RADIUM AND RADIO-ACTIVITY.

The popular literature concerning radium and radio-activity is so extensive, confusing, and in many cases misleading, that a succinct account of the whole subject and of the experimental proof of the most important phenomena may be of interest. The emission of Roentgen rays from that part of the glass tube which the impact of cathode rays from within had made fluorescent suggested the thought that Roentgen rays might accompany other cases of fluorescence. Becquerel found, indeed, that the well-known fluorescent uranium compounds emit also invisible rays which have much in common with Roentgen rays, but the same property is shown by non-fluorescent uranium compounds and still more strongly by metallic uranium, so that the invisible rays are not caused by fluorescence. It was soon proved, also, that the Becquerel rays are not identical with those of Roentgen, and it is now known that radio-activity, or the power of emitting Becquerel rays, is possessed by many substances, though by most of them so slightly that exceedingly delicate methods are needed for its detection. Thorium and its compounds are nearly as radio-active as uranium; but by far the most radio-active substances known are radium, polonium, and actinium, recently discovered by the Curies, Bemont, and Debierne. All of these, together with two other strongly radio-active substances, "radio-lead," discovered by Hofmann and Strauss, and "radio-tellurium," discovered by Marckwald, are obtained from pitchblende and other uraniferous ores. Radium is the only one of the five whose elemental character has been established by a distinctive atomic weight and spectrum. It has not been isolated, but its chloride and bromide have been obtained free from salts of other metals. Polonium is closely associated with bismuth, actinium with thorium, radio-lead with lead, and radio-tellurium with tellurium. The elemental character of all four is still in question. Five thousand tons of Joachimsthal pitchblende yield about one gramme—15 grains—of pure radium chloride. Traces of radio-activity are found in air, especially the air of caves and of the ground, in clay soils, water, the gases evolved by certain springs, and in "fango," the mud of a hot spring near Padua. The radio-activity of the last named is less than a thousandth part of that of pitchblende.

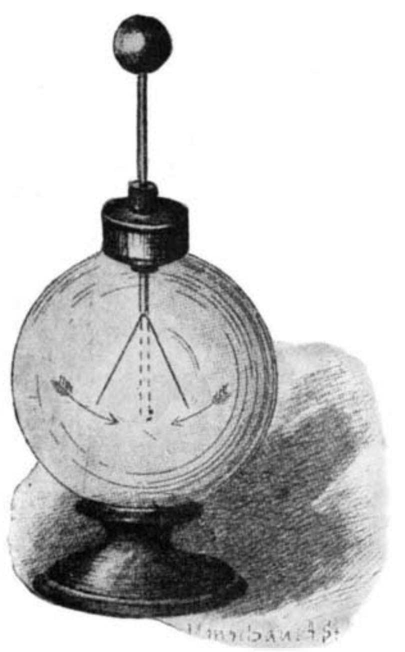

Fig. 1.—Electroscope for Detecting Radio-Activity.

The existence of such infinitesimal proportions of radio-active matter cannot be detected by chemical methods, nor even by the spectroscope, but only by the phosphorescent, fluorescent, photographic, and electrical effect of the radiation itself. If an electroscope (Fig. 1) is charged by touching its knob with a rubbed stick of sealing wax the strips of gold or aluminium leaf, being charged alike, repel each other and diverge, and the angle of divergence forms a measure of the charge. Now, if a radio-active substance is brought near, the charge gradually diminishes and the leaves approach each other.

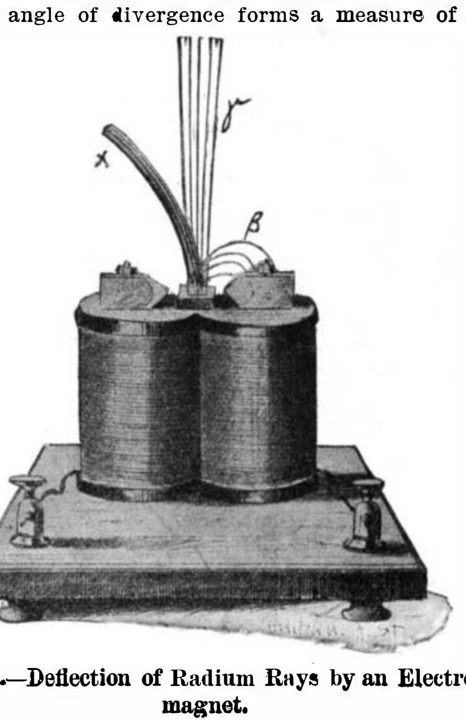

Fig. 2.—Deflection of Radium Rays by an Electro-magnet.

A given electrical charge is dissipated one hundred thousand times as rapidly by pure radium chloride as by metallic uranium, but it does not follow that the total intensity of radiation of the two substances is in the same ratio. For the radiation in question, like that which constitutes light, varies in quality according to its source and it may be analyzed by a magnet as light is analyzed by a prism.

If a little radium chloride is placed in a lead box with a perforated cover between the poles of a powerful electro-magnet (Fig. 2), the entire radiation which escapes goes vertically upward so long as the magnet remains inactive, and its path may be traced by means of photographic plates exposed at different heights. When the current is turned on, however, the beam divides into three, of which one (γ) remains vertical, a second (α) curves slightly to one side, and the third (β) curves much more strongly to the opposite side and is also dispersed or spread out as sunlight is dispersed by a prism.

The α rays suffer great loss by absorption in passing through thin layers of solids and even through air. The γ rays pass with little loss and the heterogeneous β rays are absorbed more or less in proportion to their deviation by the magnet. The α rays constitute almost the entire radiation of polonium and the greater part of that of radium which also emits both β and γ rays, the latter of very small intensity. Thorium, uranium and actinium emit and rays.

The γ rays seem to be identical with Roentgen rays and are therefore the result of wave motion in the ether. The action of the magnet on the α and β rays indicates that these are streams of electrically charged particles. The direction in which such a stream is deflected depends upon the character of the charge (whether positive or negative) and its extent depends on the amount of charge, and the velocity and mass of the particles. From these considerations it has been inferred that the α rays consist of positively charged particles of the size of chemical atoms or molecules moving with not more than one-tenth the speed of light, and that the β rays are composed of very much smaller negatively charged particles, or possibly free "electrons," or atoms of negative electricity, moving almost as swiftly as light. In other words the β rays are identical with the well-known cathode rays emitted by the negative electrode of a Crookes tube, and the α rays are the same as the "canal" rays proceeding from the positive electrode, which were discovered by Goldstein a few years ago. Though the general properties of radium or Becquerel rays resemble those of Roentgen rays, they are not so well suited for making radiographs.

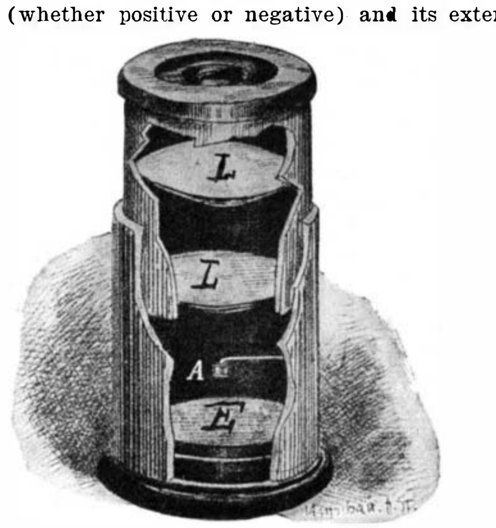

Fig. 3.—Crookes Spinthariscope for the Observation of Radium Rays.

Bodies on which Roentgen rays fall emit secondary rays which are not quite identical with the rays which excite them and these secondary rays may give rise to tertiary rays in like manner. Radium rays have similar effects, and it should be noted that Roentgen rays themselves are the secondaries of the cathode rays. All of these are distinct from the phosphorescence and fluorescence, that is to say, the true light rays, excited by the impact of radium rays, as well as of cathode and Roentgen rays. In the case of radium rays there are some peculiar phenomena which are best observed by means of Crookes spinthariscope (Fig. 3), in which a plate *E*, covered with zinc sulphide, is exposed to the radiation from a bit of radium salt *A*, and observed through lenses *LL*. The plate appears dotted with points of light which flash out and vanish in a manner that suggests bombardment by myriads of tiny projectiles.

The destructive action of Becquerel rays on the skin is far greater than that of Roentgen rays, hence the former seem likely to be more effective in the treatment of lupus and cancer. The Roentgen rays afford no parallel to the paralysis of nerve centers produced by Danysz with radium rays. As a radio-active body emits both positively and negatively charged particles it must acquire an electric charge unless these leave in compensating proportions. As a matter of fact the light negative particles escape far more readily than the heavier positive particles and therefore the substance shows a continually increasing positive charge. Mme. Curie and others have received slight shocks accompanied by sparks on opening sealed glass tubes in which radium bromide had been long kept. The accumulation of the charge is well shown by an apparatus devised by Righi (Fig. 4). A few milligrammes of radium bromide are inclosed in a glass capsule, *B*, to which are attached a thick and a thin strip of aluminium *A*, and the whole is suspended by an insulating rod in an exhausted glass tube through the bottom of which is fused a wire *C* connected to earth. The increasing charge is shown by the gradual divergence of the aluminium foil from the thick strip. When the foil touches the wire the charge escapes to earth and the foil falls to a vertical position but at once begins to diverge again.

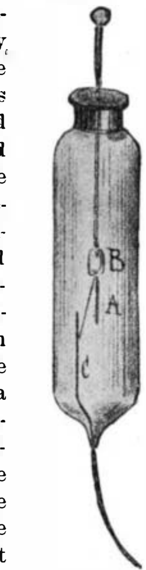

Fig. 4.—Apparatus for Detecting the Spontaneous Electrical Discharges of Radium.

Discharges occur at intervals of a few minutes until the strip is worn out by its ceaseless motion.

Radium and thorium compounds emit also an unquestionably material "emanation" or gas which has been condensed to the liquid form.

Being radio-active, the gas seems to confer the same property, temporarily, on substances to which it clings. According to Giesel, it contains an element related to lanthanum, which he has named emanium, but the investigation is still unfinished.

Others have observed that the emanation gradually changes into helium, a gas long suspected to exist in the sun and recently found on the earth, especially in radio-active minerals and springs. The continuous production of the emanation points to a gradual transformation of the radio-active substance and suggests a cause of the spontaneous evolution of heat also observed in radium. According to the theory of Rutherford and Soddy, indeed, radio-activity is merely a subsidiary [an accompanying] phenomenon of the transformation of unstable into stable forms of matter.—Condensed from Dr. Bernard Dessau, in Die Umschau.

Fig. 5.—Condensation of Radium Emanation by Liquid Air.

An interesting trial was recently made by a German firm to discover whether lighters can be safely employed for the transit of timber from the Norwegian coasts, across the North Sea, to English ports. For the trial a new type of lighter was constructed, with a carrying capacity of 1,200 tons of lumber, which is about four times the carrying capacity of the sailing vessels at present employed in this traffic. Powerful tugs were also built to tow the lighter across the North Sea. The passage of the cargo from Riga to the Tyne occupied eight days, which compares very favorably with the time occupied by the sailing vessels. The success of this experiment opens up new possibilities for the transit of lumber between these two points, since it is much cheaper, owing to the greater tonnage that can be handled on a single journey.

Speaking at the International Geographical Congress on the formation of Niagara Falls and Gorge, Prof. Grove Karl Gilbert, of Brooklyn, prophesied that the Niagara River will probably run dry in 3,500 years, because Lake Erie will find another outlet.

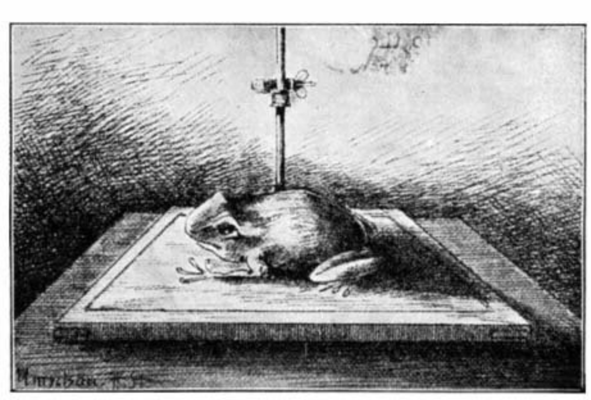

Fig. 6.—How a Radiograph of a Frog is Made.