A still more recent device, also due to Dr. Hull, is the pliodynatron, a combination of the pliotron and the dynatron. This device has a true grid as well as the anode and plate electrodes and is an interesting four-electrode device. The grid, as usual, is an electrostatic control member, and, if the conditions are properly chosen, enables the stable control of the oscillating energy in the circuit, *LC*. That is, the variation of the grid potential (as determined by the battery, *B"*, or otherwise) will cause variations in the oscillation output of the bulb. This feature will be further considered under "Modulation Control for Radio Telephony", page 175. The wiring of a pliodynatron is clearly indicated in Figure 99.

The actual appearance of the dynatron is illustrated in Figure 100 and of the pliodynatron in Figure 101. It will be hoted that the anodes are naturally much heavier than the grids of pliotrons, which must, of course, be the case, since their functions are quite different and since they must carry very considerable currents in their own circuits and be subjected to energetic electron bombardment.

(Picture from page 100)

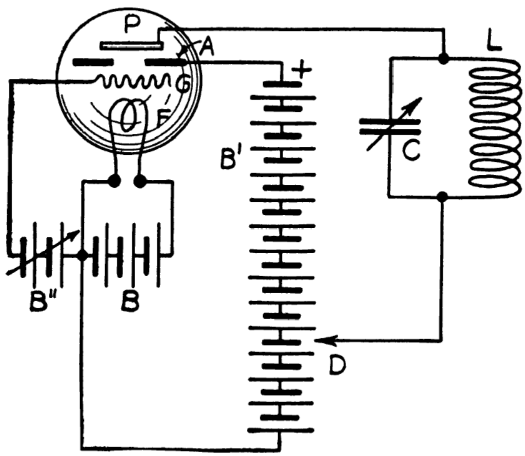

FIGURE 99—General Electric Company-Hull pliodynatron controlled oscillator.

which is mounted inside the various coils. The filament is lit from the 125-volt circuit through an appropriate resistance. These various resistances and potentiometer are shown in the foreground at the bottom of the box. The two left hand coils are the grid circuit coupling to the antenna and the coils at the right the plate circuit coupling, a circuit

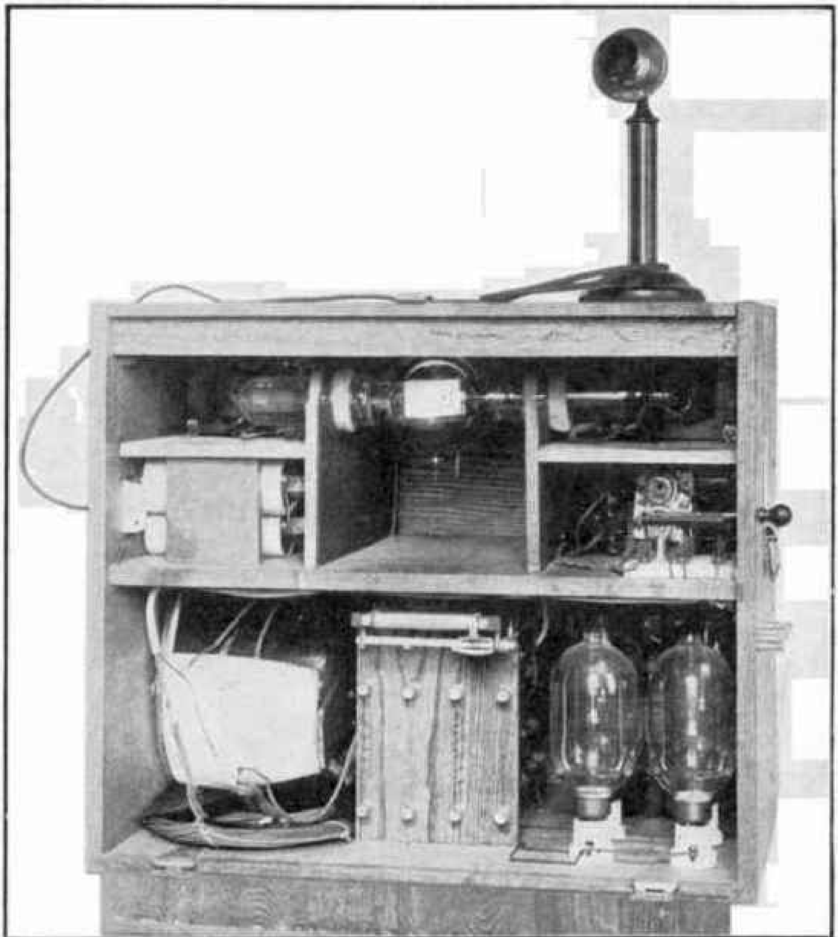

FIGURE 172—General Electric Company-White radiophone transmitter for alternating current supply.

somewhat like that in Figure 169 being used. The entire set weighs only 54 pounds (20 kg.) complete. Completely satisfactory operation over 10 miles (16 km.) is possible, and laboratory tests have given ranges up to 65 miles (105 km.).

A more powerful set for use with 60 cycle alternating current supply is shown in Figure 172. The wiring of this set is almost identical with that shown in Figures 168, 169, and 170. The two pliotrons are mounted at the top of the box. To the left, under them, are the microphone dry batteries. To the right, under them, are the "smoothing condensers" (two sets) for the high voltage supply in the plate circuits. To the bottom left are mounted the radio frequency coupling coils and to the right the four kenotron rectifiers. The panel in the middle carries various filament resistances, and back thereof are mounted the microphone transformer (*PS* of Figure 169) and the amplifier transformer (*P'S'* of the same figure). The entire set weighs 150 pounds (68 km.). The transmitting range for satisfactory service is 50 miles (80 km.).

We consider next the control systems suitable for use with the dynatron and pliodynatron tubes of the General Electric Company as developed by Dr. Albert W. Hull. A description of the dynatron (and

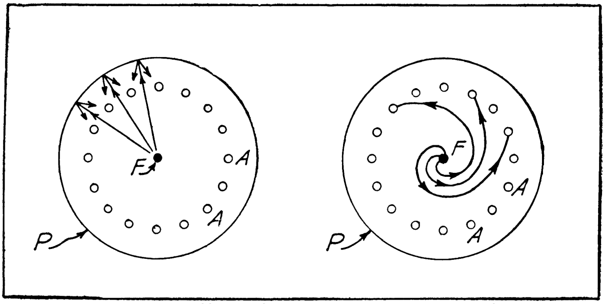

FIGURE 173—Effect of longitudinal magnetic field on electron paths in dynatron.

pliodynatron) together with their mode of operation is given in connection with Figures 96 through 101, page 100, and the reader is referred to this material as an introduction to the present discussion.

Figure 173 represents the cross section of a dynatron where *F* is the filament, *A* the wires, or solid portions, of the anode, and *P* the plate. The paths of a few electrons away from the filament and a diagrammatic representation of a few of the electrons leaving the plate by secondary emission are given for normal conditions in the left hand portion of the diagram. The effect on the electron paths of a longitudinal magnetic field (parallel to the filament) is shown in the right hand portion of the figure. It will be seen that the electrons now pursue spiral paths and strike the anode very obliquely, particularly if the magnetic field is very powerful and the electron velocity small. In consequence, comparatively few will get through the anode with a high velocity, and therefore the re-emission phenomena from the plate will be much diminished. The characteristics of the dynatron will be progressively altered, as indicated in Figure 174, whence the magnetic field is increased. The dotted curve, *A*, is the normal dynatron potential-current curve. On applying a moderate magnetic field the dashed curve, *B*, is obtained. This shows no current reversal since the secondary emission is already small. With a strong magnetic field, the characteristic becomes the full line curve, *C*, and shows very little of the usual dynatron effect. It is therefore pos-

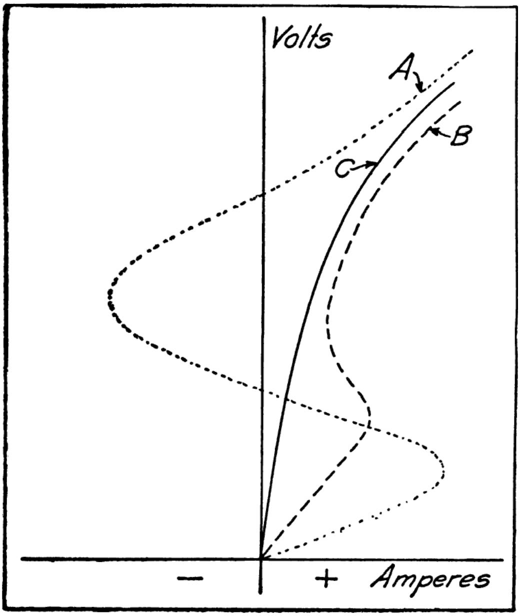

FIGURE 174—Characteristics of dynatron in various magnetic fields.

sible to control the negative resistance (and hence the output) of a dynatron by the superposed magnetic field, and this field may be that due to the current from a microphone transmitter passing through a coil suitably mounted relative to the tube.

The method of controlling the output of a pliodynatron would naturally be by varying the potential of the grid. Offhand it might seem that this would either stop all oscillations (if the grid were sufficiently negative) or else let them remain at full intensity. As a matter of fact, because of the curvature of the dynatron characteristic under certain conditions, it is possible to get a control curve of the pliodynatron (grid potential-plate current) similar to that shown in Figure 175. This curve has a considerable straight line portion, and consequently between *A* and *B* thereon, it becomes possible to control the output of the tube by varying the grid potential. The actual arrangement is shown in

Figure 176. As will be seen, the circuit L_1C_1 is connected in the usual fashion for dynatrons between the plate and the battery tap point D.

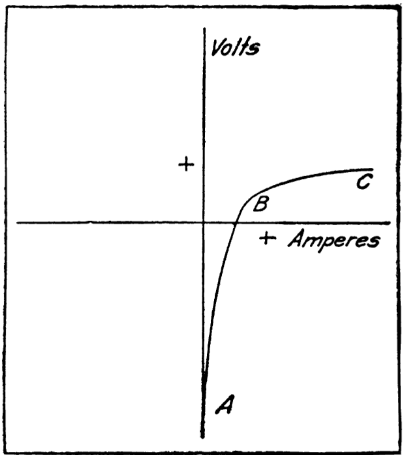

FIGURE 175—Grid potential-plate current characteristic of a pliodynatron.

The potential variations corresponding to the speech are placed on the grid by the secondary *8* of the audio frequency microphone circuit transformer. The modulated output passes to the antenna circuit through the inductive or other coupling at L. In practice, radio telephony over a distance of 16 miles (26 km.) was easily accomplished with one pliodynatron; but this range could doubtless be much increased since no attempt was made at the time to get the greatest possible output or range.

A system of radio telephonic control involving both an Alexanderson alternator for the direct generation of the radio frequency energy and one or more pliotrons for the modulation and control thereof is shown in Figure 177. As will be seen, the radio frequency alternator is coupled inductively to the antenna by the coils L_1 and L_2. The antenna is tuned by the variable inductance L,

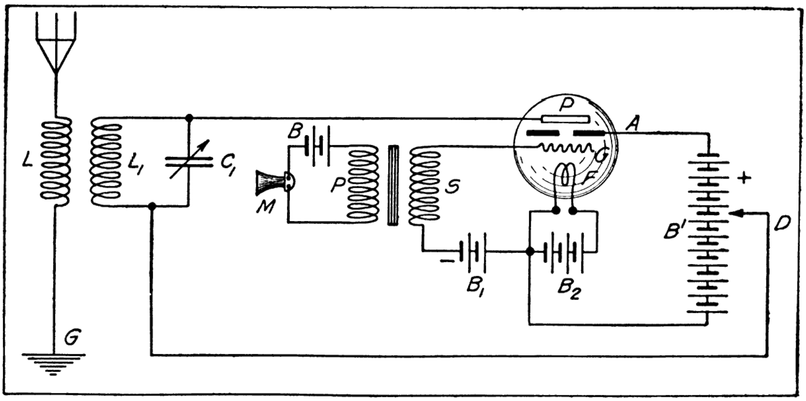

FIGURE 176—General Electric Company-Hull pliodynatron radiophone transmitter.

and the top H of the tuning inductance is the point of highest potential within the station building. (Of course, the highest potential produced by the set is at the relatively inaccessible top of the antenna.) The filament of a large pliotron is connected to the ground, and the plate of the pliotron to the point H at the top of the tuning inductance. If the filament is heated by alternating current, the mid-point of the step-down transformer secondary whereby this is accomplished is connected to ground thus equalising the thermionic current in all parts of the filament as much as possible (as indicated in the description of Figures 74 and 75, page 80). If the grid of the pliotron is kept at a very negative potential, the effect on the antenna energy will be practically nothing. As the grid becomes less negative, the pliotron permits increasingly more radio frequency current to pass through in rectified half cycles,

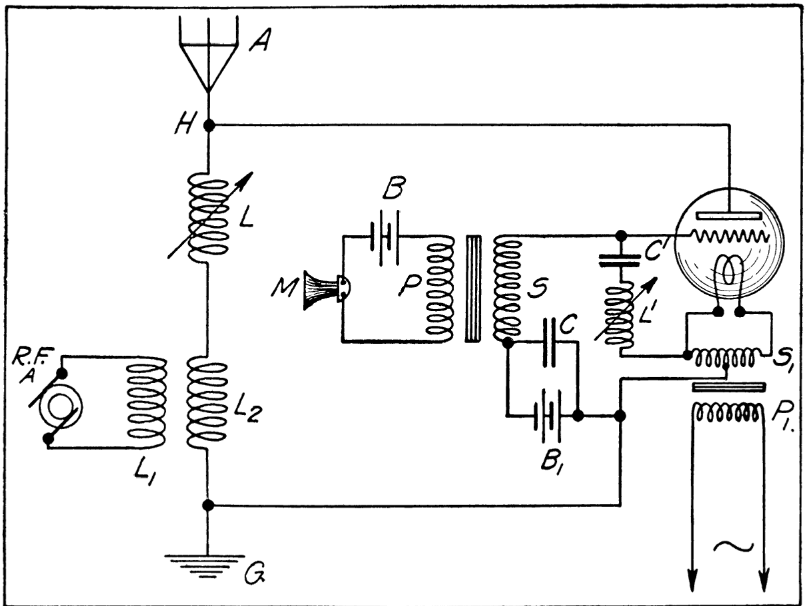

FIGURE 177—General Electric Company-Alexanderson-White alternator-pliotron radiophone transmitter.

thus withdrawing energy from the antenna. In other words, the output of the alternator either passes into the antenna system or into the pliotron bulb. It is found by experience that the fact that the pliotron absorption takes place only for half cycles does not affect this conclusion.

It will be noted that the grid is normally maintained at a negative potential by the battery B_1, which battery is shunted by the condenser *C* which acts as an audio frequency by-pass. The secondary of the audio frequency transformer *S* is also included in the grid circuit, and thus the grid potential is also caused to vary in accordance with the speech forms. In thus controlling the antenna energy by the pliotron, a curious difficulty arises. The impressed radio frequency plate potentials are quite high, and there is capacitive coupling between the plate and grid *within the bulb* since these metallic masses are, in effect, the parallel plates of a condenser. In consequence, there will be induced smaller, though still troublesome, radio frequency potential variations on the grid. During the positive half cycle, a positive potential is induced on the grid which may be much larger than the potential supplied to the grid from the telephone transmitter. This action, therefore, prevents control. This would render the system inoperative, but the effect is avoided by the introduction of the radio frequency short-circuit *L'C'* between the grid and the filament, whereby no radio frequency potential variations call occur on the grid.

Another form of the same general type is shown in Figure 178. In this form also the control system of energy absorption by the pliotron is

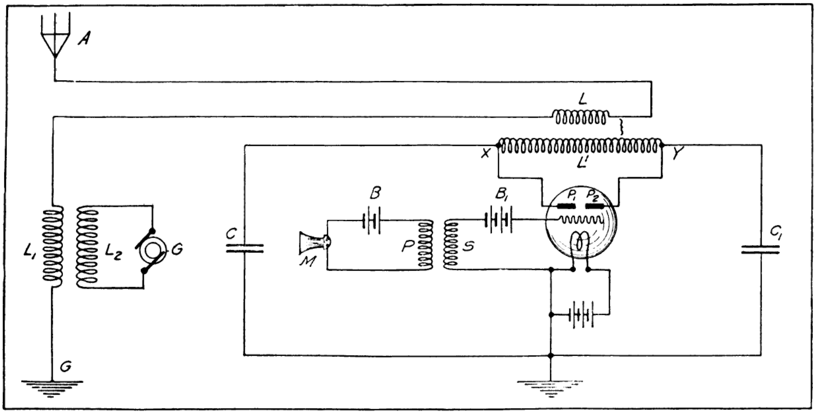

FIGURE 178—General Electric Company-Alexanderson alternator-pliotron control radiophone transmitter.

used, but in addition an appropriate radio frequency transformer *Jul!* is provided. This raises the applied voltage to a value most suitable for the pliotron actually available. In other words, instead of absorbing a given amount of energy at low voltage and high current it is absorbed at high voltage and low current. Furthermore, there are provided two plates P_1 and P_2 of the pliotron so that absorption occurs during both half cycles. The actual appearance of the step-up transformer which has been used experimentally is given in Figure 179. It is an open core auto-transformer consisting of a number of flat coils hung on wooden rods. One or two of the central sections are tapped to form the primary and the whole set of coils, terminating at wires *X*, *Y* constituted the secondary. Special forms of end shields designed to prevent excessive corona and break-down are mounted at the ends of these sets of coils. The exact mode of operation of this transformer is described in “Proceedings of the Institute of Radio Engineers”, Volume 3, number 2, page 138.

This transformer has very low losses, so that it becomes possible to transform from 250 volts to 100,000 volts at 100,000 cycles. Under these conditions, the inductance of the transformer system was such that 2 amperes appeared at the center of the secondary winding. A study of the action of this transformer shows that if the decrement of the secondary tuned circuit be increased (by the pliotron) from its normal value of about 0.008 to about 0.8, the effective impedance of the system will

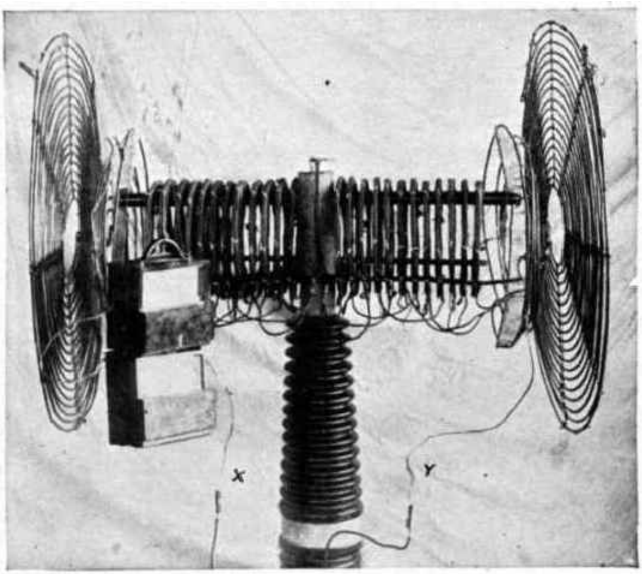

FIGURE 179—Step-up transformer for radio-frequency high voltage transformation.

increase from 125 ohms to 12,500 ohms. One unusual characteristic of this method of varying the radio frequency resistance of the antenna, by inserting therein the primary of a transformer the secondary circuit of which contains a pliotron, is that maximum secondary current naturally corresponds to minimum antenna current.

This system of control enabled radiophone communication between Schenectady and Pittsfield, a distance of 50 miles (80 km.), a small 2 K. W. alternator running at 90,000 cycles being used as the source.

Absorption systems of these types may be used as direct, median, or inverted modulation systems. That is, we may arrange so that, when no speech is taking place and the microphone circuit resistance is therefore a maximum, the maximum current flows in the antenna; this current to be suitably. diminished by modulation whenever speech begins. Or the current in the antenna may center about a median value corresponding, for example, to half-energy. Or finally, the antenna current corresponding to the undisturbed microphone may be practically zero, to increase by modulation at the beginning of speech. This inverted modulation would seem preferable on the basis of reduced radiation during inactive periods. However, only the median modulation will, in general, give satisfactory articulation.

One interesting point remains to be mentioned in connection with all modulation systems. If a 100,000 cycle sustained wave be modulated by a 1,000-cycle note, both theory and practice agree as to the propriety of regarding the modulated wave as the resultant of *three* separate waves: namely, one corresponding to the frequency of 100,500, one corresponding to the frequency of 99,500, and one corresponding to the frequency of 100,000. All three, being physically present, are detectable with a wave meter, and this has a certain bearing on the selectivity in radio telephony, particularly at very long wave lengths, corresponding to low radio frequencies.

Extract from “Radio Telephony”, Alfred N. Goldsmith Ph.D., The Wireless Press (1918)
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