

April 3, 1928.

R. W. KING

1,664,455

ELECTRICAL TRANSLATING CIRCUIT

Filed Jan. 4, 1922

2 Sheets-Sheet 1

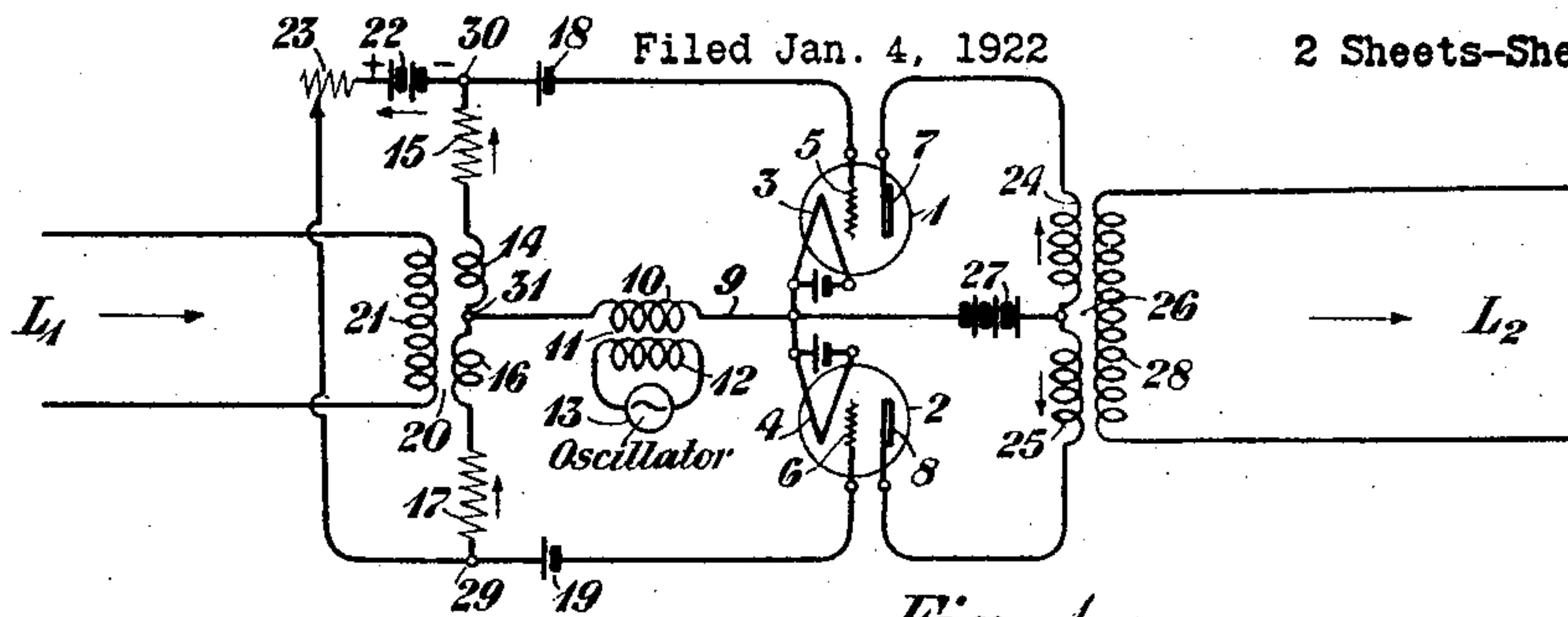


Fig. 1

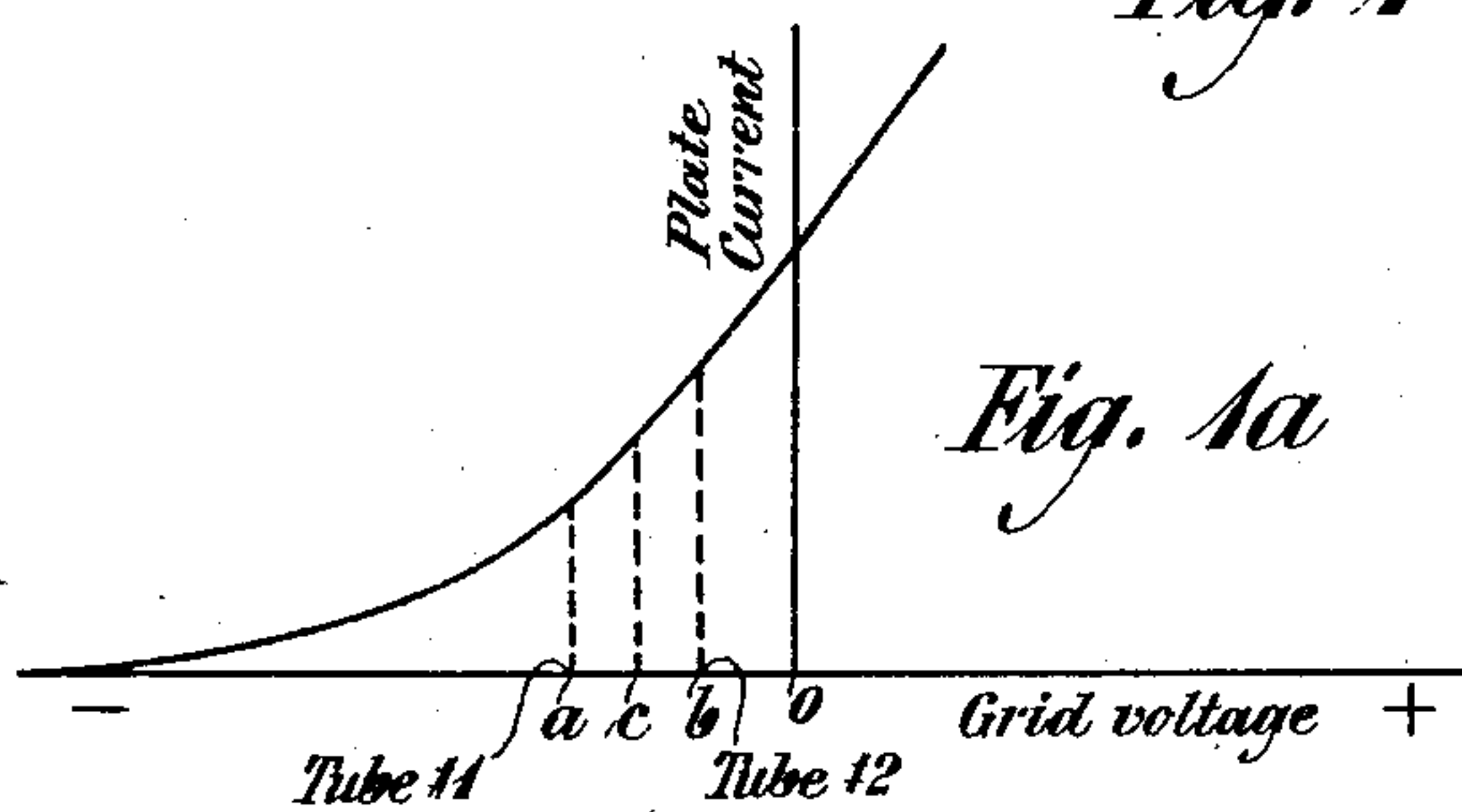


Fig. 1a

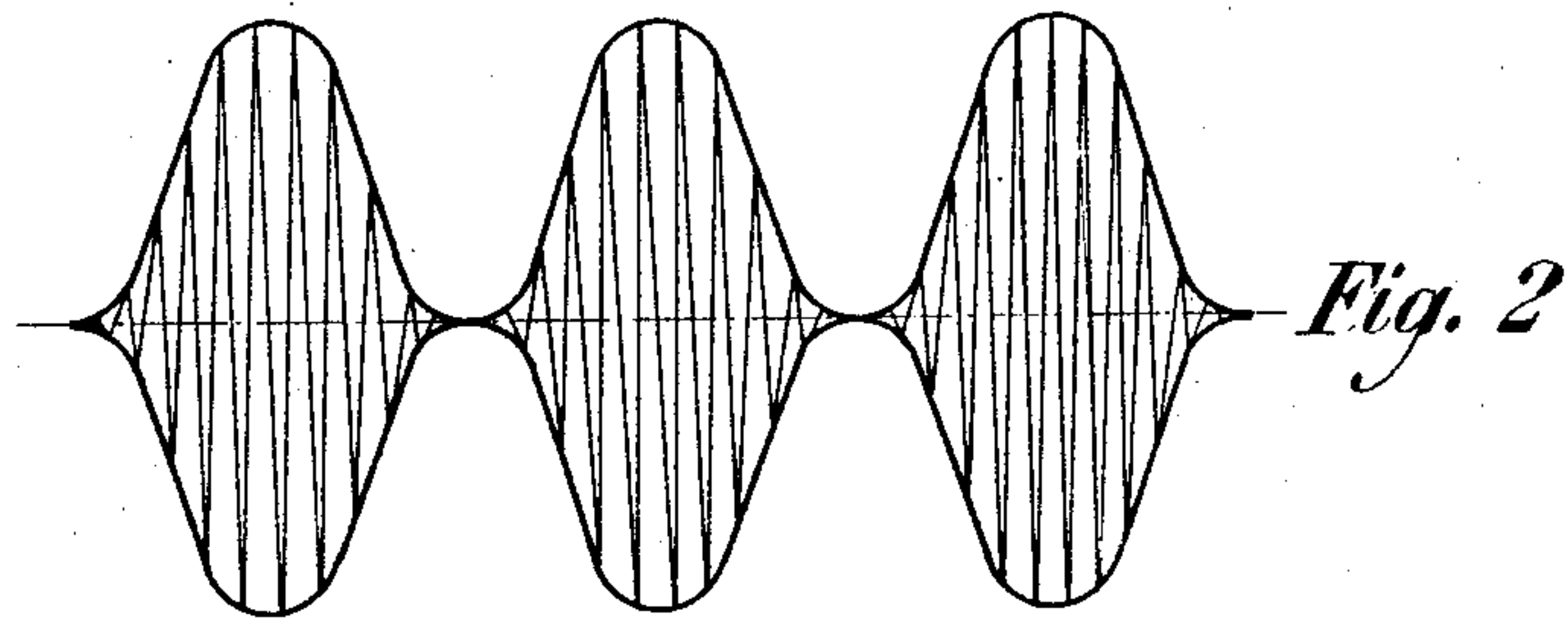


Fig. 2

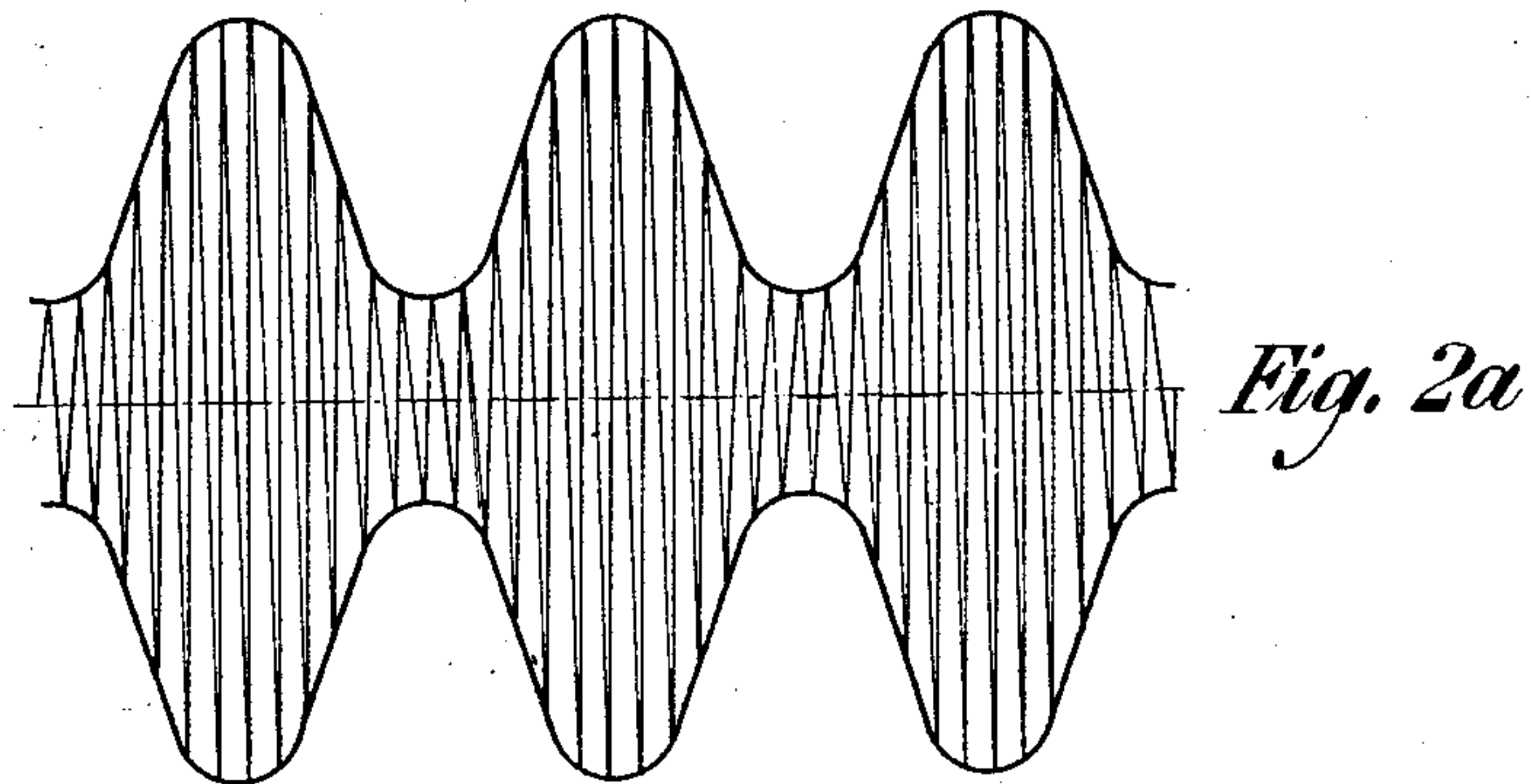


Fig. 2a

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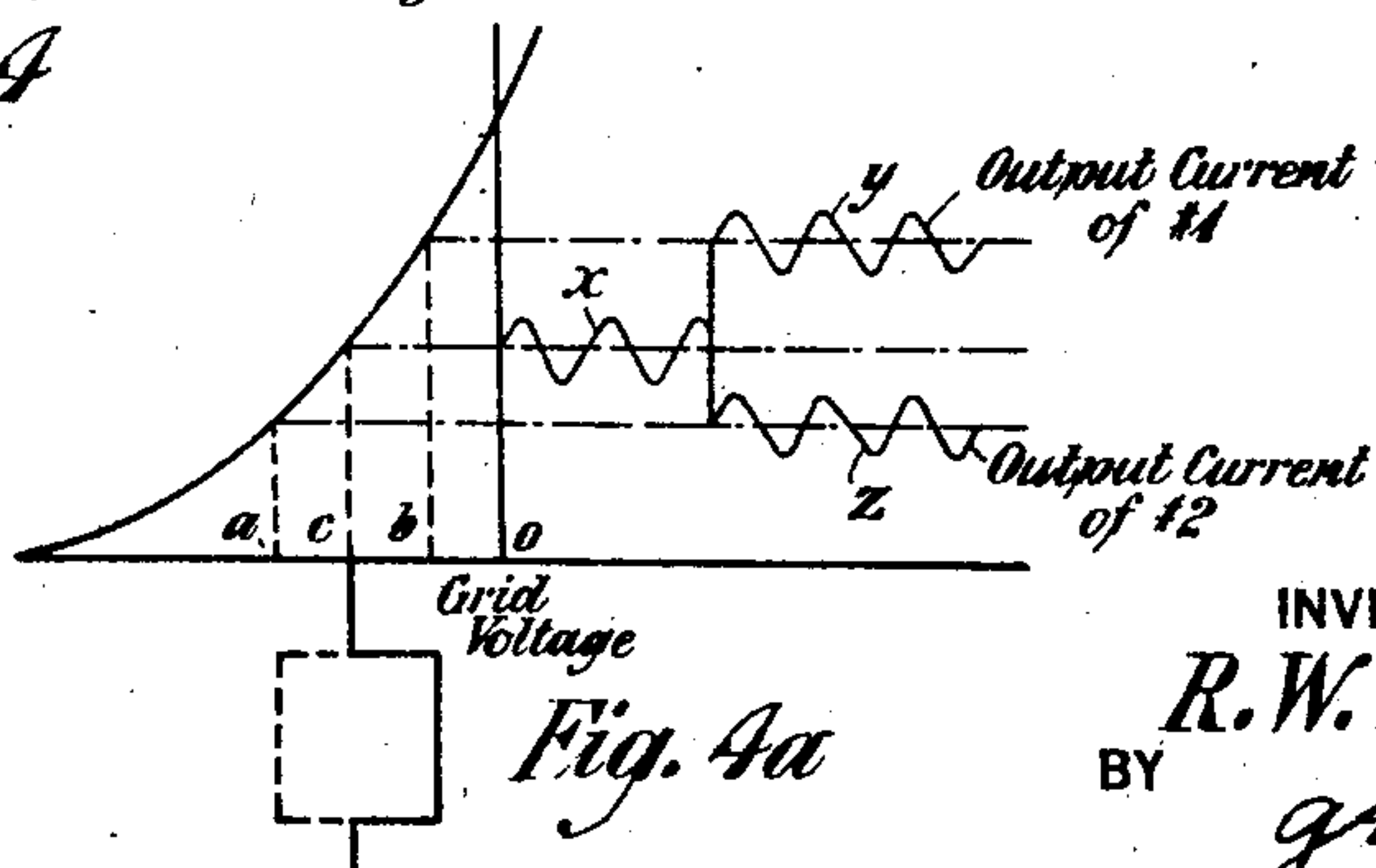
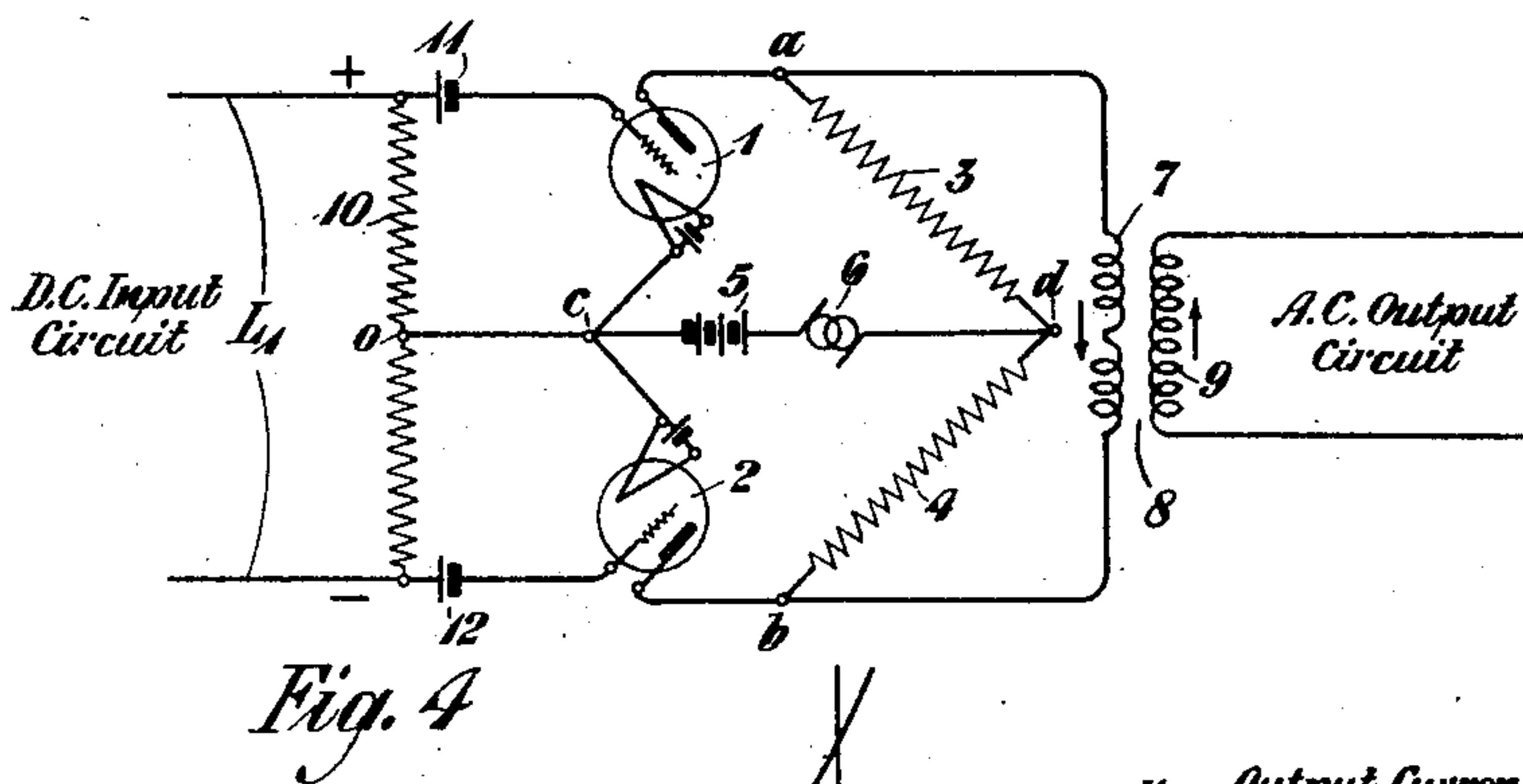
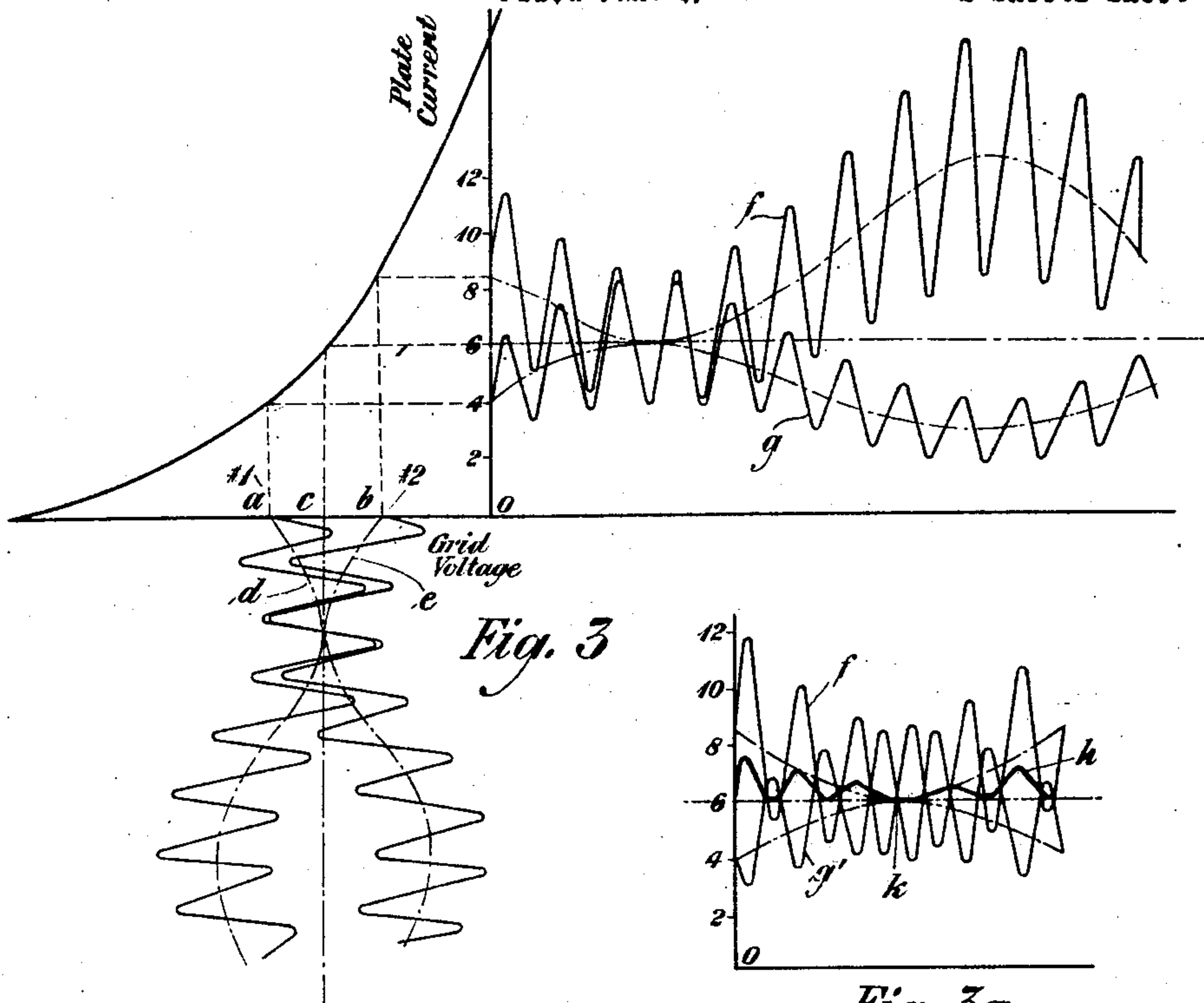
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

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ELECTRICAL TRANSLATING CIRCUIT.

Application filed January 4, 1922. Serial No. 526,924.

This invention relates to electrical translating circuits and particularly to means for controlling the degree of modulation of a high frequency alternating current by an impressed modulating current.

In the patent to J. R. Carson, 1,343,306, dated June 15, 1920, there is disclosed, for example, in Figure 6 a circuit employing two thermionic vacuum tubes and a plurality of transformer windings symmetrically disposed so that the frequency which is intended to be modulated by an impressed frequency is suppressed in this circuit, and its transmission to the output circuit is prevented. In the Carson circuit, the degree of modulation, by which is meant the ratio of the amplitude of the modulating wave to the modulated wave, is fixed for any particular circuit by the constants of that circuit.

It is one of the objects of my invention to provide an arrangement by which the degree of modulation may be controlled. Another object of this invention is to provide means for modulating an alternating current wave of definite frequency by means of direct current impulses, such, for example, as may be transmitted over a direct current telegraph circuit.

Further objects of this invention will be apparent from the following description when read in connection with the attached drawing, of which Fig. 1 shows one form of circuit by means of which the degree of modulation of a carrier current by an impressed modulating current may be determined, and Fig. 1^a graphically describes a part of the operation of the circuit shown in Fig. 1; Figs. 2 and 2^a represent respectively a completely modulated wave and an incompletely modulated wave; Figs. 3 and 3^a describe graphically the operation of the circuit shown in Fig. 1; Fig. 4 shows another form of circuit by means of which a high frequency alternating current may be modulated by direct current impulses, and Fig. 4^a shows graphically the operation of the circuit shown in Fig. 4.

In Fig. 1, 1 and 2 represent two thermionic vacuum tubes of the well known type embodying three electrodes, viz, filaments 3 and 4, the grids 5 and 6 and the plates 7 and 8. The filaments are connected together to a common conductor 9, which has in series therewith, a winding 10 of a transformer 11. The other winding 12, of said transformer

has connected therewith a source 13 of high frequency oscillations. The common conductor 9 is connected with the grid 5 of the tube 1, through the inductive winding 14 and a resistance 15. Similarly, the conductor 9 is connected with the grid 6 of tube 2 through an inductance 16 and a resistance 17. The inductances 14 and 16 have the same effective resistance; and the resistances 15 and 17 are also of equal magnitude. Connected with the grid circuits of the tubes 1 and 2 are the batteries 18 and 19 which have the same potential across their respective terminals. The windings 14 and 16 constitute secondary windings of the transformer 20, the primary winding 21 of which is connected with the input circuit L_1 . It should be noted that the windings 14 and 16 are reversed so that the potentials induced in these windings by the current flowing through the winding 21 are in opposite directions. Bridged across the grid circuits is a battery 22 having in series therewith a variable resistance 23, by means of which the current flowing from the said battery may be controlled. Current from this battery will flow from the positive terminal through the variable resistance 23, the resistance 17, the windings 16 and 14 and the resistance 15 to the negative terminal of the said battery. The plates of the tubes 1 and 2 are connected with the windings 24 and 25 respectively of the transformer 26. The windings 24 and 25 are connected together to the filaments of the two tubes and a plate battery 27 is connected in this common conductor. Another winding 28 of the transformer 26 is connected with the output circuit L_2 .

Having in mind the foregoing description of the parts of the circuit in which this invention is embodied it will be clearly understood from the following description of the method of operating the circuit.

When the battery 22 is not effectively connected into the circuit and when oscillations are not being impressed upon the common conductor 9 by the source 13, the only potentials upon the grids of the vacuum tube 1 and 2 are those created by the batteries 18 and 19, which, as stated, are of equal potential. This grid potential, which is negative, is represented in Fig. 1^a by the distance oc . If, now, the battery 22 is effectively connected into the circuit, current will flow through the circuit previously traced from the posi-

tive to the negative terminal of said battery. There will accordingly be established a difference of potential across the points 29 and 30, the point 29 being at a higher potential than the point 30. The drop in potential from the point 29 to the point 31 will be in such direction as to reduce in magnitude the negative potential upon the grid of the tube 2, and the drop in potential from the point 31 to the point 30 will be in such direction as to increase the magnitude of the negative potential upon the grid of the tube 1. This is clearly shown in Fig. 1^a, where the normal potential of the grid of tube 2 has shifted to the point *b*, and that of the grid of tube 1 has been moved to a point *a*.

Let it be assumed that a low frequency sinusoidal wave, for example, arriving over the line L_1 is impressed upon the winding 21 of the transformer 20. This low frequency current will induce potentials in each of the windings 14 and 16, the directions of which are at all times relatively opposite. The effect of these alternating potentials is to continually shift the grid voltage of the two tubes. This is clearly shown in Fig. 3 by the curves *d* and *e*, each of which represents the locus of the instantaneous values of the grid potential. If now oscillations of the carrier frequency created by the source 13 are impressed upon the common conductor 9 by the transformer 11, these oscillations will be symmetrically disposed with regard to the curves *d* and *e*, which represent the axes of the high frequency carrier oscillations. The plate current resulting from the variations of the grid voltage of the tube 1 are represented by the lower band of oscillations designated *g* and the resulting plate current of tube 2 by the band *f*. It will be seen that these plate currents vary in magnitude throughout their cycle and that they are in the same phase. Since, however, these currents flow in their respective plate circuits from the outer terminals of the windings 24 and 25, toward the common filament conductor, the effect of these currents upon the secondary winding 28 is such as would result if the currents were 180 degrees apart. This is represented by Fig. 3^a, where the upper curve designated *f* is the same curve as *f* of Fig. 3, and the curve *g'* is a curve of the same magnitude as *g* of Fig. 3, but 180 degrees displaced in phase. The resultant curve *h* represents the difference in the instantaneous values of the curves *f* and *g'*. It will be seen by means of the curve *h* that complete modulation of the carrier wave has been effected. This has resulted by making the voltages *ac* and *bc* equal to the peak values of the low frequency voltage wave impressed upon the winding 21 of the transformer 20.

From the foregoing description of the manner in which complete modulation of the

high frequency current has been effected, it will be apparent that by varying the drop of potential through the resistances 15 and 17 (which may be assumed to include the resistance of the inductive windings 14 and 16), the degree of modulation of the high frequency output current can be varied within wide limits and can be readily controlled. Thus, for example, we may effect complete modulation such as shown in Fig. 2, or any degree of modulation such as shown in Fig. 2^a.

In the foregoing description of the operation of the circuit shown in Fig. 1, I have considered the use of an alternating wave from the line L_1 for modulating the wave from the oscillator 13 and have shown how the current from battery 22 may be used for fixing the initial setting of the grid potentials as shown in Fig. 3. It is desirable to point out that the arrangement shown in Fig. 1 is adapted to modulate the waves from source 13 by D. C. signaling impulses transmitted from the battery 22 and controlled by a suitable key in series therewith. Thus, with no alternating potential on line L_1 , the opening and closing of a key in series with battery 22 will allow current impulses to flow through the grid control circuits which cause the grid potentials to vary accordingly, making one of said grids more negative than the other, thus destroying the balance of the circuit and causing a current flow in the output circuit L_2 . This will be clearly understood from the description of Fig. 4 which specifically illustrates this phase of the invention.

Fig. 4 shows a method of modulation by direct current impulses which, in effect, is capable of amplifying direct current impulses. The circuit of this figure represents a modified Wheatstone bridge network employing two balanced thermionic vacuum tubes 1 and 2, each of the three-electrode type. The circuit of the plate and filament of each tube may be considered as constituting the ratio arms of the bridge network, and the balanced impedances 3 and 4 constitute the other two arms of the network. Bridged across the corners *cd* of the network is a space current battery 5, with which is connected in series a source of alternating current 6. Similarly bridged across the corners *ab* of the bridge network is the winding 7 of the transformer 8, the other winding of which, 9, is connected with the output circuit of the system. Bridged across the input circuit L_1 is an impedance 10, the midpoint of which is connected with the corner *c* of the Wheatstone bridge network, which is also connected with the filaments of the two tubes. The sides of the circuit L_1 are connected respectively with the grids of the two vacuum tubes. Batteries 11 and 12 of equal potential are also connected with the grids

of the said tubes. Fig. 4^a shows graphically the current changes in operating the circuit. When direct current impulses are not being received over the line L_1 , the grids of the vacuum tubes are maintained at the same potential by the batteries 11 and 12, which is indicated upon the Fig. 4^a by the distance oc . Consequently, the current which flows from the battery 5 and the generator 6 through the impedance 3 and from the plate to the filament of the tube 1 will be of the same magnitude, and in phase with the current that flows from the said sources through the impedance 4 and from the plate to the filament of the tube 2. Consequently, the points a and b will be at the same potential and no current will flow through the coil 7 of the transformer 8. This is represented graphically in Fig. 4^a by the curve x , which in effect, represents the current curves of the two plate filament circuits superimposed upon each other. When a direct current impulse is transmitted over the line L_1 , making, for example, the upper conductor positive and the lower one negative, a difference of potential will be established across the impedance 10. This difference of potential reduces the negative charge on the grid of the tube 1 and increases that of the tube 2, which condition is represented in the drawing by the distance ob . The charge upon the grid of the tube 2, which is made more negative, is represented by the distance oa . The variations of the grid voltage of tube 1 are shown by the solid line, and the variations of tube 2 by the dotted line of the grid voltage shown in Fig. 4^a. The balance of the Wheatstone bridge circuit is disturbed by the impressing of a direct current impulse across the impedance 10 so that the resultant plate currents are no longer equal. The plate current of the tube 1 is represented by the curve y , and that of the tube 2 is represented by the curve z . Current of the magnitudes represented by y will flow through the impedance 3, and that of the magnitudes of the curve z will flow through the impedance 4. Due to their inequality, a difference of potential is established across the points a and b , which causes a current flow of the frequency of the generator 6 through the windings 7 of the transformer 8. This will establish a potential across the winding 9 of the said transformer, which is connected with the output circuit. These direct current impulses can either be received as successive alternating current trains or they may be demodulated and received as amplified direct current impulses. Such detecting means are well known to the art and are not shown or specifically claimed as part of this invention.

It will be apparent from the foregoing description that this invention covers broadly the idea of means for controlling and de-

termining the degree of modulation of a wave of definite frequency by another wave of the same or different frequency. There is also shown a specific means for modulating an alternating wave by direct current impulses, thereby providing an arrangement for amplifying the said direct current impulses.

Although this invention has been disclosed as embodied in a particular form and arrangement of parts, it is to be understood that it is capable of embodiment in other and different forms without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. In a modulating system, the combination with a plurality of three electrode vacuum tubes, of an input transformer having its primary winding connected with a source of modulating current and having two differential secondary windings individual to the grids of said tubes and connected by common conductor with both filaments of said tubes, a source of varying E. M. F. adapted to impress its potential upon said common conductor, a source of direct current potential adapted to control the normal relative potential of the grids of said tubes, and a second transformer having one winding connected between said plates with its mid-point connected with both filaments of said tubes and its other winding connected with an output circuit.

2. In a modulating system, the combination with a modulating circuit containing a plurality of vacuum tubes symmetrically disposed therein, and having a source of carrier frequency current associated therewith, of a second source of current connected with the said modulating circuit to modulate the current of the said first source, and a source of direct current potential common to the grids of the said tubes and connected unsymmetrically therewith to control the degree of modulation.

3. In a modulating system, the combination with a modulator having a plurality of vacuum tubes symmetrically disposed therein of a source of current to be modulated, means to apply like currents from said source to each of said vacuum tubes, a source of modulating current and a source of direct current potential common to the grids of the said tubes and connected unsymmetrically therewith to control the degree of modulation.

4. In a modulating system the combination with two vacuum tubes each having a filament, a plate and a grid, an input impedance effectively bridged across the grids of the said tubes, and having its midpoint connected with the filaments, the said connection including a source of carrier current, an output impedance effectively bridged across

the plates of the said tubes, the midpoint thereof being connected with the said filaments and including a source of plate potential, a source of modulating current effectively connected with the said input impedance, and a controlled source of direct current potential effectively connected across

the said input impedance, whereby the degree of modulation may be controlled.

In testimony whereof, I have signed my name to this specification this 3rd day of January, 1922.

ROBERT W. KING.