presented experiments strongly confirmatory of this hypothesis. These cathode rays can be deflected by a magnet, behaving precisely as a current in a perfectly flexible conductor would in a magnetic field. Crookes also showed that these rays on striking a wheel with very light vanes can make the latter rotate, thus producing a mechanical effect.

Now Roentgen's discovery was that outside the tube peculiar effects may be produced. He wrapped a tube in dark paper, and found that, in a room absolutely dark, substances could be made to light up and fluoresce at every discharge of the coil. He also found that a board or a paper interposed did not prevent the transmission of the effect. Almost every substance was transparent in some degree, though of the metals aluminum was the most transparent, and lead the most opaque, a thin sheet being practically impervious. Afterwards the dry plate was tried; and the fact that this is quite sensitive has caused the perhaps unprecedented scientific sensation of which we have heard so much of late. Not like some sensations, however, there is much genuine and remarkable value at the bottom of it all.

Roentgen next showed that the rays outside are not the same as those within the tube. They did not follow the same laws, and so to distinguish them he called them the X-rays, X here having the common algebraic meaning—namely, an unknown quantity. Hence we see the whole process. The induction coil (and a pretty large one works best, one which will give a 2-inch spark, say,) produces the cathode rays in the tube, and these on bombarding the opposite side of the tube, excite the Roentgen, or X-rays in the ether outside. The latter rays can penetrate some substances easily, others with difficulty, and hence if a hand be placed on the dry plate below the tube—or in the line of the cathode rays—the X-rays pass through the flesh much more easily than the bones, and so on the plate the bones will be shown apart from the flesh—indeed in some cases they come out with startling distinctness.

I may say, however, that the discoverer's theoretical explanation of the new phenomena is not accepted by all. Prof. A. W. Wright, of Yale University, thinks they are the real cathode rays, filtered or modified somewhat on passing through the glass. In England, Prof. Oliver Lodge* and other physicists do not see their way clear to accepting Roentgen's views. They are divided between ultra-violet waves on the one hand and longitudinal vibrations on the other, which latter is the suggestion of Roentgen. At any rate, the theoretical interest is immense.

For best effects the tube should be not many inches from the plate, and the object should be as close to the plate as possible, and, as just mentioned, the cathode rays should be directed towards the object to be photographed. Perhaps the most obvious application is in surgery, since a broken or deformed bone, or the presence of foreign substances, especially if metal, can be shadowed out.

In Toronto the new process has received considerable attention. At both the chemical and physical departments of the University of Toronto many pictures have been taken.

Mr. J. C. McLennan, B.A., of the Department of Physics, working with Messrs. C. H. C. Wright, B.A. Sc., and Jos. Keele, B.A. Sc., of the School of Practical Science, have produced some excellent pictures, some of which are illustrated herewith (Figs. 2, 3). Roentgen made experiments to determine if his new rays were reflected or refracted. With a water or carbon bisulph-

SET OF SPRING BOWS TAKEN THROUGH CASE, EXPOSURE TEN MINUTES.

ide prism no effect was observed; with ebonite and aluminum a possible deviation, giving a refractive index of perhaps 1.05. Moreover the rays seemed to pass through a plate of substance equally well, whether the substance was solid, or in a powdered state. Thus he could not conclude any regular reflexion or refraction. Experiments with metals seemed, however, to point to the probability that platinum, lead and zinc can reflect. On this he says: *

"If one considers this observation (on the metals) with others, namely, on the transparency of powders, and on the state of the surface not being effective in altering the passage of the X-rays through a body, it leads to the probable conclusion that regular reflexion does not exist, but that bodies behave to the X-rays as turbid media to light."

However, in an experiment by the above three gentlemen a porcelain shade was held over the tube and as a result it was found that the time for exposure was very greatly shortened. Using a glass bell-jar over the tube, pictures have been taken through wood with five seconds' exposure, and through several sheets of paper in a single second of time. I have not heard of this effective arrangement being utilized anywhere else.

The practical use of these experiments was very well illustrated a few days ago. A Toronto lady had unfortunately run a broken needle into her foot, and all means to find it were unavailing. However, on taking a picture of the foot there was visible a faint shadow of the metal. Thus it was located and a single incision reached the end of it, about half an inch beneath the skin.

Prof. McKay, of McMaster University, has successfully used a burnt-out incandescent lamp as a

*London *Electrician*, Jan. 31, 1896; reprinted in N. Y. *Electrical World*, Feb. 22nd, 1896.

* For a translation of the original paper, with the discoverer's illustrations, which have hardly been equalled for clearness of detail, see *Nature*, Jan. 23, *Science*, Feb. 15; *Electrical Engineer*, N.Y., Feb. 12; *Western Electrician*, Feb. 15; *Scientific American*, and other papers.