on which he believes the originals were constructed. Some of these are shown in the accompanying illustrations. None was found in the ruins. The manner in which these writing instruments were used is also shown in one of the engravings herewith.

CARBORUNDUM AND SILICON DETECTORS FOR WIRELESS TELEGRAPHY.

BY A. FREDERICK COLLINS.

A novel detector for determining the presence of electric waves, has just been brought out by General H. H. C. Dunwoody, and has been found sufficiently sensitive and trustworthy to be used for commercial wireless telegraphic work.

The device in question consists of a minute mass or fragment of carborundum—an artificial compound made of carbon and silicon in the electric furnace—held in place between two metallic terminals or conductor plugs, usually formed of copper or brass.

This detector has recently been made the subject of exhaustive tests by Mr. G. W. Pickard, who has found that it is somewhat less sensitive than the magnetic detector of Marconi, which in turn follows the electrolytic detector of Fessenden; that is to say, while it requires from 350 to 400 micro-ergs (1 micro-erg being 1/1000 of an erg*) to operate the electrolytic detector, and from 400 to 500 micro-ergs to impress a magnetic detector, it requires between 9,000 and 14,000 micro-ergs to carry the conductivity of a carborundum detector so that it will produce an audible tone in a telephone receiver, with about the same amount of energy required by a microphone detector.

Notwithstanding this very considerable difference in the sensitiveness of the electrolytic and carborundum detectors when measured in the C. G. S. system of units, in the actual practice of wireless telegraphy the difference in receptiveness is barely perceptible over similar distances. In the first experiments with carborundum as an electric wave detector, it was found that its sensibility to the electric oscillations set up in the circuit of which it was a part, was a maximum when a certain critical potential prevailed in the local circuit of which it also formed a part.

In this respect it resembles the electrolytic detector when in action. For this reason a potentiometer or variable resistance is used in shunt with the detector. As carborundum is obtained in the form of crystalline masses, it has, in consequence, a very high resistance where the current flowing in the internal or dry cell circuit is small, but as the strength of the current is increased the resistance drops very rapidly.

Various curves have been plotted showing the resistance variation against the difference of potential across the conductor plugs of the detector, and in one of these it was demonstrated that the conductive charge occurred most rapidly between 1.0 and 1.1 volts. The conductance of the detector at this potential was about 250 microhms, or 0.4000 ohm, and a variation of 0.01 volt at the above potential value will produce a change in conductivity of about 10 microhms, or 4 per cent.

It is well known that the flat side of carborundum is a very poor conductor and in order to obtain good electrical contact, the sharp edges of the carborundum fragment must be clamped between the opposed surfaces of the plug ends of the detector, when the actual contact is limited to an exceedingly small area—not more than one millionth of an inch and probably less.

In common with the Fessenden hot-wire barretter and responders of the bolometric type, the action of the new Dunwoody detector is purely thermal. But instead of utilizing either an exceedingly fine metal wire of relatively low specific resistance and temperature coefficient, as does the barretter, or a large radiating or absorbing surface in proportion to its mass as does the bolometer, the carborundum detector employs a constricted current path lying along the edge of the crystal in contact with the oppositely-disposed surfaces of the conductor plugs.

The new carborundum detector is so designed that it can be inserted in circuit with a De Forest receptor instead of the detector formerly used; in other words, the carborundum detector is made interchangeable with the electrolytic detector, which it has superseded. When placed in such a receiving circuit, the manifestation is greatest when the potential impressed upon the detector is between 1.0 and 1.2 volts.

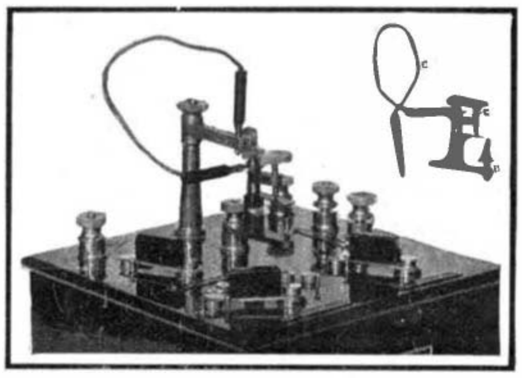
In other tests, the conductor plugs supporting the carborundum crystals were heated by a spirit lamp, when the resistance of the detector was observed to decrease greatly, but on cooling again it assumed its former resistivity, which is of the order of a megohm.

The crystals of carborundum employed in the Dunwoody detector are microscopically selected and only those having the sharpest edges are chosen, since these have been found to give the best result. The fragment of carborundum is placed between a spring and an adjustable screw plug, and by varying the pressure of the spring by means of a screw the point of maximum sensitiveness can easily be obtained.

*In the C. G. S. system the erg is the unit of work and of energy, being the work done in moving a body through a distance of one centimeter against the force of one dyne, or the kinetic force of two grammes moving at the rate of one centimeter per second.

The exact proportions of the crystal are not essential and it may vary from one to three millimeters on the side. The crystal to be used should never be touched by the fingers, as this often reduces its sensitiveness to an appreciable extent; the proper way to handle the element is to use a pair of tweezers.

Since the advent of the Dunwoody carborundum de-



THE NEW DUNWOODY CARBORUNDUM DETECTOR INSERTED IN A RECEPTOR.

tector, Pickard has brought out one using silicon as the sensitive medium. Silicon is a non-metallic element, prepared as a dull-brown amorphous powder, as shining metallic scales or as dark steel-gray granules, sometimes showing crystallization. Any one of these may be used as a detector, and in any case it is pressed into good electrical contact between two conducting plugs as in the ordinary coherer.

Different from the coherer, this latest "thermo-electric regenerative detector" converts the energy of the oscillation set up in the receiving aerial, into heat at the junction of the silicon and the metal forming the conductor plugs by virtue of the high resistance of the former and the low resistance of the latter.

The amount of heat developed by the high thermo-electromotive force, and the consequent temperature rise, is proportional to the square of the resistance, according to the well-known law of Joule. The detector gets its name as indicated above from the fact that this thermal energy is converted or regenerated into a direct electric current, the detector performing the same function as all others that have been devised, namely, that of a very delicate relay.

A machine for applying screws at the rate of fifty a minute, if necessary, has recently been placed on the market and consists of a hopper connected by a vertical flexible shaft and tube to the driving mechanism below. The withdrawal of the bit from each screw as it is

THE DETECTOR APPLIED TO A DE FOREST RECEPTOR.

driven causes a new screw to drop out of a magazine and fall in line with the bit and also allows a screw to fall from the hopper into the magazine. The use of the intermediate magazine was found necessary, as the operation of the machine is so rapid that too much time would be wasted in waiting for it to drop from the hopper. The screws are caused to revolve at the rate of 1,200 revolutions a minute by means of a friction drive so adjusted that the screw stops after it has been driven the required distance.

LEDUC'S ARTIFICIAL PLANTS AND CELLS.

BY DR. ALFRED GRADENWITZ.

A strong reaction against the somewhat childish endeavors of the alchemists to convert one element into another and to generate living beings from inert matter, pervades the history of nineteenth century science. Perhaps we have been prone rather too eagerly to discard the doctrines of former times, banishing many theories which in the course of the last few years have again been found worthy of serious discussion.

We are no doubt at present on the eve of great revolutions in our scientific views; the phenomena of radioactivity have shaken the belief in the immutability of the atom and even the principle of the preservation of matter, at least in its familiar form. Nor does the distinction of three strictly separated states of aggregation stand the test of recent investigation; transitions are found to exist between the different states, and we are warranted in presuming that between the material and the immaterial (the luminous ether) there are likewise numberless intermediary states. Finally there have been discovered transitional stages between inert matter and living beings, from which many interesting conclusions in regard to the nature of life can be drawn.

While Prof. Lehmann's recent researches on apparently living crystals have shown that certain bodies, mineral in outward appearance, behave like living organisms of the lowest type (bacteria), Prof. Leduc, of Nantes, has found the vital functions in animal and vegetable cells to be controlled exclusively by the physical laws of diffusion (osmosis) and cohesion (molecular attraction). On the basis of these phenomena he has even succeeded in artificially producing objects which, not only in appearance but in behavior, closely resemble natural cells, growing, absorbing food, and propagating themselves in exactly the same way.

The botanist might be somewhat embarrassed when asked to incorporate in his familiar system of classes, orders, and families the forms illustrated in Figs. 1 to 4. Still he would hardly have any doubt of their genuineness, their whole aspect being typical of representatives of the vegetable kingdom, especially of certain water plants.

Nevertheless, they are not living beings of any sort, but artificial bodies formed in the laboratory of the chemist. While their very aspect is certain to inspire interest, it is obviously far more interesting to observe them in the making, to watch how from an artificial seed a shoot springs and develops (at a rate readily controlled by the experimenter) into stems, leaves, buds, twigs, ears, and blossoms, and after some time dies like a real plant. The birth and death of a plant can thus be artificially reproduced within the space of a few hours.

Below are given some details concerning the artificial seed and the medium in which it is immersed for germination. A seed one to two millimeters in diameter, consisting of two parts of saccharose (cane sugar) and one part of copper sulphate, is immersed in an aqueous solution containing two to four per cent of potassium ferrocyanide, one to ten per cent of sodium chloride or some other salt, and one to four per cent of gelatine. In this solution, the seed germinates in a few days or a few hours according to temperature; under favorable conditions the germinating process can even be shown as a lecture experiment in a few minutes.

The seed surrounds itself with a membrane of copper ferrocyanide which is permeable to water and to certain ions, but is impermeable to sugar. This semi-permeability produces a high osmotic pressure in the interior of the artificial seed, resulting in the absorption of matter from the surrounding medium and thus in the growth of the whole structure. If the liquid be spread on a glass plate, the growth takes place in a horizontal plane. In a deep vessel, on the other hand, the plant form grows simultaneously in a horizontal and a vertical direction, forming stems which on arriving on the upper surface of the liquid, spread out in flat leaves resembling those of a water plant.

A single artificial seed one millimeter in diameter can thus produce 15 to 20 vertical stems which sometimes reach a height of 25 to 30 centimeters, being either simple or branched, frequently carrying lateral leaves or twigs and terminals shaped like spheres, mushrooms, ears, spires, etc., according to the composition of the culture liquid.

These experiments thus prove that the functions formerly considered as being characteristic of the process of life are due to and controlled by purely physical forces. In fact, the forms in question obviously receive their food by intussusception or internal absorption like living beings, whereas crystals, as is well known, increase by external accretion. Furthermore, the plant forms are really organized, possessing all those organs (stems, leaves, and terminal parts) which are characteristic of plants. As finally the substance used in building up these artificial plants, viz., copper sulphate, rises in stems up to 30 centimeters in height (with a diameter of one millimeter) they are necessarily provided with an apparatus of circula-