was wanted was an experiment to decide between the hypotheses of direct action at a distance and of action by means of a medium.

At the time that Clerk-Maxwell delivered his address, no experiment was known that could decide between the two hypotheses. Specific inductive capacity, the action of intervening matter, the delay in telegraphing, the time propagation of electro-magnetic actions by means of conducting material—these were known; but he knew that they could be explained by means of action at a distance, and had been so explained. Waves in a conductor do not necessarily postulate action through a medium such as the ether. When we are dealing with a conductor and a thing called electricity running over its surface, we are, of course, postulating a medium on or in the conductor, but not outside it, which is the special point at issue. Clerk-Maxwell believed that just as the same air that transmits sound is able by differences of pressure—*i. e.*, by means of its energy per unit volume—to move bodies immersed in it, so the same ether that transmits light causes electrified bodies to move by means of its energy per unit volume. He believed this, but there was no experiment known then to decide between this hypothesis and that of direct action at a distance. As I have endeavored to impress upon you, no *experimentum crucis* between the hypotheses is possible except an experiment proving propagation in time either directly, or indirectly by an experiment exhibiting phenomena like those of the interference of light. A theorist may speak of propagation of actions in time without talking of a medium. This is all very well in mathematical formulæ; but, as in the case of light, we must consider what becomes of it after it has left the sun and before it reaches the earth. So every hypothesis assuming action in time really postulates a medium, whether we talk about it or not. There are some difficulties surrounding the complete interpretation of some of Hertz's experiments. The conditions are complicated, but I confidently expect that they will lead to a decision on most of the outstanding questions on the theory of electro-magnetic action. However, there is no doubt that he has observed the interference of electro-magnetic waves quite analogous to those of light, and that he has proved that electro-magnetic actions are propagated in air with the velocity of light. By a beautiful device Hertz has produced rapidly alternating currents of such frequency that their wave length is only about two meters. I may pause for a minute to call your attention to what that means. These waves are propagated three hundred thousand kilometers in a second. If they vibrated three hundred thousand times a second, the waves would be each a kilometer long. This rate of vibration is much higher than the highest audible note, and yet the waves are much too long to be manageable. We want a vibration about a thousand times as fast again, with waves about a meter long. Hertz produced such vibrations, vibrating more than a hundred million times a second. That is, there are as many vibrations in one second as there are seconds—in a day? No; far more. In a week? No; more even than that. The pendulum of a clock ticking seconds would have to vibrate for four months before it would vibrate as often as one of Hertz's vibrators vibrates in one second. And how did he detect the vibrations and their interference? He could not see them; they are much too slow for that; they should go about a million times as fast again to be visible. He could not hear them; they are much too quick for that. If they went a million times more slowly, they would be well heard. He made use of the principle of resonance. You all understand how by a succession of well timed small impulses a large vibration may be set up. It explains many things, from speech to spectrum analysis. It is related that a former Marquis of Waterford used the principle to overturn lamp posts; his ambition soared above knocker wrenching. So that it is a principle known to others besides scientific men. Hertz constructed a circuit whose period of vibration for electric currents was the same as that of his generating vibrator, and he was able to see sparks, due to the induced vibration, leaping across a small air space in this resonant circuit. The well timed electrical impulses broke down the air resistance, just as those of my Lord of Waterford broke down the lamp post. The combination of a vibrating generating circuit with a resonant receiving circuit is one that I spoke of at the meeting of the British Association at Southport, as one by which this very question might be studied. At the time I did not see any feasible way of detecting the induced resonance; I did not anticipate that it could produce sparks. By its means, however, Hertz has been able to observe the interference between waves incident on a wall and the reflected waves. He placed his generating vibrator several wave lengths away from a wall, and placed the receiving resonant circuit between the generator and the wall, and in this air space he was able to observe that at some points there were hardly any induced sparks, but at other and greater distances from his generator they reappeared, to disappear again in regular succession at equal intervals between his generator and the wall. It is exactly the same phenomenon as what are known as Lloyd's bands in optics, which are due to the interference between a direct and a reflected wave. It follows hence that, just as Young's and Fresnel's researches on the interference of light prove the undulatory theory of optics, so Hertz's experiment proves the ethereal theory of electro-magnetism. It is a splendid result.

Henceforth I hope no learner will fail to be impressed with the theory—hypothesis no longer—that electro-magnetic actions are due to a medium pervading all known space, and that it is the same medium as the one by which light is propagated; that non-conductors can, and probably always do, as Professor Poynting has taught us, transmit electro-magnetic energy. By means of variable currents energy is propagated into space with the velocity of light. The rotation of the earth is being slowly stopped by the diurnal rotation of its magnetic poles. This seems a hopeful direction in which to look for an explanation of the secular precession of terrestrial magnetism. It is quite different from Edlund's curious hypothesis that free space is a perfect conductor. If this were true, there would be a pair of great antipoles outside the air, and terrestrial magnetism would not be much like what it is, and I think the earth would have stopped rotating long ago. With alternating currents we do propagate energy through non-conductors. It seems almost as if our

future telegraph cables would be pipes. Just as the long sound waves in speaking tubes go round corners, so these electro-magnetic waves go round corners if they are not too sharp. Professor Lodge will probably have something to tell us on this point in connection with lightning conductors. The silvered glass bars used by surgeons to conduct light are exactly what I am describing. They are a glass, a non-conducting, and therefore transparent, bar surrounded by a conducting, and therefore opaque, silver sheath, and they transmit the rapidly alternating currents we call light. There would not be the same difficulty in utilizing the energy of these electro-magnetic waves as in utilizing radiant heat. Having all the vibrations of the same period, we might utilize Hertz's resonating circuits, and in any case the second law of thermodynamics would not trouble us when we could practically attain to the absolute zero of these, as compared with heat, long period vibrations. We seem to be approaching a theory as to the structure of the ether. There are difficulties from diffusion in the simple theory that it is a fluid full of motion, a sort of vortex sponge. There were similar difficulties in the wave theory of light owing to wave propagation round corners, and there is as great a difficulty in the jelly theory of the ether arising from the freedom of motion of matter through it.

It may be found that there is diffusion, or it may be found that there are polarized distributions of fluid kinetic energy which are not unstable when the surfaces are fixed; more than one such is known. Osborne Reynolds has pointed out another, though, in my opinion, less hopeful, direction in which to look for a theory of the ether. Hard particles are abominations. Perhaps the impenetrability of a vortex would suffice. Oliver Lodge speaks confidently of a sort of chemical union of two opposite kinds of elements forming the ether. The opposite sides of a vortex ring might perchance suit, or may be the ether, after all, is but an atmosphere of some infra-hydrogen element: these two latter hypotheses may both come to the same thing. Anyway, we are learning daily what sort of properties the ether must have. It must be the means of propagation of light: it must be the means by which electric and magnetic forces exist: it should explain chemical actions and, if possible, gravity. On the vortex sponge theory of the ether there is no real difficulty by reason of complexity why it should not explain chemical actions. In fact, there is every reason to expect that very much more complex actions would take place at distances comparable with the size of the vortices than at the distances at which we study the simple phenomena of electro-magnetism. Indeed, if vortices can make a small piece of a strong elastic solid, we can make watches and build steam engines and any amount of complex machinery, so that complexity can be no essential difficulty. Similarly the instantaneous propagation of gravity, if it exists, is not an essential difficulty, for vortices each occupy all space, and they act on one another simultaneously everywhere. The theory that material atoms are simple vortex rings in a perfect liquid otherwise unmoving is insufficient, but with the innumerable possibilities of fluid motion it seems almost impossible but that an explanation of the properties of the universe will be found in this conception. Anything purporting to be an explanation founded on such ideas as "an inherent property of matter to attract," or building up big elastic solids out of little ones, is not of the nature of an ultimate explanation at all; it can only be a temporary stopping place. There are metaphysical grounds, too, for reducing matter to motion, and potential to kinetic energy.

These ideas are not new, but it is well to enunciate them from time to time, and a presidential address in Section A is a fitting time. Besides all this, it has become the fashion to indulge in quaint cosmical theories, and to dilate upon them before learned societies and in learned journals. I would suggest, as one who has been bogged in this quagmire, that a successor in this chair might well devote himself to a review of the cosmical theories propounded within the last few years. The opportunities for piquant criticism would be splendid.

Returning to the sure ground of experimental research, let us for a moment contemplate what is betokened by this theory, that in electro-magnetic engines we are using as our mechanism the ether, the medium that fills all known space. It was a great step in human progress when man learned to make material machines, when he used the elasticity of his bow and the rigidity of his arrow to provide food and defeat his enemies. It was a great advance when he learned to use the chemical action of fire; when he learned to use water to float his boats, and air to drive them; when he used artificial selection to provide himself with food and domestic animals. For two hundred years he has made heat his slave to drive his machinery. Fire, water, earth, and air have long been his slaves; but it is only within the last few years that man has won the battle lost by the giants of old, has snatched the thunderbolt from Jove himself, and enslaved the all-pervading ether.

TELEGRAPHING WITHOUT WIRES.

It is well known that considerable difficulties are found in effecting telegraphic communication with lightships, and even with lighthouses on rocks at a distance from the shore. Mr. Willoughby Smith has, however, devised a method of effecting the object, which he has protected by patent, and which may probably be applicable to other purposes. He points out that at the present time, wherever electric telegraphic communication is established between the shore and a lighthouse, either floating or on a rock at a distance from the shore, it is effected through an insulated conductor or a telegraph cable; but much difficulty is experienced, owing to the rapid wearing of the cable, so that it is liable to break whenever a storm comes on, and when, consequently, it is most required to be in proper working order. By his invention he is able to effect communication between the sending station and distant point without metallic connection one with the other. This is effected in the case of a lighthouse erected on a rock at a distance from the shore by submerging one or more metallic plates or masses on opposite sides of the rock, so that the two plates or sets of plates may be as far apart as practicable, and from each plate or sets of plates he leads an insulated

conductor to a telephone in the lighthouse. A two-conductor cable is led from a signal station on the shore toward the rock. At a distance from the rock one of the conductors of the cable is led to a metallic plate submerged on one side of rock at such a distance from it as to be in water deep enough for it not to be affected by waves. The other conductor of the cable is similarly led to another metallic plate or mass similarly submerged at a distance from the opposite side of the rock.

To communicate from the shore to the lighthouse, an interrupter or reverser and battery are connected to the shore ends of the two insulated conductors, and the telephone in the lighthouse responds to the repeated makes and breaks or reversal of the current, so that communication can readily be carried on by the Morse alphabet. If a vibrating interrupter or reverser be used, a short or long sounding of the telephone can be obtained by a contact key held down for short or long intervals. A more convenient way is to use two finger keys, one of which by a series of teeth on its stem, or in other more convenient way, produces a few breaks or reversals of the current, while the other key when depressed produces a greater number of breaks or reversals. In the same way communication could be carried on from the shore to a vessel at a distance from it, if the vessel were in the vicinity of two submerged plates or anchors, each having an insulated conductor passing from it to the shore, and if two metallic plates were let go from the vessel, so that these plates might be at a distance apart from one another. The position of the two submerged plates coupled to the submerged insulated conductors might be indicated by buoys. In this way communication might be effected between passing vessels and the shore or between the shore and a moored lighthouse or signal station. A similar result might be obtained with a single insulated conductor from the shore by the use of an induction apparatus with the ends of the secondary winding coupled by insulated conductors to submerged plates at a distance apart.—*Electrician*.

CHEAP APPARATUS FOR GENERATING SULPHURETED HYDROGEN.

By J. MARTIN, Lecturer at the Diocesan College, Rendebosch, Cape Town.

THE apparatus shown below for generating H_2S for a practical class was designed by me a short time ago, and has given the greatest satisfaction on the score of

both cheapness and convenience. The diagram will sufficiently explain its action.

A is a large glass cylinder, such as is used for deflagration experiments, tightly fitted with a well paraffined cork with three holes. C is a stout glass rod which passes through the center hole in the cork and through a hole in the bottom of a cylindrical porcelain vessel, E, which is supported by the end of the rod being flattened. The bottom of the porcelain vessel is drilled with several small holes. B is the delivery tube for the gas, and D is a short wide tube so placed that its lower end is perpendicularly over the interior vessel and closed at the top with a cork. The gas is, of course, generated by placing FeS in the porcelain vessel, and acid in the lower part of the glass cylinder, and pushing down the rod. The strength of the current can be regulated with considerable nicety. To charge the apparatus for use I take out the cork from the tube, O, and drop in small pieces of FeS, which fall into the porcelain vessel. The acid is sent in through the tube, B, by means of a funnel and India-rubber tubing. When the acid is the first to be used up, I draw up the interior vessel to the cork, take out the cork of the tube, D, and invert the whole apparatus. The liquid, of course, runs out, but the FeS is retained so as to fall back again afterward to bottom of the inside cylinder. I find that friction is sufficient to support the FeS, but to prevent accidents I place a small piece of caoutchouc tubing on the rod above.

The whole apparatus only costs about three shillings. It can, of course, be made of all sizes.—*Chem. News*.

EXAMINATION OF HONEY.

By K. KAYSER.

THE residue from the fermentation of pure honey is, as a rule, optically inactive, and, if heated with hydrochloric acid, it contains only exceptionally traces of reductive sugar. Sieben's first two methods for the examination of honey should therefore be modified as follows: 25 grms. honey are mixed with 12 grms. solid yeast (free from starch), and made up with water to 200

c. c., and let ferment for forty-eight hours at a medium temperature. Aluminum hydroxide is then added and the mixture made up to 250 c. c.; 200 c. c. of the clear filtrate are concentrated to 50 c. c. and polarized in a 200 mm. tube. A deflection of more than 1° (Wild) proves that starch sugar has been added. 25 c. c. of the liquid used for polarizing are then mixed with 25 c. c. water and 5 c. c. strong hydrochloric acid and heated for an hour in a boiling water bath, neutralized, made up to 100 c. c., and any sugar formed is determined by Allihn's method in one-quarter of the liquid. The sugar thus found, multiplied by 40, gives the quantity of sugar which comes to the fermentation residue from 100 grms. of honey. If this exceeds one per cent., starch sugar has been added.

A NEW METHOD OF DETERMINING LITHIUM BY MEANS OF FLUORIDES.

THE spectroscope gives valuable indications for the qualitative detection of lithia, but a comparison of the intensity of the spectral rays gives merely a doubtful approximation as to the proportion of the metal, especially if more than a few milligrammes per liter are present. The reagent used is ammonium fluoride. As the commercial salt is often contaminated with fluosilicate, it is purified as follows: Some grammes of the salt are dissolved in a small volume of water, a double volume of ammonia is added, the whole is boiled for a few seconds, let cool, filtered, and washed with ammonia. The silica is thus eliminated, and we have the fluoride in a strong ammoniacal solution, which is preserved in a covered platinum crucible. If we have in solution a few decigrammes at most of a salt of lithium with quantities of other alkaline salts not more than ten or fifteen times greater, we operate as follows: The solution is reduced to a few c. c. in a tared platinum capsule; ammonium fluoride and an excess of ammonia are added up to a volume of 15 to 20 c. c. The whole is well mixed and let settle, when there is formed a white gelatinous precipitate, scarcely visible, of lithium fluoride, which partly adheres to the bottom of the capsule. The next day it is complete, when we decant almost all the liquid upon a very small filter and pour in its place a few c. c. of ammoniacal water and ammonium fluoride, stir up with a platinum spatula and let settle. Soon afterward we make a second and a third decantation, and wash the filter with a few drops of the same reagent. Thus we remove all the soluble alkaline salts, and we have, partly on the filter and partly in the capsule, all the lithium salt imbued merely with ammonia and ammonium fluoride. The volatile matter is expelled at a very gentle heat, the filter is burnt, the ash treated with a few drops of dilute sulphuric acid, and all the liquid is collected in the tared capsule. It is evaporated and ignited gently until all acid vapors have completely disappeared and the residue is weighed as neutral lithium sulphate. To take account of the solubility of lithium fluoride in the ammoniacal liquid, its total volume is measured, ranging from 30 to 50 c. c. According to former results, and remembering that the washing waters remained in contact with the precipitate for a short time only, we may admit that 10 c. c. of the liquid contains approximately 2 milligrammes lithium fluoride = 4 milligrammes sulphate or 1 milligramme lithia. The quantity thus calculated is added to that weighed directly.—A. Carnot.

ON RHINANTHIN.

By Dr. T. L. PHIPSON, F.C.S.

IN my *Journal of Medicine*, etc. (No. 100, p. 66), I noted that I had discovered a glucoside similar to digitalin in the leaves of the *Antirrhinum majus*, which flourishes abundantly in the sandy soils of Surrey. Further investigation of this substance has shown me that it is *rhinanthin*, a glucoside extracted twenty years ago by an Austrian chemist, H. Ludwig, from the seeds of *Rhinanthus hirsutus* and *R. crista-galli* (Rattle).

I find that rhinanthin exists rather plentifully in the leaves and stalks of the *Antirrhinum majus* (snapdragon), and that it shows a reaction by which it can be recognized, even when present in very minute quantity in an aqueous solution. According to my experiments, rhinanthin can be extracted from the plant either by means of methyl alcohol or by cold water. The former process gives the larger yield, but the latter gives a purer product, and is in every respect easier and more economical. The plant, when fresh, is very brittle, and can be easily broken up or cut into small fragments, leaves and stalks, and allowed to remain in water in a closed vessel for a few days. The liquid is then filtered, treated with a small quantity of subacetate of lead (which does not precipitate rhinanthin), filtered again, and the slight excess of lead having been separated from the filtrate, the latter is evaporated carefully (on a water bath) almost to sirupy consistency, and then the vessel is allowed to remain in a warm, dry place for a few days. In these circumstances rhinanthin forms transparent colorless rhombic crystals, which are very brilliant; it can be purified by a second crystallization from water. It has a peculiar sweetish acid taste, and is very soluble in water and in alcohol.

The aqueous solution of rhinanthin, to which a few drops of hydrochloric acid are added, and then heated, gradually turns brown, finally deposits an amorphous dark brown precipitate (*rhinothogen*), and the supernatant solution contains glucose.

This reaction is very sensitive, and precisely similar in appearance to the brown tint developed in solutions of glucose heated with soda (for instance, diabetic urine), only in the present case the color is produced by acid. A perfectly clear, colorless solution of rhinanthin in water, placed in a test tube with a few drops of HCl and heated, turns gradually brown, and in a few moments, just after the solution has reached its boiling point, it is quite dark and opaque. A copious precipitate of rhinanthogen results, in the form of a dark reddish brown amorphous powder, which can be filtered off and washed. The filtrate contains glucose.

This rhinanthin dissolves in hot concentrated sulphuric acid, forming a greenish black solution. It is also attacked easily by nitric acid.

Ludwig has given to rhinanthin the formula $C_{25}H_{42}O_{10}$; my analyses of this substance do not

exactly correspond with his single analysis, but lead to the formula—

Nevertheless, I have not had sufficient of the product at my disposal to pursue this subject further at present.

In treating the decoction by subacetate of lead, it is well to employ as little as possible; the slight excess of lead can be removed either by carbonate of soda, phosphate of soda, or sulphureted hydrogen. I prefer the latter, though it leaves a small quantity of acetic acid free in the liquid to be evaporated; for I have found by direct experiment that dilute acetic acid will not convert the glucoside rhinanthin, as dilute HCl does, even after boiling for a considerable time; and on the water bath the presence of a minute quantity of free acetic acid is not, in this case, prejudicial. It is best not to evaporate to a thick sirup, but to stop as soon as indications of crystallization occur at the edge of the liquid. The capsule is then removed to a warm, dry place, where it remains for several days; the crystals thus formed are very white and brilliant.

The genera *Rhinanthus*, *Antirrhinum*, and *Digitalis* all belong to the same family of plants, and probably rhinanthin will be found to possess toxic properties; perhaps the toxic properties of *Linaria* (another closely allied genus) are due to it. But whatever may be its physiological properties, it is probable that rhinanthin, like digitalin, is very liable to allotropic changes and decomposition or oxidation. I believe that most of the substances extracted from *Digitalis* are really derived from allotropic or isomeric changes and from the decomposition of digitalin, and that these changes occur during the elaborate processes of extraction.—*Chem. News*.

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