thus be a great convenience to the historian of the biological sciences and also to specialists in a number of fields, especially since American titles have often been so incompletely represented in European bibliographies of the last century.

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LABORATORY APPARATUS AND METHODS

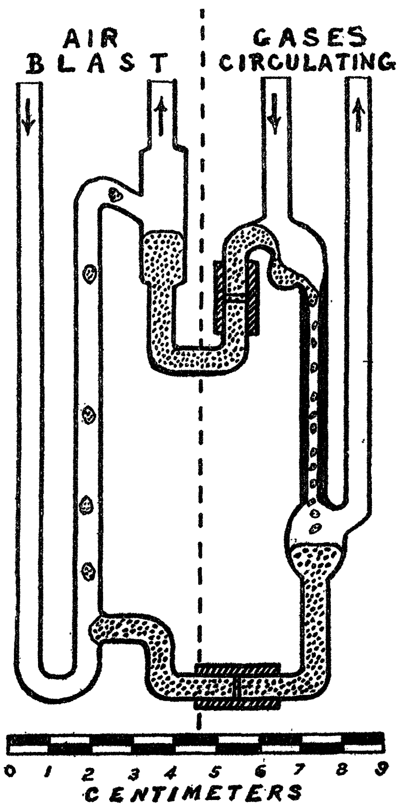
A SIMPLE CIRCULATION PUMP FOR GASES

The physicist, the chemist and the biologist all may have occasion to pass continuously the same sample of gas at ordinary pressure over an object under investigation. This is commonly done by some form of circulation pump involving valves, which gives stepwise circulation and requires an individual motor. In meeting this problem, we have secured practically uniform and continuous flow by utilizing a very simple form of gas circulation, which uses for power the customary air-blast to be found in most laboratories. We believe a brief description of our apparatus will prove of interest to other workers.

The principle on which our apparatus functions may perhaps be made clear by an analogy. If one wished to circulate water round an annular trough, one might employ a paddle wheel operating at a constricted part of the annulus. In our gas-circulator, we paddle the gas round the closed system by means of a constant stream of droplets of mercury falling by gravity down a narrow tube which forms part of the circuit. This constant falling of mercury is reminiscent of the operation of a Sprengel pump, in which, however, the mercury droplets, by filling the bore of the fall-tube, act rather as pistons than as paddles. The portion of the figure to the right of the vertical dotted line shows the construction that serves the fall-tube.

The portion of the apparatus to the left of the dotted line is devoted solely to the purpose of raising the fallen mercury back to the level of the top of the fall-tube. Its action is precisely the converse of that of the right-hand portion, for here an air-blast from outside is employed to blow the mercury in droplets, which do not fill the bore of the rise-tube, from the low to the high level.

The entire apparatus as sketched is smaller than a man's open hand, and is constructed of glass tubing of 4 to 5 mm bore, except for the fall-tube, whose bore is about 2.5 mm. The two rubber connections shown in the figure make for ease in construction; and, in any case, the gases to be circulated come in contact only with glass and mercury. About 7 cc of mercury are sufficient. As in Bunsen and other pumps which incline to temperamentality, slight differences of construction sometimes lead to large changes in efficiency. A satisfactory model is furnished by the Eastern Instrument Company, 109 Oliver St., Newark, N. J.



A single such apparatus will circulate gases against back pressures in the circuit corresponding to a head of over 30 cm of water at a speed of two liters per hour; while, if the back pressure or resistance is negligible, the speed of circulation may exceed eight liters per hour. The consumption of air-blast air, at the customary six pounds pressure, is about one eighth of a cubic foot per minute, which is but half what a blast lamp uses. If greater volume of air circulation is desired, several such circulators may be used in parallel.

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SPECIAL ARTICLES

PROPAGATION OF ELECTROMAGNETIC WAVES OVER THE EARTH

Among the facts to be explained in a satisfactory theory of the propagation of radio waves over the earth's surface are the curvature of the rays in transmission between stations far apart, the absorption during transmission, the peculiar phenomenon of fading in which the magnitude of the received wave fluctuates more or less rapidly, the differences in transmission in different directions over the earth and the extraordinary differences in the transmission of long and short waves.

This preliminary note is to outline a new theory of transmission which accounts quantitatively for many previously unexplained facts of radio transmission. A detailed treatment of important cases will appear shortly.

The atmosphere to a considerable height above the earth contains ions which react upon electromagnetic waves and, as shown by Larmor[1] may account for bending of long waves around the earth. His explanation, however, does not show the large and characteristic differences between short and long wave transmission which become especially marked in passing through the region between 100 and 200 meters. Other theories, also, have the defect of predicting entirely incorrect results for short wave lengths.

The theory now developed takes into account both the earth's magnetic field and the distribution of ionized particles in the atmosphere. It is found that this field, together with the electrons, produces marked selective effects at wave lengths between 100 and 200 meters and that these effects are different for different directions of transmission and for different planes of polarization of the wave. A summary of the effects follows.

For the case in which the electric force of the wave is parallel to the earth's magnetic field, the only effect is due to a variation in ionic density above the earth. This case is realized practically only over very limited areas of the earth's surface.

For transmission in any other direction or for any other direction of the electric field, four effects are in general produced, namely, the plane of polarization of the wave is rotated by an amount depending upon the density of free electrons, the magnetic field and the frequency. This effect reverses at the critical frequency which, for a field of one half gauss, is 1,400 kilocycles (214 meters). The second effect is that of double refraction in the medium, producing two waves of different velocities and polarizations. The third effect is a bending of the rays due to a variation in ionic concentration, as in Larmor's case, but, due to the magnetic field, this bending also, in most cases, reverses at the critical frequency, so that if long waves bend down in a certain region short waves will be deflected upward in the same region. The fourth effect is a bending of the rays due to variations in the magnetic field strength and this effect also reverses at the critical frequency.

The general solution of this problem can not be given in this note, but some interesting special cases will be described.

For transmission from a vertical antenna along a magnetic meridian the electric vector tends to be rotated and when this rotation becomes equal to 90°, the usual methods of reception produce no signals; hence we should expect, in general, better reception of east-west than of north-south signals at certain points. Also since the plane polarized ray can be resolved into two circularly polarized rays traveling with different velocities, under certain conditions both components may not be able to travel over the same path between two points.

The rotation of the plane of polarization for transmission along the magnetic field is rather large; for example, the electric vector in a wave 2 km long will turn from vertical to horizontal in about 80 wave lengths if there are present only 10 free electrons per cubic centimeter in a layer for which the mean free path is sufficiently long for free motion. A wave 100 meters long will rotate through the same angle, but in the opposite direction, in about 5,000 wave lengths or 500 km. For larger ionic densities, appropriate to high levels, the waves may be rotated very rapidly, which is one of the causes of variable transmission along a magnetic meridian.

For transmission at right angles to the magnetic field we find double refraction with the ordinary ray unaffected by the magnetic field, and the other selectively affected.

In all these cases, the variation in the number of ions and in the magnetic field at different heights above the earth produce deflections of the rays which may be calculated.

The introduction of a resistance term into the equations of motion of the electron leads to an attenuation factor in the equations of wave motion. Thus, for transmission parallel to the magnetic field the exponential term involves the reciprocal of the square of the frequency for frequencies sufficiently large compared to the critical value. This means, therefore, that attenuation due to this cause falls off rapidly as the frequency is increased. At the other extreme the same expression is found to apply except that in place of the transmitted frequency, the critical value is substituted. Hence in the range attenuation due to this cause is constant. There are, of course, other causes of attenuation, for example, the conductivity of the earth.

[1] *Phil. Mag.*, Dec., 1924.

When the frequency is near the critical value large anomalous effects occur. For example, the wave may be required to travel over a widely different path by a slight change in either the magnetic field or the ion density. The signal may arrive at the receiver from several directions simultaneously or successively, producing fading or apparent change of direction. The absorption may become extremely high for certain rays.

The detailed theory, with its predictions, will be published soon.

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CARBOHYDRATE STORAGE IN THE ENDOSPERM OF SWEET CORN

A STUDY of carbohydrate storage in the immature endosperm of sweet and waxy sweet corn has disclosed a kind of cell content not previously reported. It is a globule of cytoplasmic origin which stains red with iodine.[1] As these globules increase in size, smaller grains of solid carbohydrate are usually found within them.

The larger grains of carbohydrate, which occur both within the globules themselves and in the cells where the latter are not found, are compound and irregular in shape. There also are smaller, simple grains, ranging in size almost from the limit of visibility upward. In free-hand sections, these are found particularly in the globules and the globule-containing cells. The compound nature of the larger grains is the same in all the sweet corn studied, including the "pseudostarchy" type and has been described in one variety by Mottier in 1921.[2]

The grains of solid carbohydrate in ordinary (non-waxy) sweet corn, whether contained in globules or not, are of starch, and stain blue with iodine, whereas those in waxy sweet corn stain red. This red reaction of iodine with the carbohydrate present in the endosperm of waxy corn was reported by Weatherwax[3] in 1922. The fact that the reaction of the endosperm with iodine is similar in waxy and in waxy-sweet corn due to the nature of the grains of solid carbohydrate was reported by Kempton[4] in 1923. The identity of this carbohydrate has not been definitely determined. However, the further facts that it occurs in grains similar in form and development to the starch grains in non-waxy corn, and that these grains are digested by diastase[3] and are bright with a dark cross in polarized light, support Weatherwax in calling it a dextrin. They also indicate that it is related closely to starch.

The liquid portion of the globules apparently also is a dextrin, but nearer to sugar than are the grains of red staining carbohydrate. It is colloidal, stains red with iodine, is precipitated by alcohol and is digested by diastase. About one half of the polysaccharide content of the endosperm of sweet corn is in the form of globules, except in "pseudostarchy" corn in which there are fewer globules. The liquid portion of the globules probably is identical with the water-soluble polysaccharide obtained in analyses of immature sweet corn kernels by Culpepper and Magoon.[5] It has not been possible to isolate the globules from mature kernels of sweet corn. The membrane of the globule apparently disintegrates, the unaltered liquid portion becoming free within the cell. The nature of the membrane is unknown.

The globules of liquid carbohydrate and the grains of solid carbohydrate appear to develop from plastids imbedded in the cytoplasm. The origin and course of development of these plastids is the same in the endosperm of all the sweet corn studied. The larger granules in the cytoplasm, which may be called proplastids, show a conspicuous but temporary clumping about the nucleus during their development into plastids. This continues until the initiation of polysaccharide storage, at which time differentiation in the plastids is evident.

The kind of carbohydrate stored in the cell is governed by the genetic complex of the kernel. The recessive factor *su,* essential to the production of sweet endosperm, determines the development of the globules in both ordinary sweet and waxy sweet corn, together with the compound character of the larger grains of carbohydrate, and the reduced size of the simple grains. The carbohydrate of the grains in ordinary sweet corn, whether contained in the globules or not, is starch and is determined in development by the dominant factor *Wx.* The carbohydrate of the grains in waxy-sweet corn is determined in development by *wx,* which is essential to the production of their waxy character.

The development of the grains and of the globules in sweet corn apparently proceeds in a definite, orderly course up to the maturation of the endosperm. The accumulation of the liquid portion of the globules precedes the appearance of the carbohydrate grains within them and a surplus of this liquid is present at

[1] An aqueous solution of iodine in potassium iodide was used.

[2] Mottier, D. M., *Ann. Bot.,* Vol. 35, p. 357, 1921.

[3] Weatherwax, Paul, *Genetics,* Vol. 7, pp. 568–572, 1922.

[4] Kempton, J. H., SCIENCE, n. s., Vol. 57, pp. 556–557, 1923.

[5] Culpepper, C. W. and Magoon, C. A., *Jour. Agr. Res.,* Vol. 28, pp. 423–425, May, 1924.