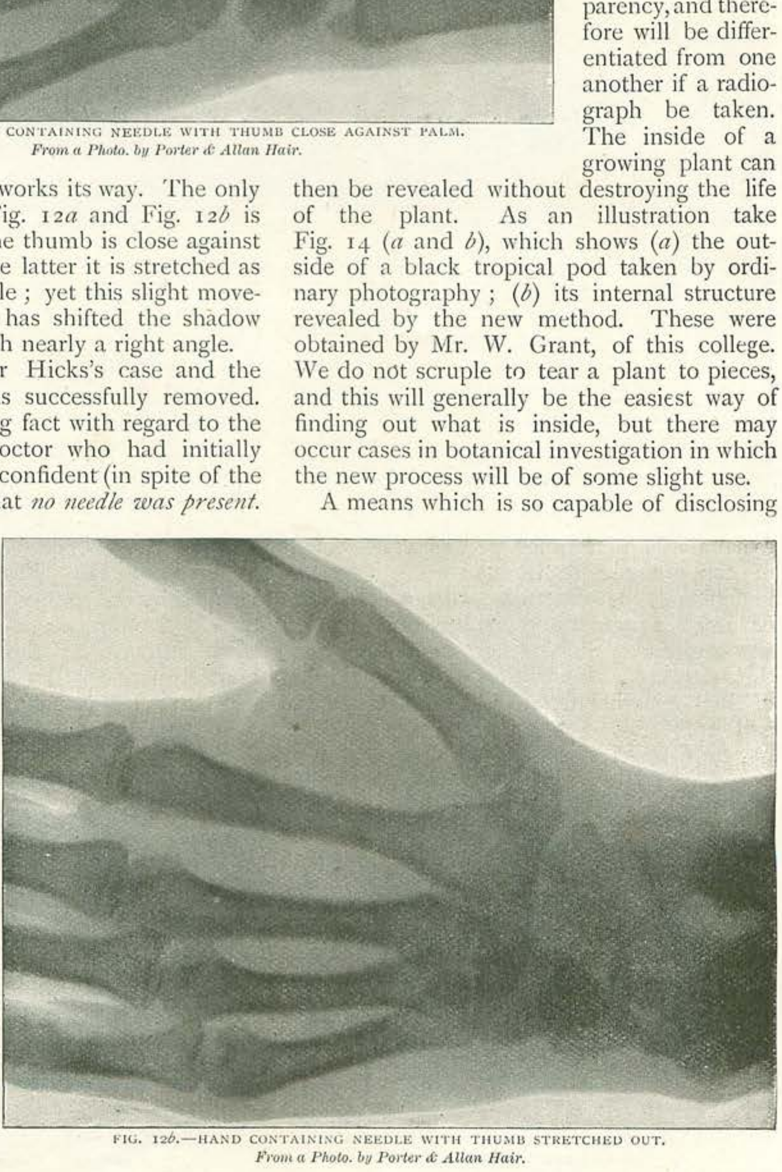
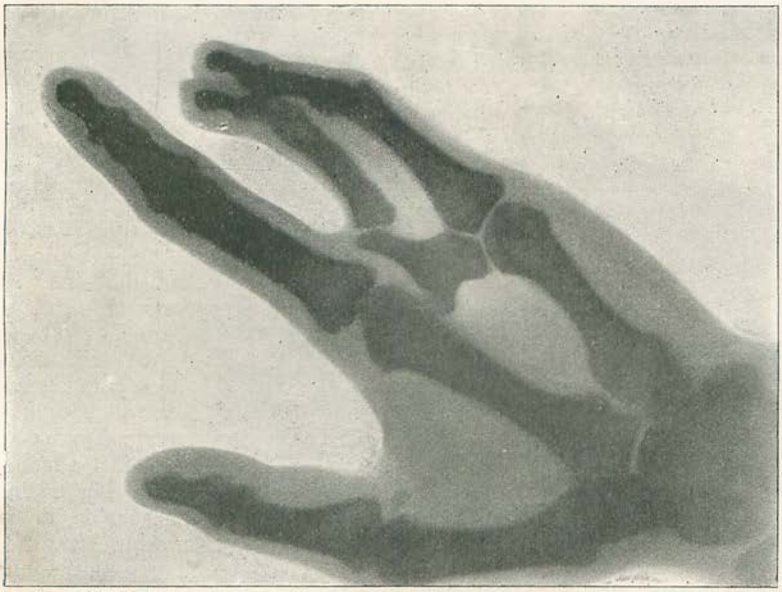


FIG. 12*b*.—HAND CONTAINING NEEDLE WITH THUMB STRETCHED OUT.
From a Photo. by Porter & Allan Hair.



From a Photo. by] FIG. 13.—MALFORMED HAND. [*A. W. Porter.*

photograph of an explosive-book, such as was sent some three or four years ago to MM. Constans and Etienne.

It is constructed on the "bon-bon" principle. One end of the cracker is attached to the cover, the other end to a box placed in a hollow inside the glued-up leaves. When the book is opened the cracker goes off and ignites the contents of the iron vessel. If this is filled with fulminate of mercury

the presence of metal might well be expected to have other useful application besides its surgical one. We have heard that it has been used by the Post Office for detecting the unlawful presence of coins in unregistered packages. A more important application is that which has been made by MM. Ch. Girard and F. Bordas, the former of whom is Director of the Municipal Laboratory in Paris.

To these gentlemen is intrusted the hazardous task of examining bombs and dynamitards' and other packages suspected of containing explosive material. We can understand the eagerness with which they have put to proof the possibility of using the new rays as an aid in their performance of their dangerous duties. Some of the results of their experiments are shown in Figs. 15 and 16. Fig. 15 represents an ordinary

and scraps of iron, the result can be better imagined than described. What the contents are can be in part discovered by the new photographic method.

The revelation made by Fig. 16 is quite sufficient to make one cautious in further investigating the encyclopædic character of the contents of this terrible volume.

We leave behind us now the period in which sharply defined results could only be obtained by the few. In the present stage anyone can obtain such results who is inclined to pay the extortionate prices charged by the sundry sellers of the "focus-tube." Results, therefore, fail to have the same interest as those obtained in the pioneer period. But I give a few here in order to bring the matter well up to date.

A remarkably clear hand, by Mr. Gifford,

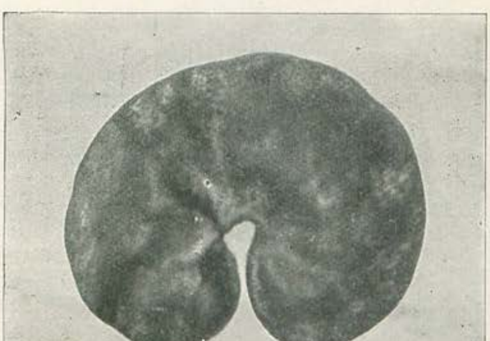


FIG. 14*a*.—ORDINARY PHOTOGRAPH OF SEED-POD.
From a Photo. by Mr. W. Grant.

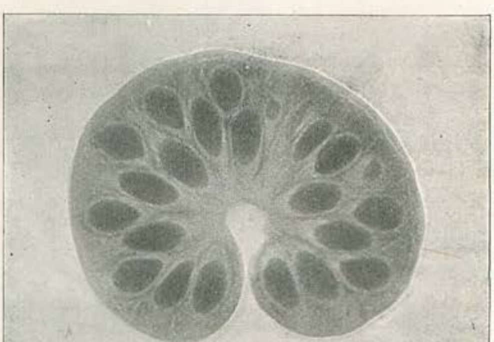


FIG. 14*b*.—RADIOGRAPH OF SEED-POD.
From a Photo. by Mr. W. Grant.

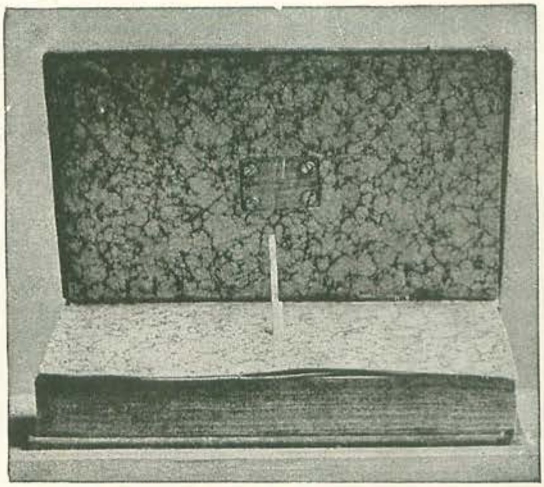


FIG. 15.—PHOTOGRAPH OF EXPLOSIVE BOOK.

is presented in Fig. 17. The amount of detail on it is surprising. The shading does not represent surface marking as it would in ordinary photography. It is an indication of the spongy nature of the bone. The shaft of each bone is seen (on interpretation) to be of much denser bone than the terminal portions. Indeed, in the first stage of life these portions have not yet become ossified. This is illustrated by the next example—a puppy, by Mr. Swinton (Fig. 18), in which the large interspaces between the bones represent regions filled with cartilaginous material, which will in part become ossified at a later period of life.

In the earlier attempts little success was obtained by those who used imperfectly acting tubes, in differentiating the various portions of the flesh from one another. A considerable amount of success has since been obtained. I give a fine example by Mr. Swinton — a side view of the heel, in which tendon, muscle, surface tissues, and bone are each distinguishable from one another (Fig. 19); and a further example is seen in Fig. 20—a pigeon by Mr. Stainer, of Folkestone. In this the trachea, or windpipe, shows plainly up to the point where the poulterer interfered. Lower down are seen the stones which the

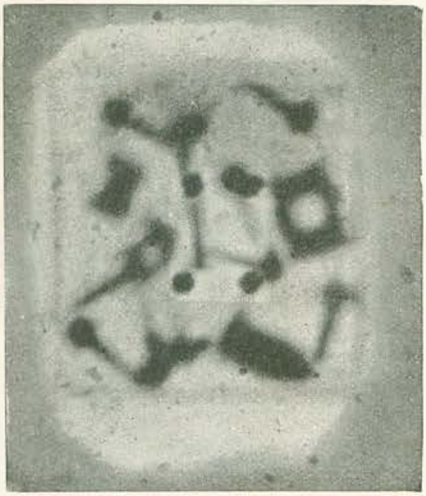
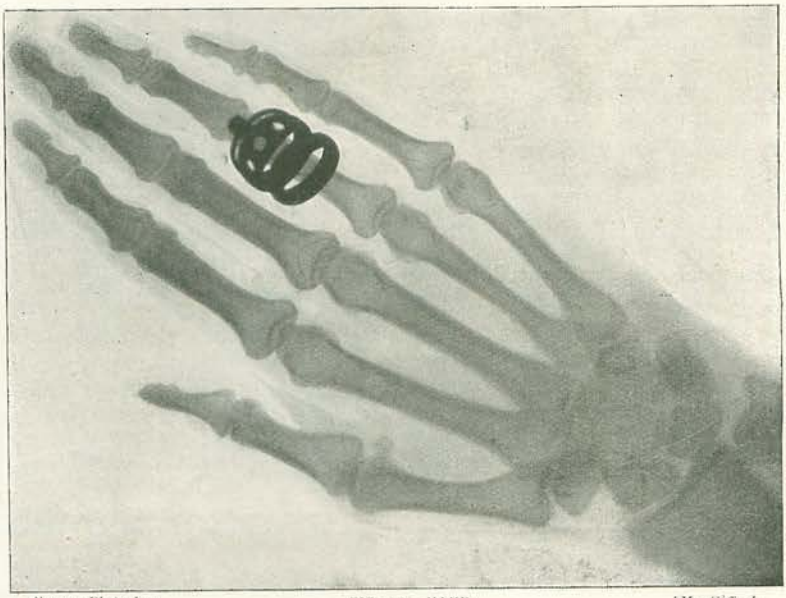


FIG. 16.—RADIOGRAPH OF CONTENTS OF EXPLOSIVE BOOK.

gizzard contains and which serve the same purpose as teeth in animals that possess them.

Finally I present a bat, by myself (Fig. 21). This animal had not awakened from his winter sleep when he was transported from the country and subjected to the radiographic ordeal.

We have been dealing with the subject



From a Photo. by] FIG. 17.—HAND. [*Mr. Gifford.*

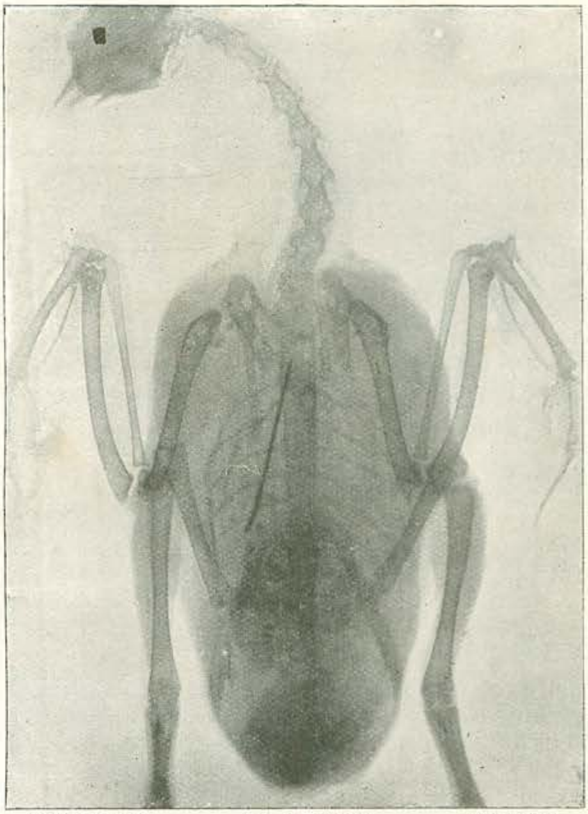
FIG. 18.—PUPPY (SHOWING INCOMPLETE OSSIFICATION OF BONES).
From a Photo. by Mr. Swinton.

chiefly in so far as it lends itself to pictorial illustration. But the matter is one which, as I stated near the beginning, has aroused an enormous amount of interest amongst scientific men. As leaders in this respect in Britain may be mentioned Dr. O. J. Lodge, F.R.S., of Liverpool, and Professor J. J. Thomson, F.R.S., of Cambridge. But there is scarcely a physical laboratory in the world in which experimental work is not being done in confirmation and extension of the valuable work done by Professor Röntgen himself.

The universality of this inquiry brings with it an important advantage. There is evidence that this radiation is not a simple thing. Just as light of many kinds is known—"blood-red and purple, green and blue"—so it would appear that Röntgen radiation is of a variegated character. It is of the supremest importance, then, that it should be developed under the greatest possible variety of conditions in order that its nature may be adequately brought to light.

What that nature is is still a mystery. No crucial experiment has been yet made deciding definitely in favour of one over the other of the two guesses which were made at first. In many respects it behaves like ordinary light. It thus behaves in its action on photographic plates and in its power of making certain bodies glow when placed in its path. It is like light also in so far as it can be reflected from certain surfaces. Here, however, the resemblance ceases. Light-rays are commonly bent on

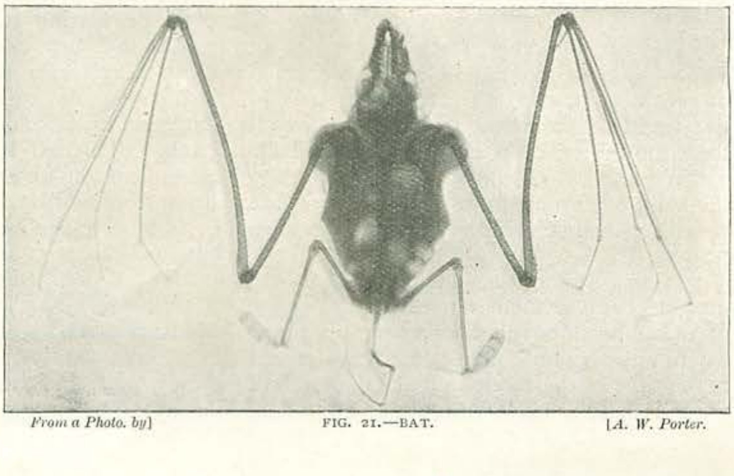
From a Photo. by FIG. 19.—SIDE VIEW OF HEEL. *Mr. Swinton.*



From a Photo. by] FIG. 20.—PIGEON. [*Mr. Stainer.*

Professor Röntgen's own suggestion was different from this. It is known that ordinary light consists of waves in a medium filling all space, to which the name "ether" has been given. If a stone is dropped into a pool of water, it starts the water moving up and down in such a way that a series of waves is propagated in every direction over the surface of the pool. When a candle or other bright point is shining, it is setting the ether particles vibrating from side to side in such a way that a series of waves passes away from it in every direction. But instead of vibrating from side to side, it is possible to imagine the ether moving backward and forward in the direction in which the waves travel. The waves produced would be called longitudinal waves. Such waves actually occur in our atmosphere, and are called *sound;* but they have never hitherto been detected in the ether. Are Röntgen waves the missing longitudinal waves in the ether? This was Röntgen's question; to it no decisive answer has yet been given, though the balance of evidence seems against an affirmative answer. Whichever of these solutions is the true one, we have been brought face to face with facts which would only a short while ago have been considered improbable, if not impossible. A new region for scientific exploration has been opened up, and no one yet knows what the extent of the new land is. But as we walk in it all regrets at our previous ignorance of its existence pass away, and the dominant feeling becomes one of joy and expectation with regard to the potentialities of our new possessions.

passing from one substance to another. No evidence of similar bending has been obtained for the new rays. Puzzling though this property of always passing in a straight course through a succession of substances undoubtedly is, it is yet not conclusive evidence against the rays being essentially similar to light-rays. A helpful analogy may be sought in the behaviour of a beam of light itself. "The gay motes that people a sunbeam" have no power to turn the beam out of its course; and if we can conceive the particles of which any substance is built up as behaving toward the new radiation in very much the same way that the particles of dust in the atmosphere act on the sunbeam which streams through them, the difficulty is to a large extent removed.



From a Photo. by] FIG. 21.—BAT. [*A. W. Porter.*