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SEE PAGE 444

Electric Property of Plants

By G. Kainz

THERE is very little in the literature of the day about the exciting of electricity in plants, but such excitation is perfectly possible, as the following experiments show.

A leaf of common kohlrabi (*Brassica gongyloides*) was connected by a wire with an electroscope, keeping the leaf insulated from the table. I sprinkled it with water from an atomizer. The bits of gold leaf of the electroscope instantly separated, showing a negative charge, and the charge soon mounted up to a potential of 700 to 800 volts.

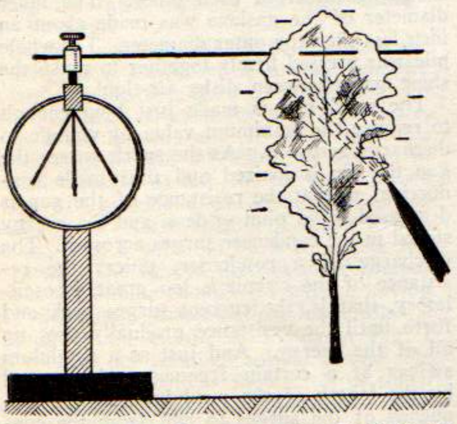
This excited my interest and induced me to carry the experiment further. I tried a whole series of plants to see which would show this electrostatic peculiarity. It was found that leaves of rape (*Brassica napus*), Mayflowers (*Convallaria majalis*), leek (*Allium ursinum*), cabbage (*Chelidonium majus*) and others showed negative excitation when sprinkled with common water.

I went on at greater length with these investigations, taking in about 200 other plant and tree leaves (*Phanerogams*) from which I got clear signs of electrostatic excitation. These samples were also subjected to impact of or sprinkling with finely divided water. The following showed negative polarity: Silver fir, large yew tree, pine tree, oak, laburnum, sumach, (*Rhus cotinus* and *Rhus typhina*) and several others. Linden, white and red beech, maple, poplar, willows and fruit trees showed no electrostatic excitation.

In order to avoid giving the names of every single plant that was investigated, it is necessary for the sake of brevity to put all the plants into groups or families to elucidate this electrostatic feature, as grasses, cereals (the *Cyperaceae*) and various kinds of clover, cultivated and wild, kohlrabi, rape, peas and vetch.

Naturally, of course, various kinds of mechanical, physical and chemical excitation could bring about electric charges, but in these cases the charge was apparently brought about by mechanical operation of the water on the face of the leaf.

The epidermis of the leaf consists on its outer layer or cuticle of the coating or cuticle, then of an intermediate layer of cell-less material and then of the lumen of the epidermis cells. The cuticle and the intermediate layer beneath it are impregnated with wax in many plants. Its presence cannot be recognized by the eye, but is proved by the fact that on heating a section in water the melting wax comes out in the form of drops. The wax can be looked upon as the separating material of the epidermis cells whose membranes come close to each other. It generally appears in the form of little grains with which the cuticle is charged.



Water sprinkled upon a tree leaf by an atomizer electrifies the latter. The sign of the charge is negative with all species of leaves tried. To detect a charge the electroscope is first charged positively. This apparatus the gold leaf strips as indicated. Then when it is connected to the leaf, if the strips fall together the tree-leaf is negatively charged.

The delicate bluish glint which can be rubbed off with the finger, and which is seen upon the leaves and stalks of grasses and other plants can be seen in especially impressive forms on plums and other fruit. Sometimes the little grains form little rods on the surface of the epidermis.

The second appearance of the wax shows itself in a thin, transparent crust which forms an unbroken layer over the cuticle. In some cases this may attain a considerable thickness.

The wax impregnating the membrane of the cuticle, as well as any layer on the surface, prevents the reception of water by the leaf, and prevents the surface even being moistened as the drops roll off it. If such a leaf with its wax coating, which might be a leaf of the rape plant is dipped into water, it appears coated with a shining thin envelope of air and is not moistened. If the wax coating is examined with a magnifying glass, fine striations or grooves are shown, and one understands the mechanical progress of the excitation.

If a drop of water from the atomizer falls upon the grooved wax coating of the leaf, friction occurs between the coating of the water, which brings about an electric charge in the water and in the leaf. The coating on the leaf becomes negatively electrified and the water becomes positively electrified. The proof of this is that only the portion of the coating which comes in contact with the water shows the electric charge, as can be seen in the following experiment. If one removes from the surface of the leaf, which on sprinkling with water has shown strong negative excitation, the wax coating, by rubbing it off, and repeats the experiment on the same leaf, either none or a very weak charge of the leaf is shown.

RADIO IN 1935

Mr. Hugo Gernsback has contributed an interesting article on the apparatus we shall probably use a decade hence. The article is full of new prediction's and theories and ideas which will prove to be very enjoyable reading. Don't miss it.

Interesting Articles Appearing May Issue of Radio News

History of Radio Inventions.
The Inventions of Reginald Fessenden.
The Life and Works of Lee DeForest.
Hotel Furnishes Radio for Its Guests. By C. Brown Hyatt.
Oscillations and How They Are Overcome. By Leon L. Adelman.
The Monophase Circuit. By Frank Dalet.
Radio in the Cave Disaster. By C. W. Williams.
A Five-Meter Transmitter. By W. B. Arvin.
Television for Amateurs. By S. R. Winters.

One can formulate the law that all plants whose leaf and stem are coated with a bluish white, glossy layer are negatively electrified by sprinkling with water.

In many grasses and grains the presence of silica on the surface of the leaves is the cause of electric excitation. In clovers oxalic acid, which is present in the outer layers of the leaves, causes electrification. The thing to be most noted in this is, that we find no plant which can be positively electrified by sprinkling with water. Water has, among all substances hitherto investigated, the highest electric constant, also called inductive capacity, namely 80. It must, therefore, electrify all things negatively which have a lower dielectric constant than itself.

What effect now have rain drops falling upon such plants? This question can again be referred to experiment. From a vessel at an altitude of about 39 inches or a meter, drops are allowed to fall upon a leaf of clover carried on an insulating stand (a block of paraffin (P) of the illustration). Wire connects the leaf to an electroscope. In a very short space of time after dripping begins, say 30 to 40 seconds, the electrometer (E) shows a tension of 400 to 500 volts for a fall of an exact meter, and at the rate of fall previous to hitting the leaf of 4.4 meters per second. If one substitutes for this terminal velocity nearly double the amount for rain drops, say 8 meters per second, we will be led to believe that a very great quantity of electric excitation may be due to rain.

We now come to this question: Can the electric content of the earth be explained by falling rain drops? There is no doubt that this can be answered affirmatively. If we picture to ourselves that the whole world of sweet and sour grasses, sugar cane and bamboo growth in the tropics, clover and the earth itself receive a negative charge from rain, we can readily understand that the earth has its charge of negative electricity increased thereby, and this has at last been proved by measurement and observation.

There is a further remark to be made. By fall of rain drops on the surface of leaves, the leaf, plant and earth are negatively charged. As this gives the rain drops positive charge, these drops falling on the earth must be exactly equal and opposite in excitation to the electricity generated on the plant. But this is not really so, for by the impact of the rain drops on the leaves they are sprinkled about and give a part of their positive charge to the air, and this always

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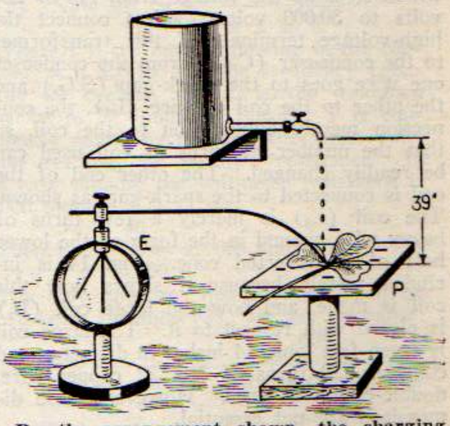

By the arrangement shown, the charging action of water or rain drops is illustrated. Water dripping from the faucet falls on a leaf and causes the latter to become electrically charged.

Physical units (including electric units) are based on the standard units of mass (as above) of length (the centimeter) and the second, in other words, on standard units of mass, lineal space and time. From these three units what are called electrical units are derived, which in their practical form are termed the ohm, the volt, the henry, the farad, etc. Each one of these can appear as based in these three units, and can be expressed in terms of them, so that some can be expressed as centimeters, such as the unit of electrostatic capacity or the unit of electromagnetic self-inductance, and these units are used quite frequently, especially by foreign waters. Thus the unit of resistance reduces to length divided by time which is velocity.

In many foreign books the centimeter is used as the unit of inductance, and at one time it was often met with here. The unit of electrostatic capacity is often to be found expressed as the centimeter by German authors.

High Voltage Experiments

By Lester Reukema

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natural frequency of the circuit formed by the coil (L_2) and the capacity (C_2) which is

$$f_2 \frac{1}{2 \times 3.1416 \sqrt{L_2 C_2}}$$

equals that of the primary circuit (f_1), then large oscillations of current will be set up in the secondary circuit, and these oscillations passing through the high inductance of coil (L_2) generate enormously high voltages. These high voltages, being impressed on the ball or other capacity (C_2), break down the surrounding air, causing the discharges of flame seen in the pictures. As soon as the energy of the primary circuit (L_1 C_1) has been handed over to the secondary circuit (L_2 C_2) the arc across the gap (S.G.) goes out, allowing the condenser (C_1) to again build up to the maximum voltage, when the cycle repeats itself.

What has taken several minutes to say occurs in less than a ten-thousandth of a second, since the natural frequency of each circuit is about 60,000 cycles per second. About five cycles are necessary to pass the energy from primary to secondary circuit. The frequencies f_1 and f_2 must be equal, which means that $L_1 \times C_1$ must equal $L_2 \times C_2$. Since the inductance L_2 is fixed, being determined by the dimensions and the number of turns of the large coil, and C_2 is fixed, being determined by the size of the ball or man used as a capacity and by its distance from surrounding objects, the frequencies are equalized by varying either L_1 or C_1. C_1 is varied by varying the number of milk bottles used, 144 bottles giving us best results. L_1 is varied by varying the number of turns used. When the frequencies are equal, the system is in resonance. The particular value of L_1 to use with any value of C_1 is easily determined by trial, merely shifting the movable connection on coil L_1 until a maximum discharge is obtained from the ball C_2.

According to the safety commission of California, one-tenth of an ampere of current passed through a man's body at ordinary frequencies will cause death. Yet, in our experiments, we pass enough current over and through the body from feet to hands to brilliantly light up several incandescent lights held in the hands. Since each wave train of energy lasts only about one five-thousandth of a second, to be followed by an interval of about one one-hundredth of a second before the next wave train comes along, at the beginning of each wave train about 200 amperes of current must be passing through the body, 2,000 times the amount which might kill at lower frequencies. Moreover, at commercial frequencies, anything over 1,000 volts is dangerous, and even voltages as low as 110 volts have killed persons many times. Yet we are impressing a million volts and more on a man's body without any danger. What causes the difference?

The higher the frequency, the less chance the current has to penetrate the conductor, whether that conductor be a copper wire or a human body. At 60,000 cycles, the frequency used in our experiments, practically all of the current passing through a half-inch wire is carried along the surface, only a negligible amount penetrating the wire more than one one-hundredth of an inch. This is the so-called "skin effect" of high frequency. In the same way the human body carries the current on the surface, the high frequency preventing any penetration farther in than the outer layers of the skin.

Certain precautions must be observed. Keep the body insulated, and far enough away from direct grounds to prevent power arcs to ground, which, though not dangerous, are unpleasant. Also remember that the circuit between the power transformer and the condenser (C_1) is carrying power at 60 cycles and at high voltage, so must not be touched; it is well not to touch any part of the primary circuit when the power is on. However, the energy in the secondary circuit is perfectly harmless.

Laboratory Reproduction of the Solvay Process

By Earle R. Caley, A. Sc.

(*Continued from page* 468)

Large clear crystals of sodium carbonate, which contain ten molecules of water of crystallization, are formed. These are removed from the disk and spread upon filter or blotting paper to dry. As soon as they are dry, which is shown by the edges turning white, they are placed in a tightly-stoppered dry bottle.

Experiment III

Preparation of Sodium Hydroxide or Caustic Soda

Sodium hydroxide or caustic soda is a powerful alkali used for a great variety of purposes in industrial chemistry. Common household lye is a form of caustic soda. This substance may be prepared from the sodium carbonate obtained in the last experiment.

A large beaker, provided with a stirring rod and mounted upon a stand over a Bunsen burner, as shown in Fig. IV, is all the apparatus needed. In addition a small amount of freshly-slaked lime is required. 200 grams of sodium carbonate are dissolved together in 200 c.c. of water in a beaker and 150 grams of slaked-lime added. The mixture is then boiled vigorously for several hours. From time to time a small quantity of the solution is removed and tested with a little dilute hydrochloric acid. Evolution of gas shows that some undecomposed carbonate still remains in solution.

As soon as a test shows that all the carbonate has been converted, the solution is filtered through the filtering arrangement shown in Fig. II. Solid calcium carbonate, which is formed and precipitated in the reaction, is left behind on the filter paper, while the solution containing the caustic soda runs through. This solution is then evaporated down (Fig. III) until the caustic alkali is obtained as a white solid cake. This may then be broken up and bottled.

Electric Property of Plants

By G. Kainz

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leaves an excess of negative charge for the earth. This can be proved on the small scale by experiment.

We can, therefore, believe that the negative electricity of the earth or by far its greater part depends on the world of plant-life, and is due to atmospheric precipitation of rain. Hitherto the radio-active emanations from the surface of the earth were assumed to be necessary for explaining or accounting for the regeneration of the negative potential of the earth, but were found by most investigations in this line to be insufficient for the requirements of the case. Elster and Geitel, the most distinguished investigators, try to explain by the process of ion-absorption the negative charge, which, however, only can answer for a small part of the requirements. Linss regards the air as a conductor and believes that the negative charge is constantly departing from it, so that it would be completely discharged in two hours if there were not a continual addition of new charge thereto.

The peculiarity of many plants noted above stands in close relationship with electric cultivation, which will excite a much greater interest in Germany than before. I am firmly convinced that by this means our yield of crops can supply food quite independent of foreign sources, and the welfare of our people can be greatly increased thereby.