pect to see in the near future a considerable improvement in lead cells in the way of longer life and greater reliability.

I think the investigations should be directed to methods for securing greater porosity and firmness in the active material of the positive electrode and to improving the electrolyte so as to prevent the formation of lead sulphate, or at least to render it insoluble in all densities of the acid solution, so that it remains in place and can be restored to the proper condition.

Other metals will undoubtedly come into competition with, and may displace, lead in batteries for traction work, but as an auxiliary in electric light and power stations lead cells will probably hold their own for some time.

Nickel is a strong metal compared with lead. Its peroxide belongs to that class of depolarizers which add electromotive force to the cell, and in this respect it is the best, so far, that it is practical to use in alkaline electrolytes. The electrolyte permits the use of steel for the grids and the containing vessel, and this gives a construction both light and strong. There seems to be no reason to believe that this cell will not do what Mr. Edison claims for it.

Silver would be a good metal to use in traction batteries if its cost were not so great. To be sure, the silver in a worn out battery would go a long way toward paying for a new set, but the first cost would be rather great. Silver is a rather abundant metal, and ought to be produced for much less than it brings at present, if the demand for it should sufficiently increase.

In the lead cell the active material of the positive is only about half of the weight of the entire plate, so the weight or silver oxide required in the silver cell would correspond to the weight of lead peroxide, and not to the whole electrode. The other materials used would be inexpensive; nickel or steel for the positive grid, and probably iron for both negative grid and active material.

Experiments indicate that a silver battery, giving the same power as a lead automobile battery weighing about 550 pounds, would require only about 70 pounds of silver oxide and perhaps less. It would not take a very extraordinary reduction in the price of silver nitrate to make the cell practical from a financial standpoint, and for the reasons given above such a cell could be made to have a comparatively long life and high efficiency, and would require but little attention to keep it in working order.

PHOTO-ELECTRIC EXPERIMENTS.

By A. FREDERICK COLLINS.

THE curious working out of another of Hertz's great discoveries in wireless telegraphy has been exemplified in the recent long-distance test made by Mr. Marconi when he received signals a distance of 2,099 miles from Poldhu, Cornwall, while on board the "Philadelphia."

On this trip it was found that the signals were distinct and clear at night for 2,000 miles, but in the day the effective distance at which the signals could be deciphered was only a fourth part as great, or 500 miles.

In tracing this effect to its cause, one finds abundant experimental proof that this is a normal and proper result. In 1887 Hertz found that one disruptive discharge on another had the effect of diminishing the spark of the latter, and upon careful analysis he determined that this untoward result was due to the ultra-violet radiation—in which the disruptive discharge is rich—dissipating the charge of the secondary oscillatory system.

The apparatus Hertz employed in his researches is shown in Fig. 1. It consisted of an ordinary Ruhmkorff induction coil, *A*, connected with an oscillator system, *B*; a second and smaller induction coil of the same type, *C*, having a very small spark gap, *D*, was set parallel with the larger coil, with the spark gap of both in alignment, so that the radiating properties of either coil will be such that the spark gap of the other will be in the best position to receive the waves. The primaries of both coils are connected in series with a battery, *E*, and an interrupter, *F*, both of which are common to and suffice for both coils.

When the spark gap, *B*, was screened from that of *D* either by a conductor or an insulator, i. e., a metal or ebonite plate, the spark discharging across *D* became much smaller. It was this fact which first excited Hertz's interest in the experiment; and in solving just such complex phenomena as this in speculative physics is where his marvelous analytical genius was shown most splendidly. Had the spark been diminished by the intervention of the conductor and not the insulator, or *vice versa*, then the explanation could have been easily traced to electro-magnetic or electrostatic displacements, since there was a synchronous action between the coils, being operated on a common circuit, but where both insulator and conductor produced the same effect, reason proclaimed the retardation of the spark due to waves emitted directly from the spark of one falling on the other oscillatory system. It was reasonable to suppose that these were light waves. To test the validity of this supposition, Hertz arranged the oscillatory system separate and the result was the diminishing of the spark as before. This the physicist attributed to the dissipation of the electric charge on the balls of the oscillator. The dielectricity of the charge on metals by light waves or rather radiation has been termed *photo-electric* action; and since Hertz the phenomenon has claimed the attention of some of the leading physicists. Hertz's researches were exhaustive in so far as the photo-electric effect of one spark on another was concerned. He tested the influence of sparks between knobs, points, and other forms of terminals forming the spark gap; he employed short, straight sparks and long, jagged sparks, the faintly luminous blue sparks, and the brilliant white sparks; he found that sparks of only 2 millimeters in length possessed the property of diminishing the secondary electric sparks at a distance of 15 or 20 centimeters.

Hertz showed that glass cuts off the photo-electric effect and this led him to suspect that it was not the visible waves of light that possessed the photo-

electric property, but the extremely rapid invisible ultra-violet radiation. When the glass tube allowed the minutest spark to be exposed at either terminal the effect was instantly reproduced. The maximum effect was obtained by short sparks between balls of different metals. Oscillatory balls of different metals were tried, but Hertz found no appreciable difference; the only conditions seemingly to be fulfilled were perfectly clean and polished sparking balls with the sparking distance not too great.

Naturally, as Hertz pointed out, the relation of the primary and secondary sparks was reciprocal, the disruptive discharge of one acting on the disruptive discharge of the other. In further demonstrating that

FIG. 1. TOP ELEVATION OF APPARATUS USED BY HERTZ IN HIS RESEARCHES IN PHOTO-ELECTRIC EFFECTS.

the photo-electric effect was not caused by the visible light emitted by the sparks, but by the invisible ultra-violet radiation, he interposed pieces of mica and glass—opaque to ultra-violet waves—between the primary and secondary sparks. There was no action, no effect, the results were *nil*, yet both of these substances are transparent to the longer waves of light.

Other sources of light were tried and the dielectricity of the changed oscillatory balls showed that they also possessed photo-electric properties, although the faintly luminous spark of the induction coil was a great deal more effectual since it is a much richer source of ultra-violet waves. Hertz tested the sunlight for photo-electric effects many different times of the day and seasons, but without result, and this lends the greater interest to the recent experience of Marconi.

After Hertz, Prof. Auguste Righi—the preceptor of

FIG. 2. RIGHI'S APPARATUS FOR SHOWING PHOTO-ELECTRIC EFFECTS.

Marconi—took up the work and his researches resulted in demonstrating that the greatest photo-electric effect was produced by an arc light, the electrodes of which were formed of rods of zinc; in accordance with Hertz, Righi was unable to discover the slightest influence exerted by the sun's rays. Righi found that the charge of copper gauze and zinc plate would be reduced under the radiation of ultra-violet light, and with a number of elements so formed, he constructed a photo-electric battery. He also observed its effect in discharging charged insulators of ebonite and sulphur. The hypothesis Righi favored in accounting for this phenomena was that the ultra-violet radiation produced convection, or the process of transmitting negative electricity, the molecules of the air acting as carriers for the minute charges. According to this hypothesis the particles of air carry definite charges of

FIG. 3. LODGE'S APPARATUS FOR SEPARATING THE ULTRA-VIOLET RADIATION FROM THE VISIBLE LIGHT WAVES.

negative electricity, and when these traverse certain paths they cast electric shadows, just as they do in a Crookes shadow tube. Righi determined that an insulated metal is charged to the *positive* sign by ultra-violet radiation, that is if the metal is neutral or has a small initial plus-charge at the beginning of the experiment. By employing a more sensitive method of detection than Hertz, Righi found the discharging effects of photo-electric radiation for negative electricity greatest when the spark gap was formed with terminals of zinc or aluminium. Righi assumed the

reason for the failure of sunlight to produce photo-electric effects to the absorbing action of the atmosphere for ultra-violet radiation. In the light of later research it is evident that the sun produces a very appreciable action, but that sensitive instruments are required to detect it. In reproducing these experiments, an easy and effectual method may be contrived with little trouble, but exceeding care must be taken in making the tests.

Fig. 2 shows the arrangement of the apparatus. *A* is an arc-light formed of zinc rods, *B* a gold-leaf electroscope to which a ball of polished zinc, *C*, is attached by a wire. Let the ball be charged with negative electricity, and then expose it to the rays of the arc lamp; almost instantly the leaves of the electroscope will converge, showing that the charge is dissipated; but let the ball be charged positively, and the experiment reproduced; it will be found that no appreciable decrease of the charge takes place.

To demonstrate more clearly that this discharging effect is due to the action of the invisible ultra-violet rays, Lodge used the combination of apparatus as shown in Fig. 3. *A* represents the zinc-rod arc-lamp, *B* a pair of plano-convex condensing lenses of quartz, *C* a diaphragm, *D* an objective convex quartz lens, and *E* a quartz prism. The shaded portion, *F*, shows the path of the visible rays, and the unshaded portion, *G*, inclosed in the dotted lines, represents the invisible ultra-violet radiation. Now the instant the negatively charged zinc ball is placed in the line of the ultra-violet radiation, the phenomenon of photo-electric action is apparent, the drop of the leaves of the electroscope showing the charge has been carried away.

While Hertz and Righi failed to observe the photo-electric effects of sunlight, Elster and Geitel succeeded, and have been able to exhibit not only the dissipating influence of the direct rays of the sun, but of diffused daylight. The apparatus with which this experiment was accomplished consisted of a zinc dish 20 centimeters in diameter and well insulated; this was connected to a quadrant electrometer and charged negatively, in the dark, to a potential of 300 volts, when it was exposed to the action of the sunlight; the test showed a drop in voltage to 0 in 60 seconds, whereas a positive charge was retained for a very long time. The leakage of negative electricity from the dish when in the dark was practically eliminated. Diffused daylight also produced an appreciable drop in potential.

There are many other experiments in photo-electric action relating to the checking of magnetism on the dissipation of an electric charge in rarefied gases, on the dielectricity of minerals by sunlight, et cetera, in which, however, vacuum tubes play important rôles; but these, while interesting, have no bearing on the subject of photo-electric action in wireless telegraphy, at least at the present time. It has been shown that silver and copper plates require a much stronger ultra-violet radiation before any dissipating discharge takes place than the other metals, while zinc and aluminium have a photo-electric sensibility even for blue light.

It would seem then that the antennæ in wireless telegraph installations could be insulated with a glass sheath, which would cut off the ultra-violet radiation; or that if copper were employed for the sending and receiving antennæ, the dissipation would be very much reduced. It would be an interesting experiment to ascertain just what effect a shield capable of cutting off the ultra-violet radiation would have upon commercial wireless telegraph apparatus. At all events, it is evident that oceanic cableless telegraphy will be productive of some wonderful modifications in the present forms of wireless telegraph apparatus, and that mountains will take the place of the mole-hills when apparatus is constructed to transmit a cableless message a distance of 2,000 miles instead of the short distances covered by miniature laboratory sets that have already developed such phenomena as photo-electric effects.

THE SAFETY MATCH PROBLEM.

THE city of New York intends to make the use of safety matches compulsory. So far only the Fire Department's view of the case has been presented in the public press. The opinion of a match manufacturer, Mr. William E. Williams, of Chicago, Ill., may, therefore, not be without interest.

Mr. Williams says that in the matter of the dangers attending the use of parlor matches there is much superstition. Many people believe that mice will eat the heads of parlor matches and thereby ignite them. The only material in the head of a match which is worth eating, is the glue; and glue is not inviting when compounded with ground glass, flint and foul-smelling chemicals. Animals have a particularly fine sense of smell. For that reason they avoid matches. No one, says Mr. Williams, ever heard of a mouse's eating glued furniture, or gnawing a crack in furniture in order to get at whatever glue might be contained therein. And yet all furniture is put together with glue. He tells us that he had a desk drawer almost filled with sample matches of all kinds. Attracted by the remains of a lunch that had been hidden in the drawer by an office boy, the mice entered and gnawed a passage between the boxes of parlor matches. The pasteboard of the match boxes was completely gnawed away; and yet the match heads were not ignited.

In the matter of accidental ignition of a parlor match, Mr. Williams points out the well-known fact that the noise produced always gives the alarm. Any safety match will ignite by heat and by friction. No noise is produced.

Economically considered, Mr. Williams holds that the parlor match is far cheaper and better than its rival. He claims that it takes about four times as long to get a light from a safety match. Furthermore, safety matches of necessity are packed in small boxes holding on an average not more than 35 matches, while for a parlor match 200 matches and over constitute the average box. The box for the safety matches is heavier and more expensive. Safety matches, says Mr. Williams, are of necessity packed in small boxes and are always accompanied by the box. Furthermore, the manufacture of parlor matches in the United States has advanced to such a stage of perfection that foreigners can no longer compete with us; but in the manufacture