

Oct. 9, 1928.

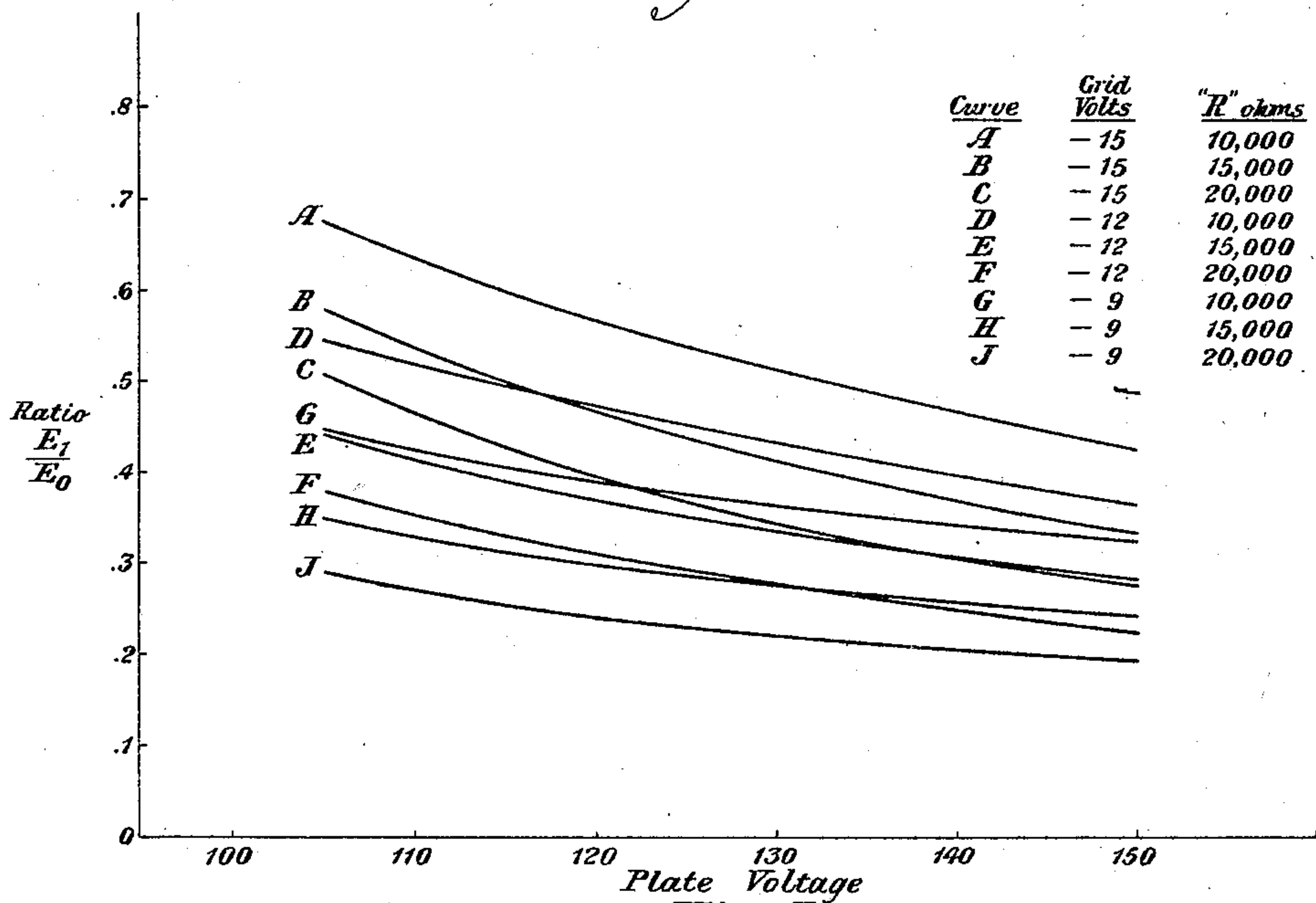
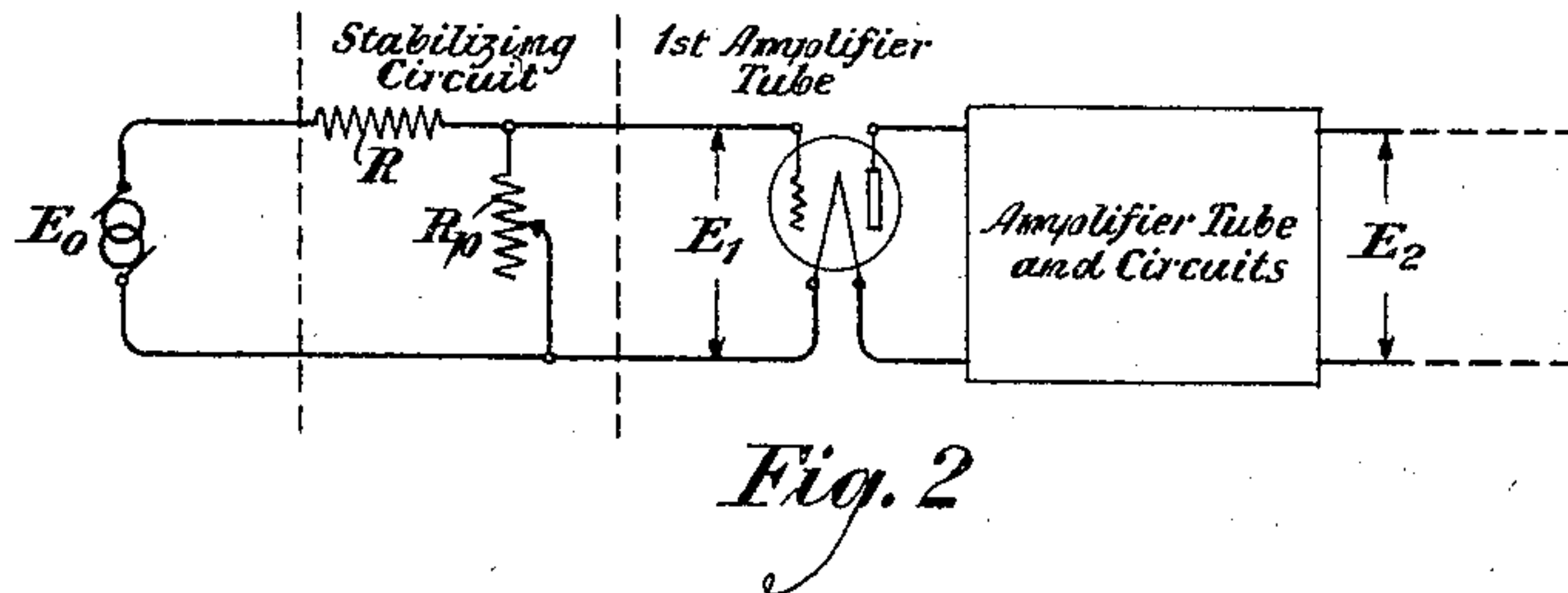
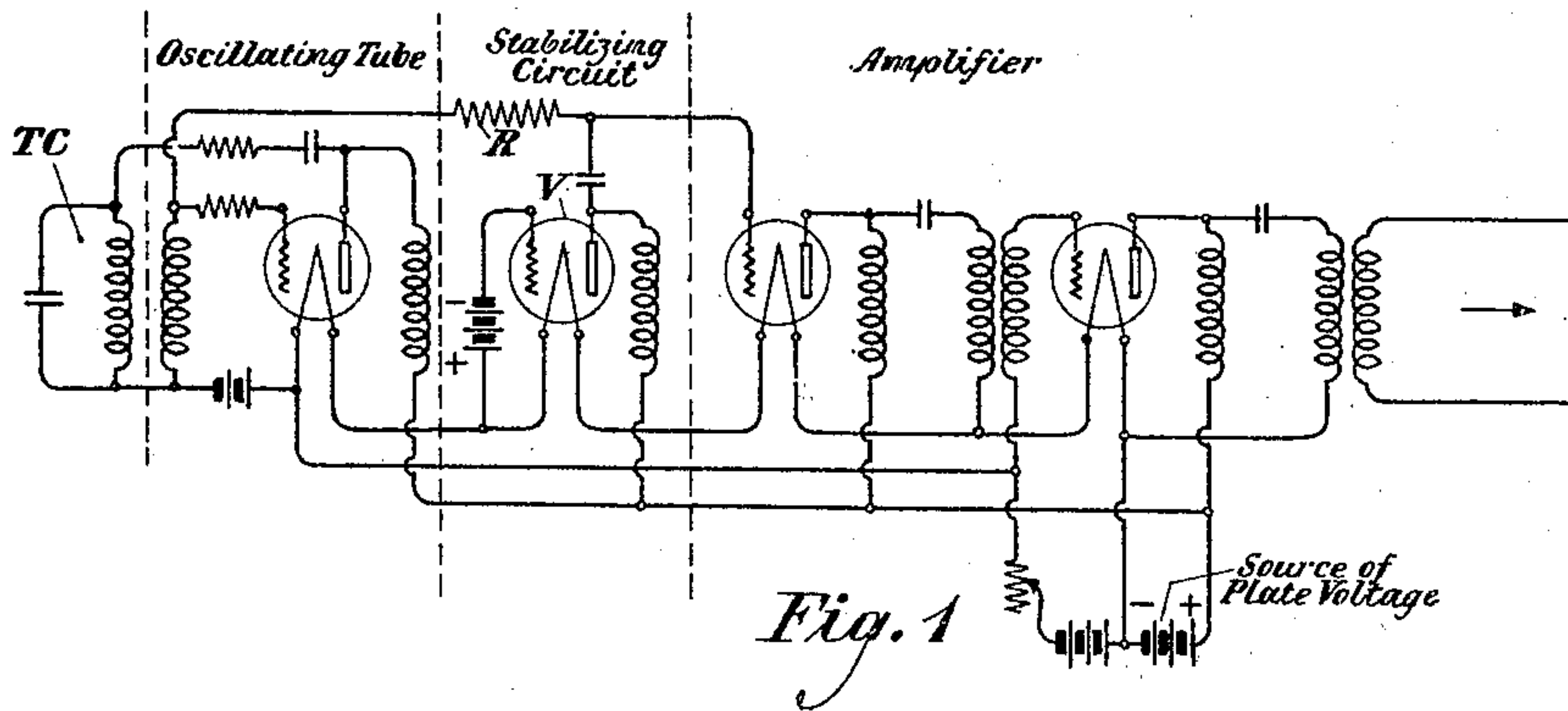
1,686,552

F. E. FAIRCHILD

STABILIZATION OF CIRCUIT OUTPUT

Filed Oct. 1, 1927

3 Sheets-Sheet 1



INVENTOR.
F. E. Fairchild
BY *GE 402*
ATTORNEY

Oct. 9, 1928.

1,686,552

F. E. FAIRCHILD

STABILIZATION OF CIRCUIT OUTPUT

Filed Oct. 1, 1927

3 Sheets-Sheet 2

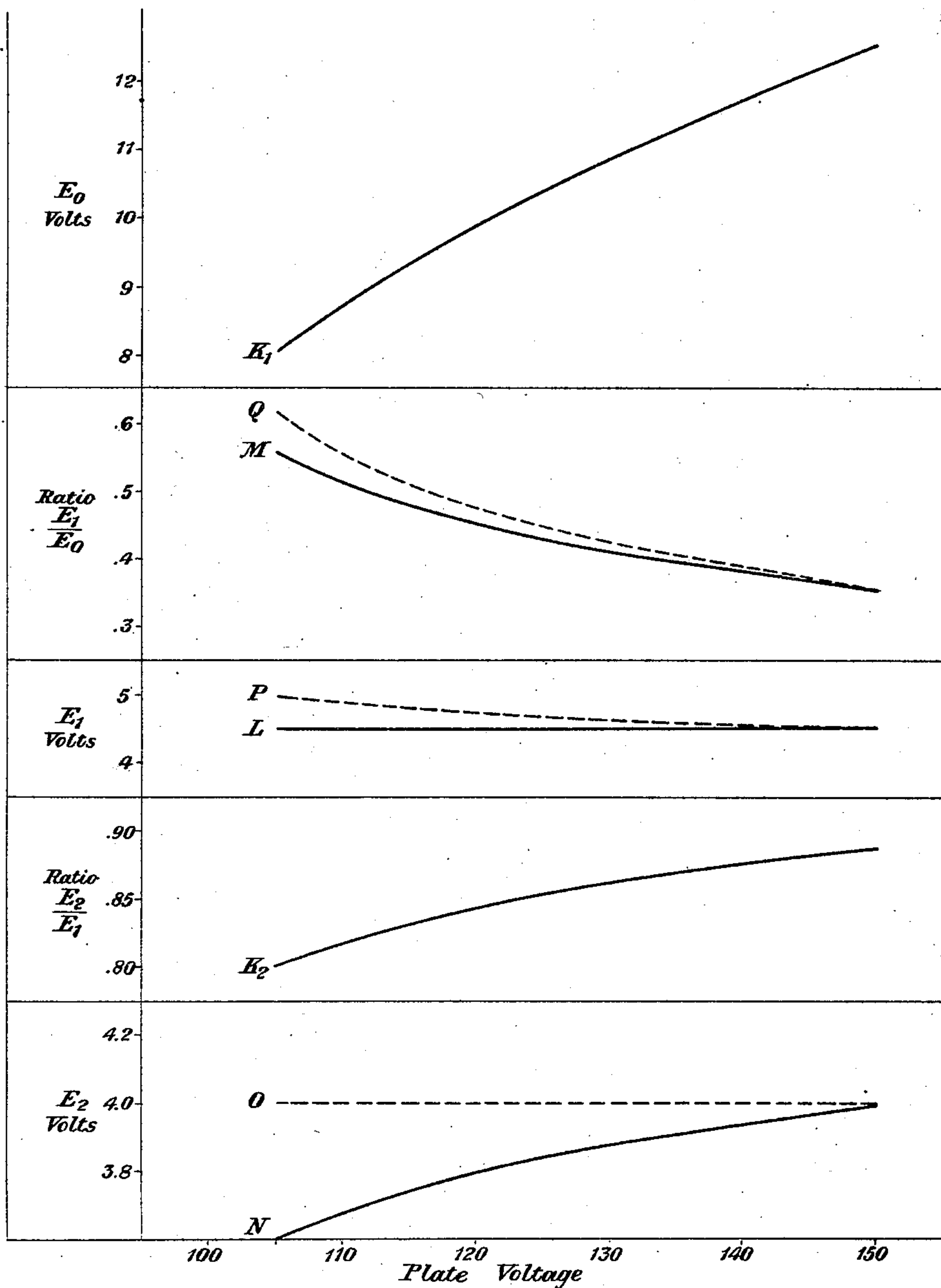


Fig. 4

INVENTOR.
F. E. Fairchild
BY *g e 702*
ATTORNEYS.

Oct. 9, 1928.

1,686,552

F. E. FAIRCHILD

STABILIZATION OF CIRCUIT OUTPUT

Filed Oct. 1, 1927

3 Sheets-Sheet 3

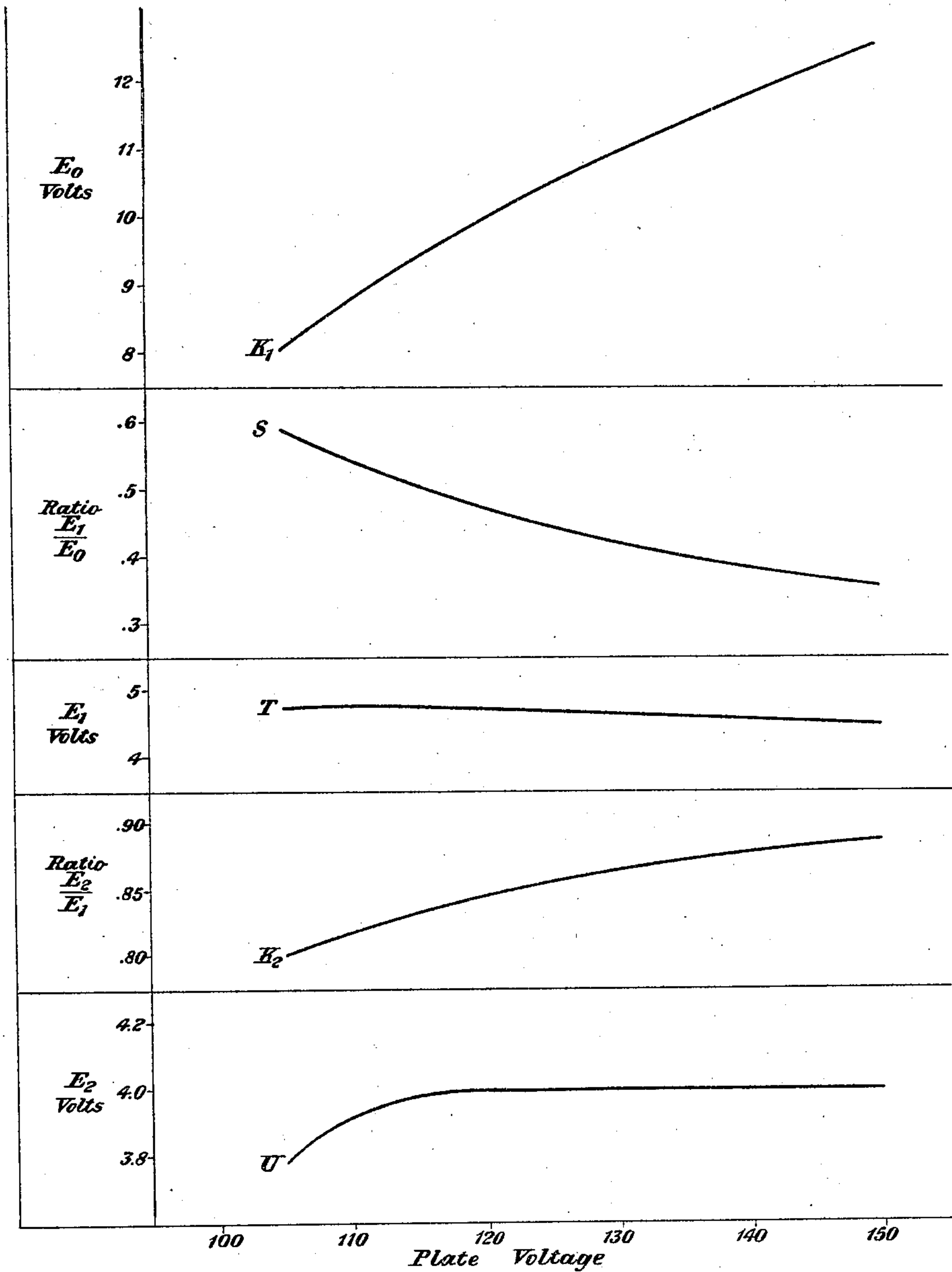


Fig. 5

INVENTOR.
F. E. Fairchild
BY *g. s. g.*
ATTORNEY

UNITED STATES PATENT OFFICE.

FRANK E. FAIRCHILD, OF RED BANK, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

STABILIZATION OF CIRCUIT OUTPUT.

Application filed October 1, 1927. Serial No. 223,345.

This invention relates to oscillation generator circuits and amplifier circuits, and more particularly to such circuits including vacuum tube elements.

5 In circuits of the type named above, the inevitable variations in plate battery supply voltage cause instability in the output of the circuit. The object of this invention is to stabilize the circuit output.

10 An oscillation generator circuit may, of course, consist of an oscillating vacuum tube and certain associated circuits, without any amplifying elements in the circuit; again, it may include tubes and circuits giving one
15 or more stages of amplification. My invention, in its broader aspect, is applicable to either of these two forms of circuit, and also, as will appear from an examination of the basic principle involved, to other circuits
20 including vacuum tube elements.

In general, the invention resides in utilizing a stabilizing circuit, which is placed between the oscillating tube for instance, and the output of the generator circuit. If the
25 circuit includes an oscillating tube and amplifying elements, the stabilizing circuit is preferably placed between the oscillating tube and the first amplifier tube. The impedances of this stabilizing circuit are adjusted, as will be fully disclosed hereinafter,
30 to give an output substantially unaffected by variations of plate voltage.

The invention will be clearly understood when the following detailed description of the proposed embodiment thereof in an oscillation generator circuit is read with reference to the accompanying drawing.

Figure 1 of the drawing shows diagrammatically an oscillation generator circuit including two amplifier tubes and the stabilizing circuit of the invention.

Fig. 2 shows schematically the impedances of the stabilizing circuit and indicates the voltages affected by adjustment of these impedances.

Fig. 3 is a diagram showing by means of curves the effect of various adjustments of the stabilizing circuit on the relation between plate voltage variation and, for instance, the ratio of the amplifier input voltage to the oscillating tube output voltage.

Fig. 4 is a curve diagram indicating the stabilizing circuit adjustment required to give (1) a constant output from the oscil-

lator and (2) a constant output from the 55 amplifier.

Fig. 5 is a diagram showing by means of curves the best practicable adjustment of the stabilizing circuit to give a final amplifier output independent of plate battery 60 changes—between 120 and 150 volts, with the tube used for the tests—and indicating the oscillator output as well as the final amplifier output produced by such adjustment.

With reference first to Fig. 1, from left to right there are shown the tuned circuit TC; the oscillating vacuum tube; the stabilizing circuit, including the vacuum tube V with the grid battery poled as indicated, the resistance R, and the indicated connections; an amplifier consisting of two vacuum tubes; and batteries common to all four vacuum tubes for supplying the necessary electrode voltages. It is the variation of the supply 75 voltage of the plate feed battery which causes the instability of the generating circuit output and of which the output is to be made independent.

With reference to Figs. 1 and 2 of the 80 drawing, the plate-filament impedance (R_p of Fig. 2) of the tube V is bridged across the oscillator output and the amplifier input, being in the circuit between the oscillating tube and the first amplifier tube. This impedance is directly controlled by changes 85 of the voltage impressed on the grid of the tube V. The resistance R is in series between the oscillating circuit and the tube V. In Fig. 2 and as used hereinafter, E_0 represents the voltage generated by the oscillator—this voltage being affected by variations of plate voltage, E_1 represents the output voltage of the oscillator circuit—which, of course, is the input voltage of the amplifier, and E_2 represents the output voltage of the amplifier—that is, the final output of the oscillation generator circuit shown in Fig. 1.

It is readily understood from an examination of Fig. 2 that

$$\frac{E_1}{E_0} = \frac{R_p}{R + R_p}.$$

Therefore

$$E_1 = \frac{R_p}{R + R_p} E_0.$$

It thus appears that in order that E_1 may

be rendered constant in spite of changes of the plate battery voltage, $R_p/(R+R_p)$ must be caused to vary inversely with E_o as the plate voltage varies. Substantially the desired result can be accomplished if the negative voltage on the grid of the tube V and the resistance R are given the proper values. The trial method necessary to the determination of these proper values and the approximate values determined will appear from the following discussion.

The curves A to J of Fig. 3 show how the ratio

$$\frac{E_1}{E_o},$$

or the ratio of the oscillator output voltage to the oscillator "input" voltage, varies with changes of the plate voltage for various values of the grid voltage of tube V and the resistance R , a standard type of tube being employed, of course, for the tests. It will be noted that the grid voltages determining the curves are -15 , -12 and -9 volts, while the values of the R are 10,000, 15,000 and 20,000 ohms. An examination of curves A to J reveals that the following two rules are generally applicable: (1) to decrease the negative grid voltage, the resistance R being constant, lowers the curve and makes the curve more nearly horizontal; (2) to increase the value of resistance R , the grid voltage being constant, lowers the curve without any great change in the slope of the curve.

In Fig. 4, the top curve K_1 shows how the voltage E_o changes with changes of plate voltage between 105 and 150 volts. If it is desired to have E_1 , the oscillator output voltage, absolutely constant (as indicated by the curve L, determined by plotting E_1 volts against plate voltages from 105 to 150), which condition would be desirable in the case of an oscillation generator circuit without amplifying elements, it is necessary to have the relation of the ratio

$$\frac{E_1}{E_o}$$

to plate voltage as shown by the curve M, obtained by plotting for the various plate voltages the quotients found from curves L and K_1 . It is seen from a comparison of curve M with the curves of Fig. 3 that curve D of Fig. 3 shows diagrammatically a relation of

$$\frac{E_1}{E_o}$$

and the plate voltage which is close to the perfect relation desired. This curve D is given by the combination in the stabilizing circuit of a grid voltage of -12 and a resistance R of 10,000 ohms. To alter the curve D so that it will more closely approach

coincidence with curve M of Fig. 4, it is required, in accordance with the rules derived from an examination of Fig. 3, to increase the slope slightly by slightly increasing the negative grid voltage—which increase involves a raising of the curve—and to lower the curve somewhat by an increase of the resistance R . Thus, it is seen that a grid voltage of about -12.5 and a value for R of about 14,000 ohms would give a curve approximating the curve M_1 and the result would be a substantially constant oscillator output.

Let it be assumed, now, that the circuit includes an amplifier, as shown in Fig. 1. The curve K_2 of Fig. 4 is obtained by plotting the ratio

$$\frac{E_2}{E_1}$$

against the plate supply voltage, and accordingly indicates the gain of the amplifier. By multiplying the values for the various plate voltages as shown in curves K_2 and L (the absolutely constant oscillator output), there may be plotted the curve N. This curve N indicates the variation of amplifier output with changes of plate voltage if the ratio

$$\frac{E_1}{E_o}$$

follows curve M—that is, if the stabilizing circuit has a grid voltage of -12.5 and a resistance R of about 14,000 ohms. This output is not constant, and therefore is undesirable. It remains to be determined what values for the stabilizing circuit will give a constant amplifier output.

If the absolutely constant amplifier output curve O (broken) is drawn (Fig. 4), and, for the various plate voltages, the values taken from this curve are divided by the values taken from the curve K_2 , the broken curve P is obtained for the oscillator output, varying slightly from the curve L. By dividing the values of curve P by the values of curve K_1 and plotting the results, the broken curve Q is found to represent the desired relation between the ratio

$$\frac{E_1}{E_o}$$

and the plate voltage. If curve Q is compared with curve M, it is discovered that the values determining curve M must, in order to give a curve closer to Q, be changed to increase the slope slightly—requiring a slight increase of the grid voltage of the establishing circuit, which involves a raising of the curve—and to lower the curve slightly when allowance is made for the slope correction. Therefore, it will be seen that the ideal curve Q would require a grid voltage of slightly greater negative

value than -13 and a resistance R slightly less than $17,000$ ohms.

It has been found that the best results practicable in the case of the circuit which includes the amplifier (with the standard tubes used in the tests) are obtained if the stabilizing circuit is adjusted to have a voltage of -13 on the grid of the tube V and a value of $17,000$ ohms for the resistance R . With these values, the stabilizing circuit acts as is indicated in Fig. 5 of the drawing. The curves K_1 and K_2 , which show, respectively, the variation of E_0 with plate voltage changes and the amplifier gain, are the same as the corresponding curves of Fig. 4. The values chosen give a variation of

$$R_p/(R+R_p)$$

with plate voltage variation which produces the variation of

$$\frac{E_1}{E_0}$$

with changes of plate voltage shown by curve S . The result in the oscillator output is not absolutely constant, E_1 varying as is indicated by curves T . This variation of E_1 , however, is such that the amplifier output—that is, the final output of the oscillation generator circuit—is quite independent of changes of plate supply voltage between 120 volts and 150 volts, as shown by the curve U . This is the condition desired.

While the invention has been specifically described above, for the purpose of illustration, it is to be understood that its true scope is not limited by such description, but is defined in the appended claims.

What is claimed is:

1. In an oscillation generator circuit, a vacuum tube oscillator, a source of plate voltage therefor, a work circuit, an output circuit to which there will be applied by said oscillator an oscillating potential the amplitude of which will vary with variations of the voltage of said plate source, said output circuit being connected to said work circuit, a stabilizing three-electrode vacuum tube having its plate-filament impedance bridged across said output circuit, means for producing changes in the plate-filament impedance of said stabilizing tube corresponding to the amplitude variations of the potential supplied by said oscillator, and means for adjusting the operating characteristics of said stabilizing tube so that the variations of the plate-filament impedance thereof will substantially compensate for the amplitude variations of the potential supplied by said oscillator, whereby a resultant potential of constant amplitude will be supplied to said output circuit.

2. In an oscillation generator circuit, a vacuum tube oscillator, a source of plate

voltage therefor, a stabilizing three-electrode vacuum tube having its plate-filament impedance bridged across the generator circuit, means for producing changes in the plate-filament impedance of said stabilizing tube corresponding to the variations of the potential supplied by said oscillator, a series resistance in the circuit, and means for adjusting the operating characteristics of said stabilizing tube so that the variations of the plate-filament impedance thereof will substantially compensate for the variations of the potential supplied by said oscillator, whereby the output potential of the generator circuit will be substantially constant.

3. In an oscillation generator circuit, a vacuum tube oscillator, a stabilizing three-electrode vacuum tube having its plate-filament impedance bridged across the generator circuit, a common source of plate supply voltage for said vacuum tubes, a source of grid biasing voltage for said stabilizing tube, and a series resistance in the circuit, the value of said series resistance and the value of said grid biasing voltage being such that the output voltage of the generator circuit is independent of fluctuations of the plate supply voltage.

4. In an oscillation generator circuit, a vacuum tube oscillator generating a voltage E_0 , a stabilizing three-electrode vacuum tube having a plate-filament impedance R_p bridged across the generator circuit, a common source of plate supply voltage for said vacuum tubes, a source of grid biasing voltage for said stabilizing tube, and a series resistance R in the circuit, the values of R and of said grid biasing voltage being such that $R_p/(R+R_p)$ varies inversely with changes of E_0 due to fluctuations of the plate supply voltage, to give a constant circuit output voltage.

5. In an oscillation generator circuit including a vacuum tube oscillator, a source of plate voltage therefor, a work circuit, an output circuit to which there will be applied by said oscillator an oscillating potential the amplitude of which will vary with variations of the voltage of said plate source, said output circuit being connected to said work circuit, and an auxiliary three-electrode vacuum tube having its plate-filament impedance bridged across said output circuit; the method of stabilizing the potential applied to the output circuit which consists in producing changes in the plate-filament impedance of the auxiliary tube corresponding to the amplitude variations of the potential supplied by the oscillator and adjusting the operating characteristics of the auxiliary tube so that the variations of the plate-filament impedance thereof will substantially compensate for the amplitude variations of the potential supplied by the oscillator.

6. In an electric circuit, means for supply-

ing alternating current, a vacuum tube amplifying device, a source of plate voltage therefor, a work circuit, an output circuit to which there will be applied an oscillating
5 potential the amplitude of which will vary with variations of the voltage of said plate source, said output circuit being connected to said work circuit, a stabilizing three-electrode vacuum tube having its plate-filament
10 impedance bridged across the circuit, means for producing changes in the plate-filament impedance of said stabilizing tube corresponding to the amplitude variations of the potential applied to said output circuit,
15 and means for adjusting the operating characteristics of said stabilizing tube so that variations of the plate-filament impedance thereof will substantially compensate for the amplitude variations of the potential ap-
20 plied to the output circuit, whereby a resultant potential of constant amplitude will be supplied to said output circuit.

7. In an electric circuit including means for supplying alternating current, a vacuum tube amplifying device, a source of plate

voltage therefor, a work circuit, an output 25 circuit to which there will be applied an oscillating potential the amplitude of which will vary with variations of the voltage of said plate source, said output circuit being connected to said work circuit, and an auxil- 30 iary three-electrode vacuum tube having its plate-filament impedance bridged across the circuit; the method of stabilizing the potential supplied to the output circuit which consists in producing changes in the plate- 35 filament impedance of the auxiliary tube corresponding to the amplitude variations of the potential applied to the output circuit and adjusting the characteristics of the auxil- 40 iary tube so that the variations of the plate-filament impedance thereof will substantially compensate for the amplitude variations of the potential applied to the output circuit.

In testimony whereof, I have signed my 45 name to this specification this 30th day of September, 1927.

FRANK E. FAIRCHILD.