## APPLICATION OF RÖNTGEN RAYS TO THE SOFT TISSUES OF THE BODY.

WHEN the photographs which accompanied Prof. Röntgen's original paper were reproduced, the question was frequently asked, Shall we ever be able to photograph every part of the human skeleton? The developments have been very rapid, and now that it has been demonstrated that we can practically photograph the whole human skeleton in life, and throw shadows of a great portion of it upon fluorescent screens, we wonder the question was ever raised. It was quite natural that a similar demand should spring up for further extension of the art, so that other tissues than the osseous might be revealed by the same methods. Like many other observers, I early satisfied myself that we could examine and photograph certain organs within the cavities of some of the lower animals, such as the frog, rabbit, fish, &c. Further, in a considerable number of photographs of the deeper-seated structures, faint shadows of the human body were now and then obtained indicating the position of certain muscles, fasciæ, and even organs like the heart itself. While experimenting, like others, with the object of overcoming the difficulties of photographing the skeleton, I made a series of observations with a view to testing how far it would be possible to obtain photographs, or shadows upon fluorescent screens, of the contents of the three great cavities of the human body as well as the surrounding osseous walls. So far these experiments indicate promise of future development, and a few photographs are here reproduced, more by way of showing what may yet be accomplished than as an evidence of what has already been done.

In placing the following statements before the readers of NATURE, I desire to emphasise the importance of combining the study of the physical with the purely medical aspect of the question. To begin with, whatever progress may in the future be made with Röntgen rays, it must be remembered that the discovery itself came from the physical laboratory. Naturally, in the advancement of the study, certain aspects of the question will be more easily overcome by those familiar with normal and pathological tissues; others will just as naturally fall to be investigated by those engaged in physical research. Of course no line of demarcation can ever be drawn between these two, and the physician or surgeon who desires to pursue the subject must to a certain extent be conversant with physical science. On the other hand, the physicist will require to make himself somewhat familiar with the needs of those engaged in the study of animal and vegetable tissues. In this paper, therefore, while demonstrating some of the earliest examples obtained in this newer branch of the art, I desire to point out wherein we need the aid of those engaged in the physical laboratory. In so doing, I shall refer for the most part to the examination of the soft tissues of the human body, although it must never be forgotten that the use of Röntgen rays is not limited to any one part of the animal kingdom, and, further, that the structures in the vegetable kingdom are also being investigated by its means.

In attempting to photograph the soft tissues of the body, it might be thought they offered so little obstruction to the passage of Röntgen rays as compared with the bones, that less force would be required to demonstrate their presence. In other words, the natural suggestion was that if the bones of the extremities were to be photographed with certain apparatus in a given time, by diminishing the exposure we might be able to catch the soft tissues before they disappeared. This, of course, is true to a certain extent, and, in a certain number of my experiments, I was able, by carefully judging the exposure, to photograph not only the bones themselves in disease, but the fleshy parts, and this with such accuracy that the surgeon could see the internal pathological change and the external configuration of the part as well on the same plate. But when it came to the examination of the organs of the body, it was found that the rule did not apply as might have been expected, and instead of a less force it became evident that we would require more force. For example, in one successful attempt to photograph the lungs of the frog, I was able to demonstrate their presence and a deposit in one of the lobes of the right side, and this with an ordinary Paget plate, the exposure only being something like the time represented to give twenty successive flashes of the tube due to twenty interruptions of a mercury interrupter with a current registering ten volts and ten ampères across the terminals, the spark being about six inches, and the focus tube one of Newton's small earliest pattern. In this case, however, the

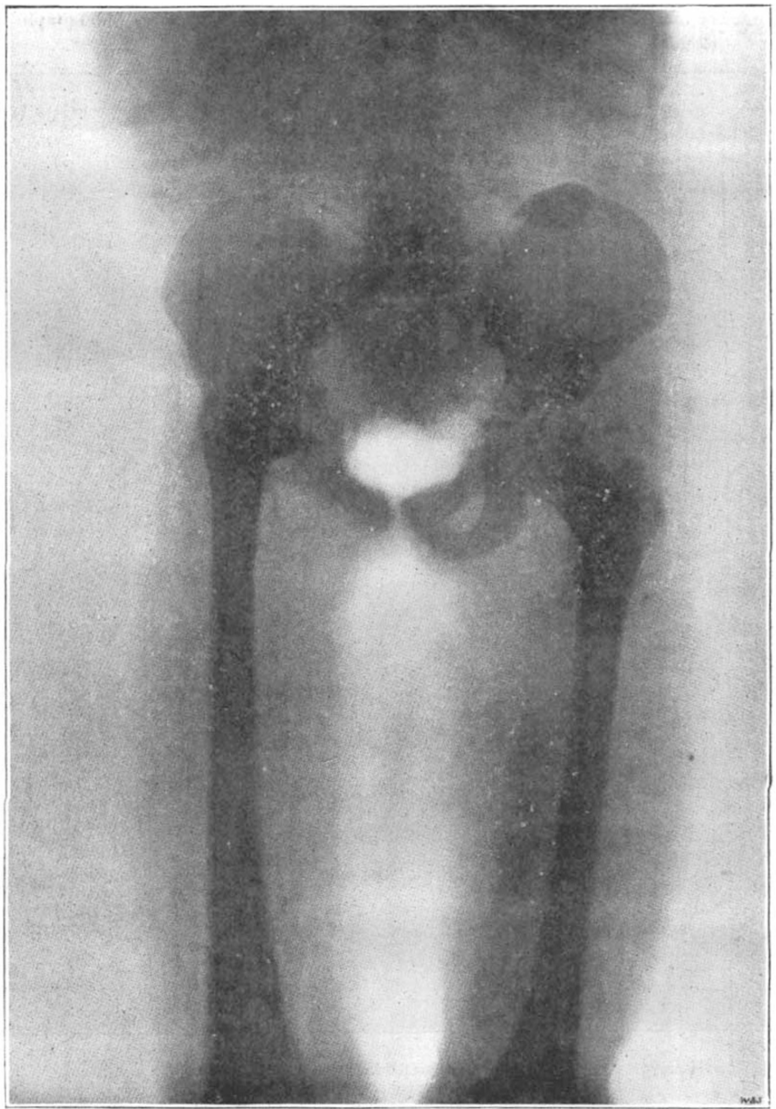

FIG. 1.—Pelvis of lad with femora, &c.

tube was removed six inches from the animal. Those familiar with this work will immediately see that, considering the difference in size of the human body, a tube placed at that distance could not possibly give the same result on a plate or fluorescent screen. To begin with, we know that there is a definite relationship between the distance at which the photographic plate is removed from the object to be photographed on the one hand, and the distance between the object and the Crookes' tube on the other. In other words, to get anything like sharp definition it becomes necessary to remove the tube to a considerable distance, which means of course loss of power, and consequently more difficulty in seeing objects on a fluorescent screen, and a longer time in exposing a plate. The distance must vary in given cases, and experience, after careful experiment, in the present state of our knowledge can only determine at what distance the tube is to be placed, although we very often get a valuable suggestion by first examining an object on the fluorescent screen, and noting the distance of the tube from the object.

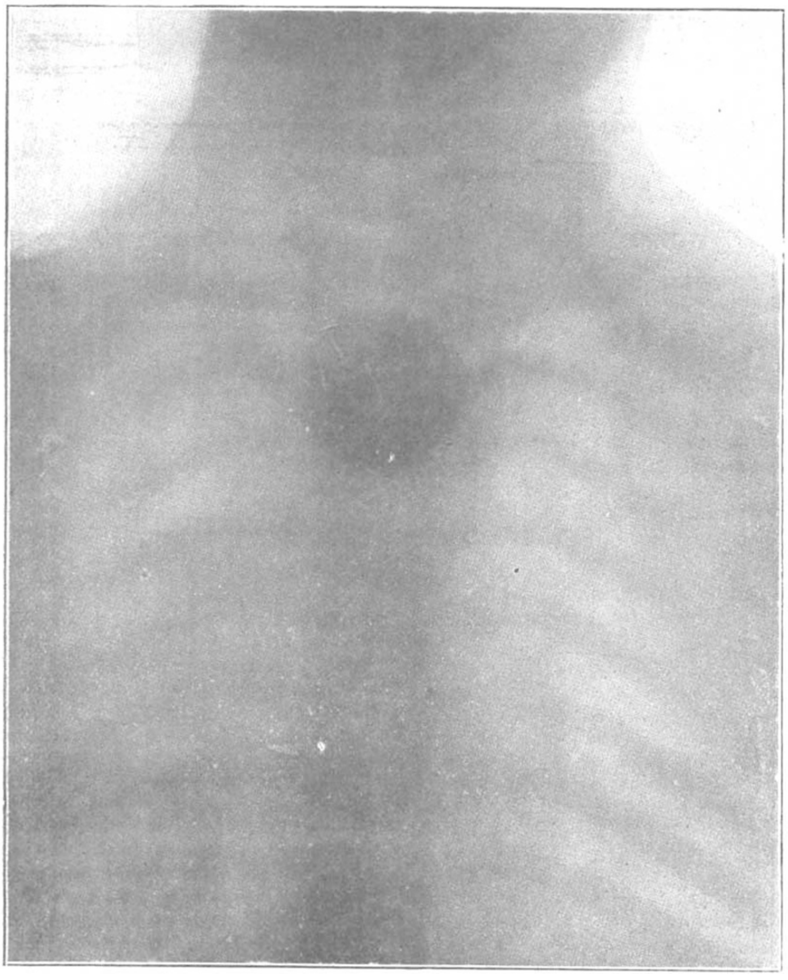

FIG. 2.—Coin impacted in gullet of boy aged six.

But another difficulty has now to be considered. Suppose we wish to try to photograph the heart. The patient must be placed on his face so that the organ may be as near the photographic plate as possible, and naturally the spine and other organs which we do not wish to be photographed will be between the object and the Crookes' tube. On the other hand, if we wish to photograph the spine, it may be necessary to omit the tissues of the heart and lungs. A still better example may be found in the case of the head, where the rays have to pass through the whole of the cranium, and yet the surgeon may desire to photograph the inside of only one side of the skull. Again, with renal calculus we do not wish to photograph the intestines lying in front, nor the muscles of the back behind. Fortunately the construction of the focus tube helps us in this way, and in an earlier number of NATURE of this year I pointed out a method by which this might be accomplished. The Röntgen rays springing from the platinum anode diverge from a point, consequently if we place the tube near the right side of the head, and the photographic plate on the left, the shadows caused by those structures immediately next the tube are so diffuse that they scarcely appear on the negative, while a sufficient number of the rays still pass through to photograph the part of the head which is in contact. By carefully arranging the tube therefore, one may photograph the heart, sternum and ribs by the same method; and if the patient be placed on his back, lying on the sensitive plate, these structures will be omitted, but the spine will be photographed. We can, also, by the same method photograph any part of the skull at will. Considering what has been said in the previous paragraph, it might be here argued that, seeing we are placing the tube near the body, less power will be required; but if we reflect in the case of the abdominal, thoracic, and cranial cavities, there is such density of tissue to overcome that we are more than ever in need of greater energy.

Following out these indications, I made a series of experiments and observations upon the apparatus at my disposal, and came early to the conclusion that more powerful currents would be necessary. Instead of measuring these in the usual way by the length of the spark of the coil, I placed Lord Kelvin's cell tester and ampère-meter in the circuit with a rheostat, so as to control the current at will, and taking a large German coil, in which the wires were thicker than the English form, the currents were gradually increased up to nearly thirty ampères. The experiments were pushed to such an extent that the focus tubes would not stand the molecular strain, and for this reason, at the instigation of Dr. J. T. Bottomley, several strands of wire were fused in the end of the tube bearing the kathode, while the anode was made adjustable so that the platinum might be removed at any distance from the kathode until the maximum result was obtained. There must be a relationship between the amount of energy passed into the coil, on the one hand, and the force coming out from the focus tube after being transformed. In other words, the coil is simply a transformer of a certain amount of energy which gives rise to conditions within the tube, which again give rise to X-rays. It was evident I had pushed this to the limit of the present make of tube. The question will naturally here suggest itself to those familiar with the subject, Is it necessary to use such currents, or could we not do with less energy by properly economising the force in the transformer and vacuum tube? The question is a very proper one, as all experimenters know that some tubes will give better results than others with a certain amount of force passed through a particular apparatus. This is yet to be settled, as well as the questions involving the amount of current absolutely necessary; the best form of coil; whether the coil itself is the best kind of transformer; and lastly, and probably most important of all, the conditions of the tube itself, and they all afford examples of what has been previously stated about the further need for physical research. What is here meant by the above statements is simply: with the apparatus as it stands at present, to get certain results, one is forced to use greater currents than might have been expected. But throughout the experiments, either upon fluorescent screens or in photography (I do not meantime enter upon the question of whether the maximum luminescence on the screen is the proper condition for obtaining the best result on the sensitive plate), the conditions were kept as nearly as possible uniform. In a previous paper in NATURE, I pointed out the advantage of a good interrupter, emphasising in attempts at instantaneous photography the value of the mercury form; but whether we use the latter or render the screw of the Apps' coil more tense so as to get larger sparks, any one watching the effect upon the ampère-meter and the fluorescent screen at the same time, will soon appreciate how important it is to control the current by means of the rheostat throughout the experiment. I have made experiments upon different kinds of glass for tubes; different sized kathodes; thicknesses of anodes; various materials for the latter; tubes have been sent to me by Mr. Friedrich, with a request that they might be compared with English forms; the Berlin Electrical Company have also placed their tubes at my disposal, but after many trials I know nothing so important as the constant attention to the vacuum throughout the exposure. Some of the best photographic results in the deeper structures of the body were obtained by the small and earliest form of Newton's tube. Another method of control is to place the two poles attached to the secondary coil at a certain distance from each other. This, of course, is used in testing the length of the spark before beginning the experiment. If these be too near during the exposure the sparks fly across, and the current being short-circuited the tube is cut out, but when the space is increased the tube becomes luminescent. This distance should be noted, and may be used to control the amount of electricity passing through the tube, as alteration in the vacuum causes the sparks again to fly across. By means of the spirit-lamp or Bunsen burner a little heat applied to the bulb at once corrects the vacuum, and a certain uniformity of condition within the tube results.

It may here be pointed out that in using fluorescent screens for the deeper structures of the body, barium-platino-cyanide in some instances gives a better result or a darker shadow than the potassium salt. I am quite aware of the fact that the potassium is more luminous, and it may be that it is a matter of construction of the screen or the particular specimen employed, because samples of these salts vary in their effects. After using a large number of different materials I, like others, have fallen back entirely upon the potassium or barium salts, but employ both, and the barium has the great advantage of being a good practical agent well suited for hospital purposes, and durable. I have still in my possession a screen made of this salt early in March of this year, and, although small in size, it gives as good results as any of my newer screens. I find a darkened room for medical purposes much better than any form of cryptoscope. Under favourable conditions many parts of the face and head can be distinctly seen on the screen. In some instances I have seen foreign bodies, such as shot in the scalp; in another I was able to differentiate, in a case of paralysis of the extremities, between fracture of the skull with pressure on the soft tissues from the effusion of blood and obstruction due to a star-shaped fracture, as opposed to the diagnosis of a bullet which was thought to be situated at a particular spot. The tissues of the neck may easily be searched for foreign bodies which obstruct the rays. Photographs of all these can of course be obtained, and I need hardly point out that, in the present state of our knowledge, the photographic plate reveals in some instances what the screen fails to show. There is one curious exception to this, where the movements of the organ are rapid, such as in the heart, because this necessarily interferes somewhat with success owing to the movement during the exposure of the plate. Passing to the chest, the outline of the pleural spaces may be seen, and in one case condensation of the apex of the lung was thrown as a shadow upon the screen. The heart itself as a body in motion, the ascent and descent of the diaphragm, the liver covered with the diaphragm, can also be made out. The majority of those conditions have been photographed as well as observed, and I have a series of pictures showing enlargement of the heart, enlargement of the liver, and in one case renal calculus. It need hardly be said in addition that every part of the trunk and extremities, as far as the osseous parts are concerned, have been photographed. I do not use fluorescent screens in photography, one amongst other reasons being that the plates used were much larger than any screen in my possession.

While these statements seem to indicate considerable progress in the art, I desire expressly to interpret them in the light a surgeon or physician would view them, lest any misconception should result. When one reads of instantaneous photography, direct inspection or photography of so many of these tissues, it may be argued that we have now brought the subject to a thoroughly practical issue; but it is not so. For this reason I have placed these statements before your readers, in the hope that those engaged in the physical research may know how much we are yet in need of their aid. Take the statement of rapid or instantaneous photography; a careful perusal of the valuable summary in the pages of NATURE for April 30, shows that this statement is applied to the extremities for the most part. It need hardly be pointed out that what the surgeon desires is instantaneous photography of every part of the body, particularly where there is movement. Further, the reader may imagine that in seeing the movements of the heart, one can examine it much as the physiologist does the beating of the same organ in the frog during dissection; but it is not so. Before the movements of the diaphragm and heart, the limits of the pleural cavities, and

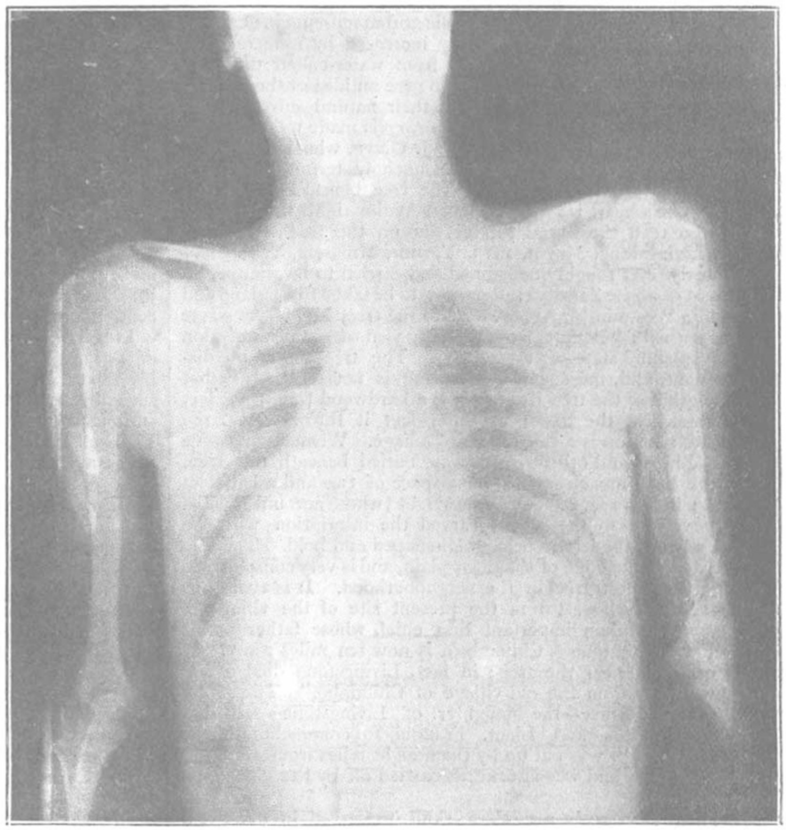

FIG. 3.—Thorax and upper extremities (adult), faint shadows of viscera.

the pathological changes in the tissues of the same, can be of great value to the physician, much more has yet to be done. The serious investigator is more impressed with what has yet to be done, than elated with what has already been accomplished. It is with great pleasure that I read in the columns of NATURE of the continued advances of those well fitted to engage in the study of the properties of Röntgen rays in the physical laboratory; and while we have reason to be pleased that the rays have been clearly proved to be of great value in the diagnosis of certain affections, every part of the apparatus must be investigated and improved upon before we obtain thoroughly satisfactory results. JOHN MACINTYRE.

## SCIENCE IN THE MAGAZINES.

PROF. H. F. OSBORN, curator of vertebrate palæontology in the American University of Natural History, New York, contributes to the *Century Magazine* a popular account of prehistoric quadrupeds found in the Rockies during the past few years, and to be exhibited to the public at that museum in October. Interest in his description is greatly increased by nine remarkably fine illustrations (reproduced from water-colour drawings by Mr. Charles Knight), designed to give an idea of the animals as they probably appeared in life in their natural surroundings. Another interesting article in the *Century* is made up of extracts from the journals of the late Mr. E. J. Glave, whose journey to the Livingstone Tree had such a melancholy termination. On July 8, 1894, Mr. Glave reached the tree beneath which Dr. Livingstone's heart is buried. Jacob Wainwright, the Nassick boy who read the burial service, cut on the tree the words: "Dr. Livingstone, May 4, 1873. Yazuza, Mniasere, Vchopere." The body was roughly embalmed and carried to Bagamoyo, on the coast opposite Zanzibar, afterwards to be taken to England and buried in Westminster Abbey. As to the tree, Mr. Glave wrote in his journal: "Although done twenty years ago, the inscription is in a splendid state of preservation. The tree shows no disfigurement, and, moreover, the carving is not on the bark but on the grain of the tree itself. It is a hardwood tree, three feet in diameter at the base; at thirty feet it throws out large branches; its top is a thick mass of foliage. When Livingstone died the heart and other viscera were buried beneath this tree, and the bark was cleared off for a space of two and a half feet square; in this space Jacob Wainwright (whose account my discovery verifies to the letter) carved the inscription with no dunce's hand, the letters being well-shaped and bold. The tree is situated at the edge of the grass plain, and is very conspicuous, being the largest tree in the neighbourhood. It is about five miles south south-west from the present site of the village of Karonga Nzofu, an important Bisa chief, whose father was a friend of Livingstone. Chitambo's is now ten miles away. It was originally near the tree; in fact, Livingstone died a few minutes' walk from the old village of Chitambo." The tablet which Mrs. Bruce—the daughter of Livingstone—sent out by Captain Bia and Lieut. Franqui to commemorate the explorer's death, was put up by them eight miles from the spot where he died, and was afterwards carried off by the chief of a slave caravan.

"There is scarcely a modern skull preserved in our great anatomical museum beside those of abnormal malefactors. There is no fairly representative collection of the variations of our race; and there is no means of learning the characteristics of it in contrast to those of other races. This is far more the case in other directions; any solid comparative study of man's framework is as yet utterly impossible. Of many races not a single skeleton is preserved; and those of which we know a little are only shown by a few scanty specimens, of which the history and details are scarcely ever recorded. Of both past and present races a collection of at least a few dozen specimens of each race, precisely dated and localised, are the smallest amount of material which would enable us to begin a scientific treatment of the varieties of man." So writes Prof. Flinders Petrie in the *National Review*; and he suggests that, to systematise the study of man, a large museum should be established where examples of every object of human workmanship can be preserved. He is sanguine enough to think that this great repository of the works of man will be realised in the course of a few years. Such an institution would undoubtedly be of service to science. From this proposal of Prof. Petrie's, ethnologists may profitably turn their attention to a paper on "African Folk-Lore," contributed by A. Werner to the *Contemporary*. While staying for some months in East Central Africa, the authoress collected a number of traditional tales of the Mangánja, and she now relates them. Many of these stories deal exclusively with animals; and all of them proceed on the assumption that animals, human beings, and inanimate objects feel and act in much the same manner. There is a striking similarity between these myth-stories and the stories of "Uncle Remus"—a fact which goes to confirm the opinion that the latter originated with the African.

Prof. Ray Lankester reviews Mr. Archdall Reid's speculations on "The Present Evolution of Man" in the *Fortnightly*. "Mr. Reid," he says, "seems to be under the impression that the lines, or rather two of the lines of the present evolution of man have been definitely and satisfactorily indicated by his speculations. I am far from admitting that he has done more than demonstrate and draw attention to some tendencies of that evolution. . . . I am by no means convinced that the present and future evolution of man is being determined exclusively or even mainly in the simple way and by the obvious factors which he has placed before us."

Two editorial notes in *Scribner* deserve mention. In one a plea is made for the adoption of the metric system throughout the United States. The Bill introduced last session, and which will again be brought before Congress in the coming session, provides for the substitution of the metric system immediately in practically all the departments of the Government of the United States, and the adoption of the metric system of weights and measures as the only legal system to be recognised after the first day of January, 1901. The second note referred to is on Summer Schools, or vacation courses. It appears from a report of the U.S. Bureau of Education, that more than three hundred vacation courses, dealing with all branches of knowledge, are now held at various educational centres throughout the world.

In the *Strand Magazine*, Sir Robert Ball, continuing his series of astronomical articles, describes the discovery of Neptune, his treatment of that well-worn subject being illustrated with several interesting pictures. A number of reproductions from curious photo-micrographs form the chief feature of Mr. W. G. FitzGerald's article on "Some Wonders of the Microscope" in the same magazine. There is also a story dignified as an "Adventure of a Man of Science," which has for its scientific foundation the cure of madness by mysterious capsules. Even this flimsy basis is better than the description, in last month's *Strand*, of the use of a camera to obtain a photograph, by means of Röntgen rays, of a stolen diamond inside the thief's body. We should have thought it was known by this time that cameras are not used in Röntgen photography. Sir C. H. T. Crosthwaite shows a little better acquaintance with the subject in a story entitled "Röntgen's Curse," contributed by him to *Longman's*. The central figure of the story concocted a liquid which, when painted on the insides of his eyelids, made him as perspicaceous as a platino-cyanide screen excited by Röntgen rays. The capacity thus gained proved anything but a source of enjoyment to the experimenter. The idea may be good enough for a story, but a cautious man of science would have tried his wonderful liquid on one eye, and not on both.

In the *Sunday Magazine* there are two popular articles of interest to naturalists: one describes and illustrates sculptures of animals adorning a number of ecclesiastical buildings; and in the other Mr. C. J. Cornish writes on nightingales' nests, his account being illustrated by photographs from life.

*Chambers's Journal* has, as usual, several popular articles on science.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. H. R. NORRIS, Mathematical and Science Master of Ipswich Grammar School, has been appointed Head-master of Barry Intermediate and Technical School, Glamorganshire.

THE Finance Sub-Committee of the Bradford Corporation recently held a special meeting and decided to allocate the following grants under the Technical Instruction Act:—Bradford Technical College, £2875; Free Library, £300; Boys' Grammar School, £500; Girls' Grammar School, £100; Mechanics' Institute, £300; School Board, £1000; Church Institute, £100; Blind Institute, £50.