

June 4, 1940.

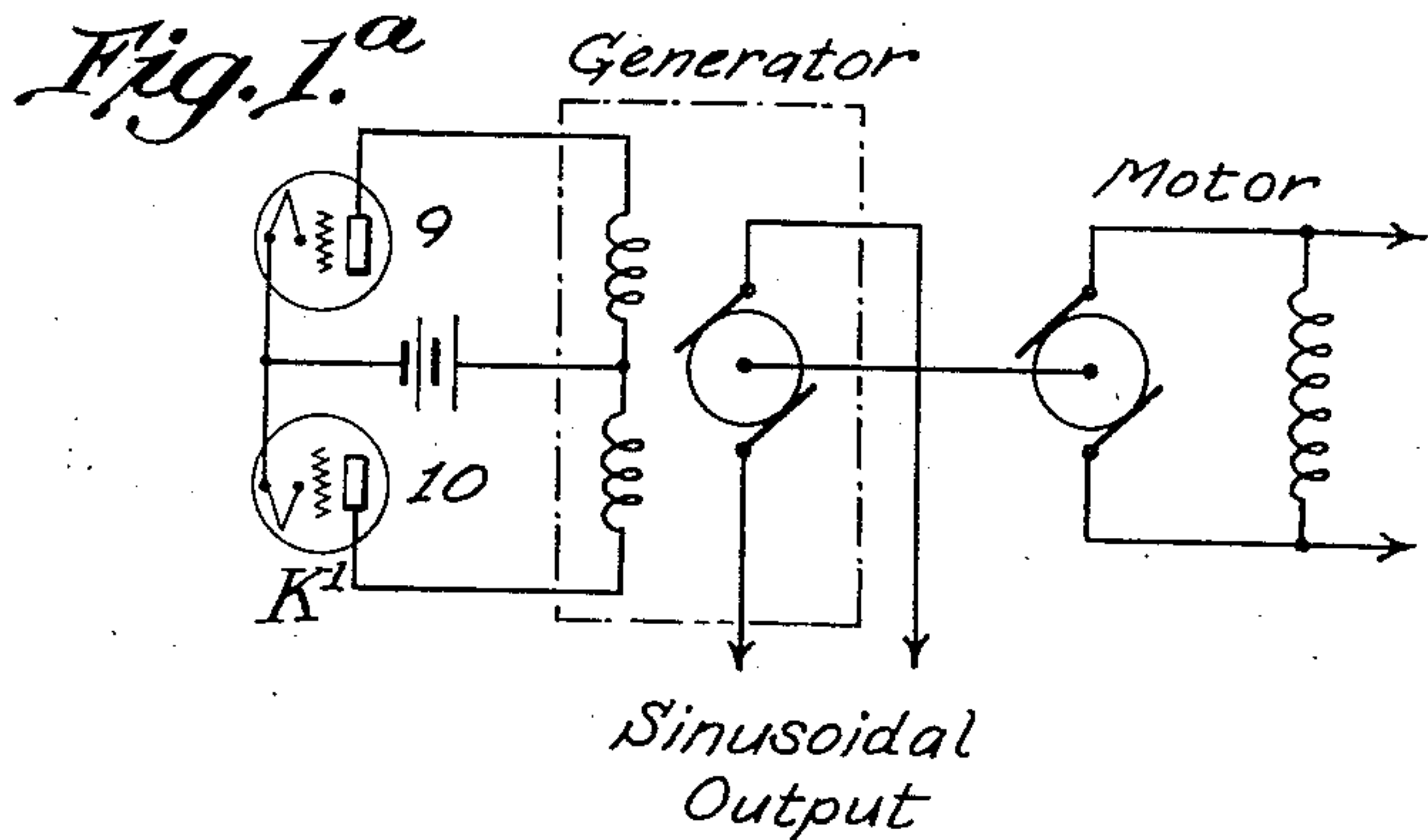
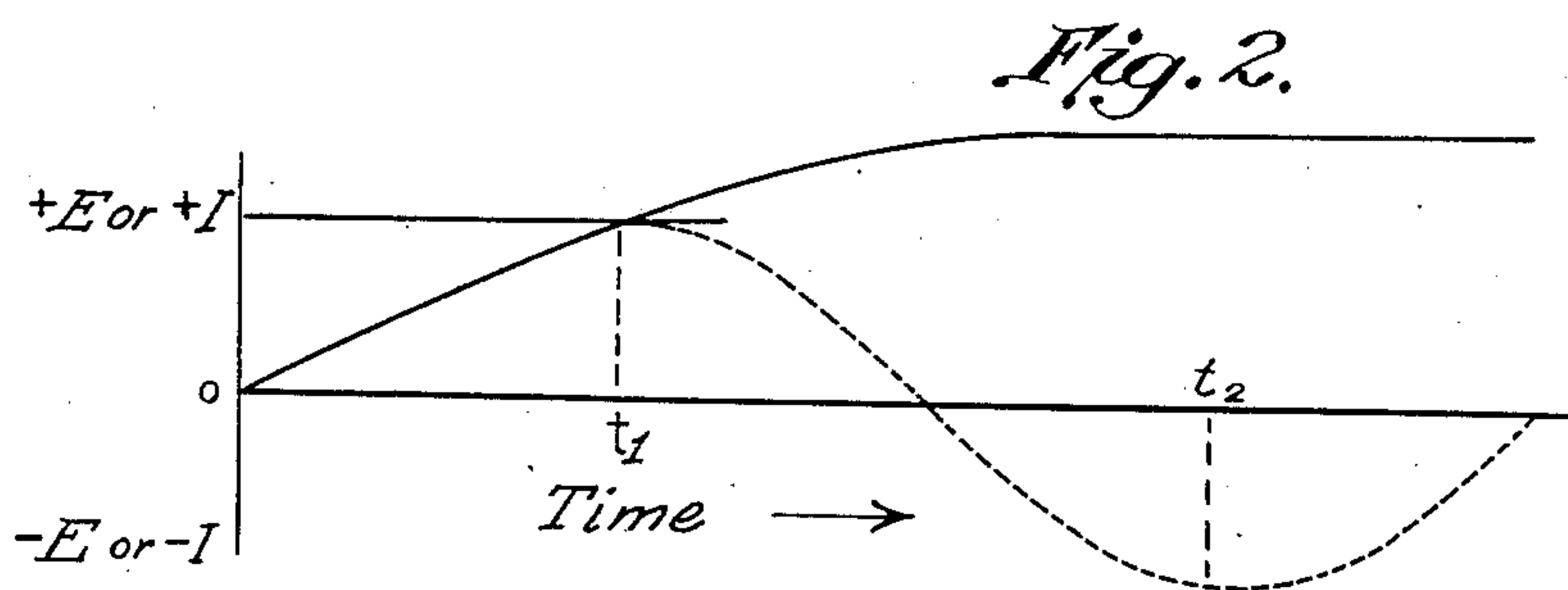
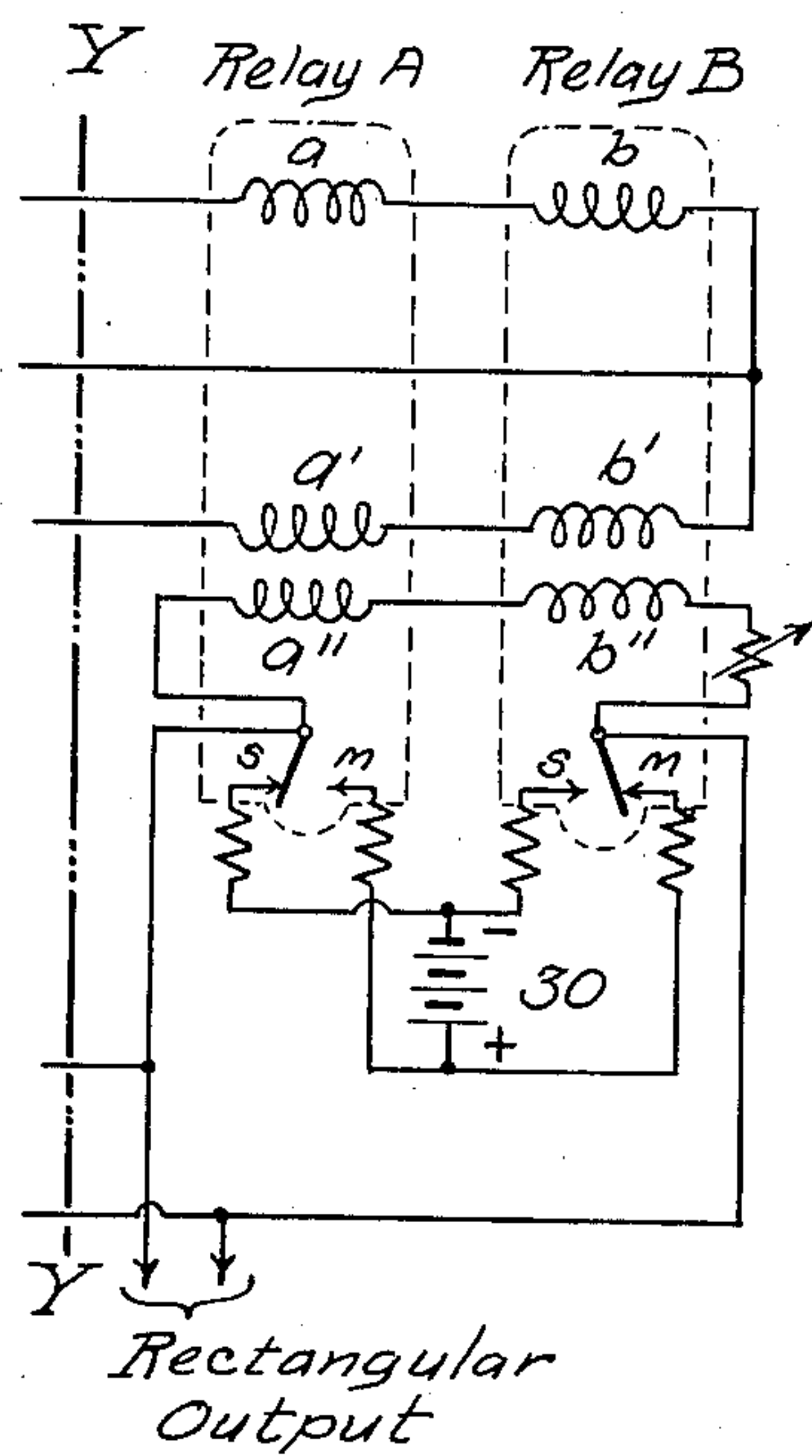
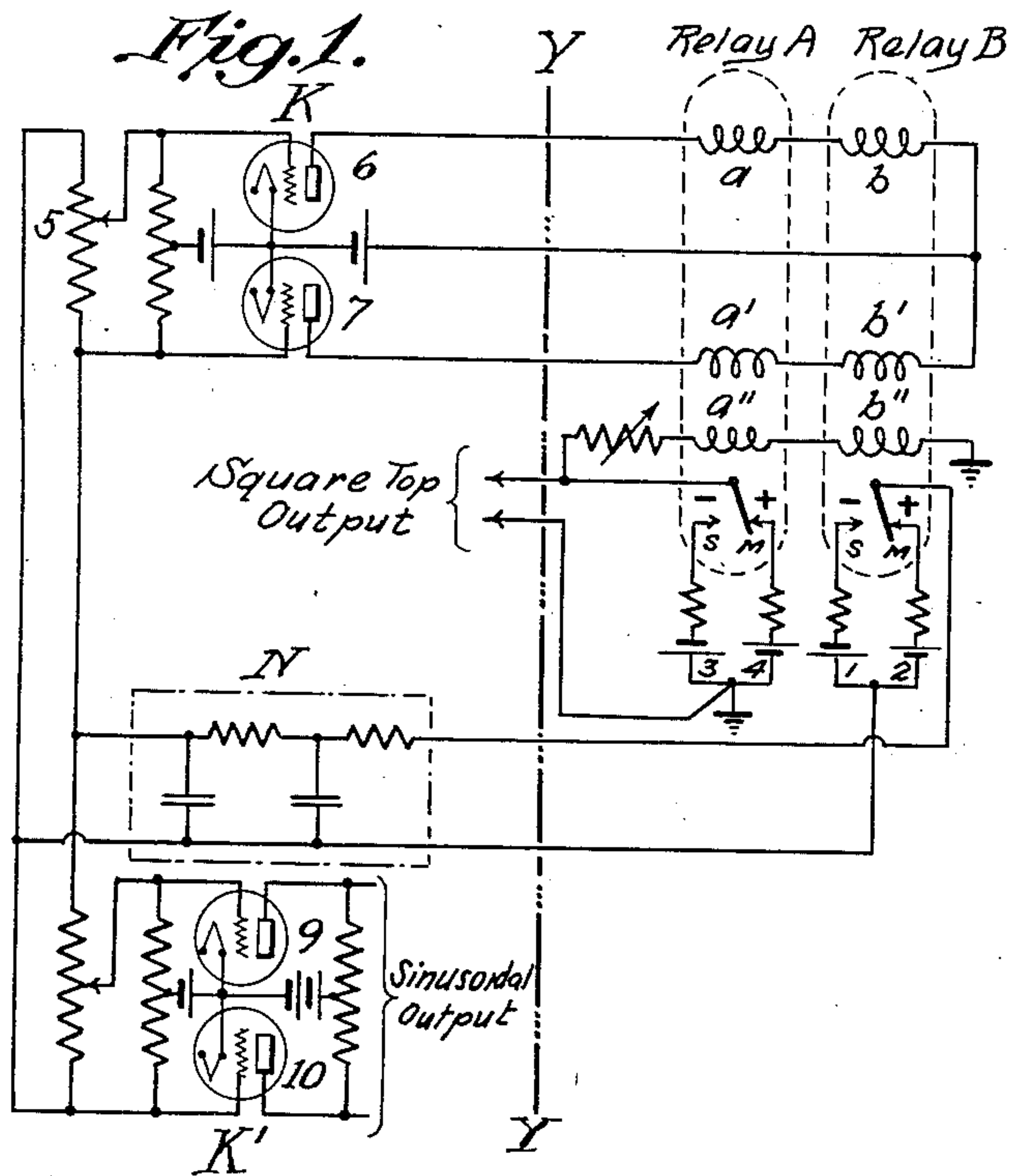
A. E. MICHON

2,203,417

LOW FREQUENCY GENERATOR

Filed May 6, 1938

2 Sheets-Sheet 1



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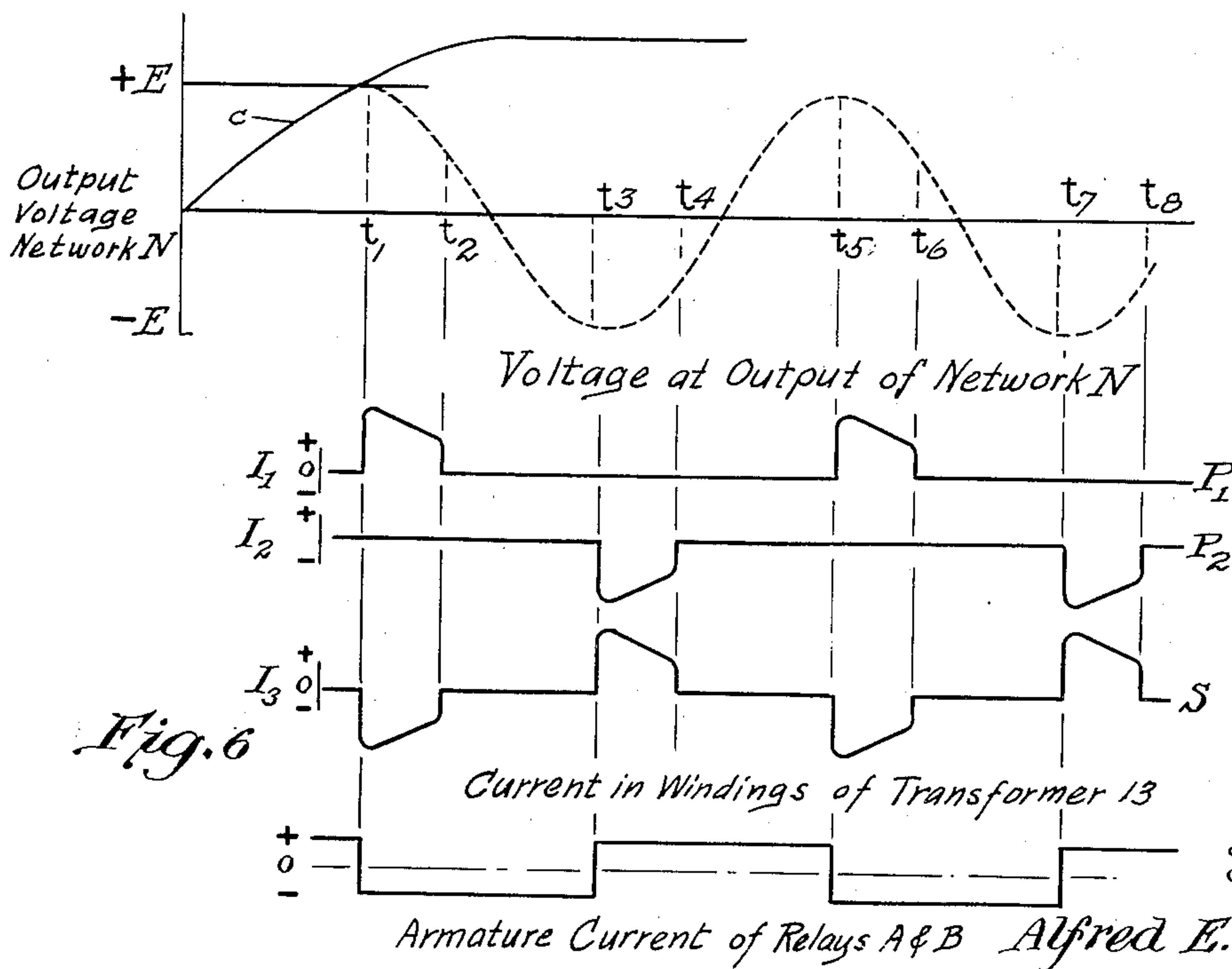
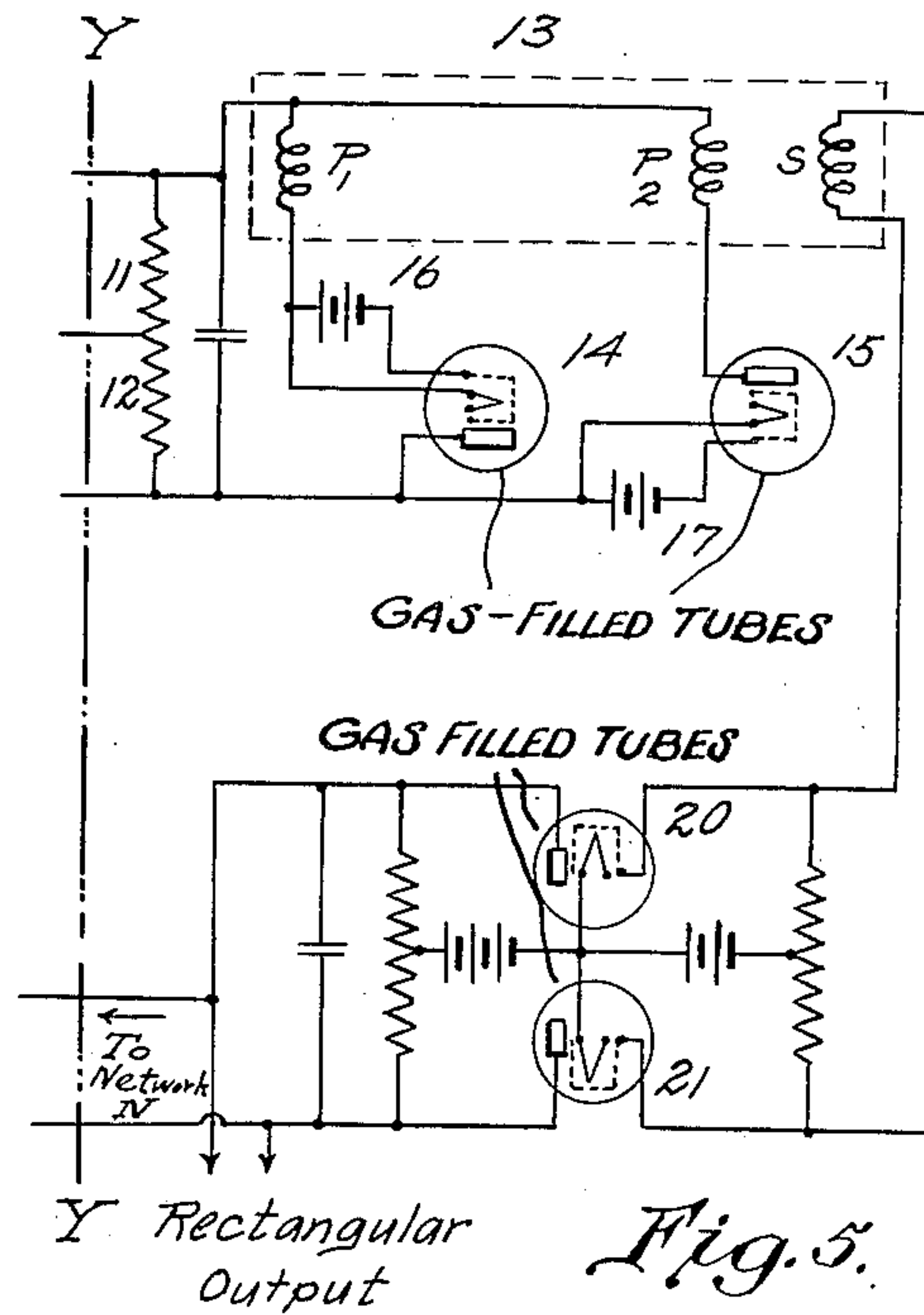
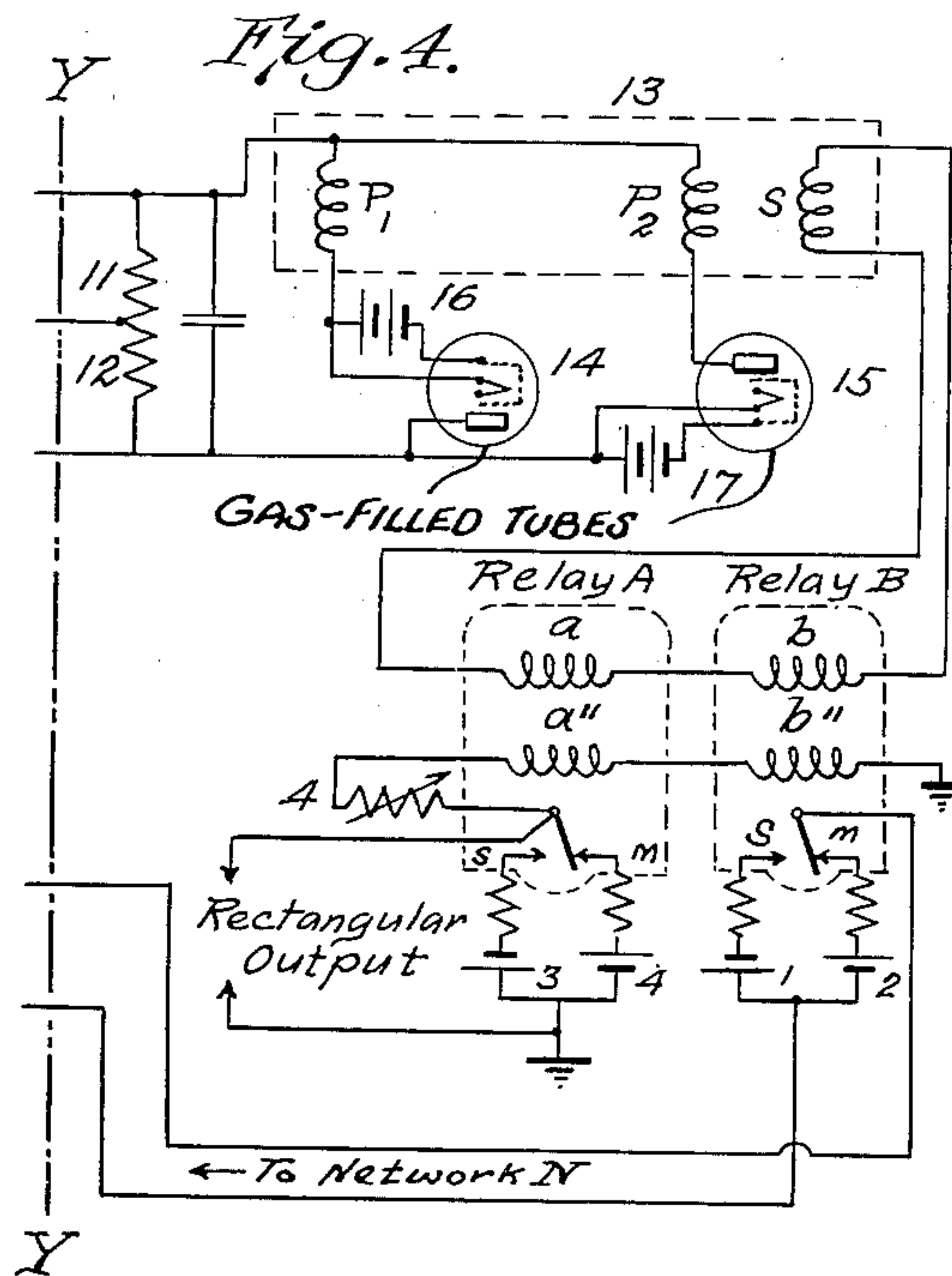
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,203,417

LOW FREQUENCY GENERATOR

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Application May 6, 1938, Serial No. 206,467

6 Claims. (Cl. 250—36)

This invention relates to generators of electric oscillations which may be employed to produce oscillations of a very low frequency.

Heretofore it has been difficult to provide generators to produce frequencies in the range from a fraction of a cycle up to say 40 cycles per second, because tuning networks at such frequencies are necessarily expensive, bulky, and subject to such high losses that reasonably sharp tuning could not be obtained. Generators of this type, however, are frequently required in laboratory investigations and, particularly, in conducting measurements and studies of submarine cables. The object of my invention is to provide a low frequency generator of a relatively simple and inexpensive type which will produce a satisfactorily pure output wave at frequencies ranging down to less than 1 cycle per second.

The generator disclosed herein is essentially a vibrating relay system or like system in which the cyclic output current is reapplied to the operating coils or elements through a wave purifying network and an amplifier. An important feature of the generator is the ability of a relay to provide a rapid reversal of output current as the slowly rising operating current passes through a selected fixed value.

The low frequency generator in its preferred form is shown in Fig. 1, while Fig. 1a shows a modification of the output system for the purpose of producing a high power output. Fig. 3 is similar to Fig. 1 but employs a single battery circuit for the coils and contacts of the relays. In Fig. 4 biased gaseous arc discharge tubes are used to more exactly define the starting of the relays; Fig. 5 illustrates an extension of Fig. 4 but employs a second pair of gaseous arc discharge tubes instead of the relays. Figs. 2 and 6 illustrate the wave shapes of the operating currents of the systems of Figs. 1 and 4, respectively.

The oscillator disclosed herein comprises in its elements a source of potential, a reversing arrangement operating at a selected fixed value of current or voltage, and a network which will transmit current having a transient value that increases gradually with time. One arrangement of apparatus embodying these essentials is shown in Fig. 1. The source of potential is the battery 1, 2, which is arranged to be reversed by the relay B. The current in the auxiliary winding b'' of this relay determines the fixed value of operating current which must flow through the operating windings b , b' , in order to operate the relay.

The armature of relay B is connected to a network N, which in this case consists of a number of sections comprising series resistance and shunt capacity. This network is capable of transmitting a current which in response to the application of the batteries 1 or 2, rises gradually from zero to a positive or negative constant value as indicated by the curve of Fig. 2. The output voltage from the network N energizes the grids of the two vacuum tubes 6 and 7 of the amplifier K, in conventional push-pull fashion to produce an unbalance in their respective plate currents to operate the relay B, thus reversing the contacts of this relay. Simultaneously, the tongue of relay A moves to its opposite contact to produce a reversal of current in the holding windings a'' , b'' of the relays A and B, respectively.

The progress of a current transient through the circuit including the relays, network, and amplifier tubes to produce continuous oscillations will now be described. Assume at time $t=0$, a closure of the M contact of the relay B. A transient voltage wave will appear at the output of the network N which will have the shape of the solid line curve of Fig. 2, and through the agency of the vacuum tubes 6 and 7, a net operating current will be produced in the windings of the relays A and B having also the same general shape. At time t_1 this net operating current will exceed the holding current and the armatures of the relays will move to their S contacts, thus reversing the potential applied to the network N and also reversing the direction of the holding current. The output voltage from the network will reverse as shown by the dotted line portion of the curve in Fig. 2 and through the same process will produce a reversal in the net operating current of the relays A and B to produce a second operation at time t_2 . After a few cycles of this process the transient effects subside and the system vibrates at a constant frequency which is inversely proportional to the values of the resistance and capacity of the network N, and to the amplitude of the holding current and directly proportional to the voltage of batteries 1, 2 and the amount of amplification of tubes 6, 7. The addition of more sections to the network N, will permit a slight improvement in wave form.

An auxiliary amplifier K' comprising tubes 9, 10 is shown for the purpose of furnishing a sinusoidal output current of appreciable power to a work circuit. The work circuit may be connected directly to the output of this amplifier or

alternatively the amplifier may be connected to a generator field while the output is taken from the generator armature as shown in Fig. 1a. Where an output current of rectangular wave form is desired, this may conveniently be obtained from the contacts of relay A as indicated. A variation of this circuit which requires but one pole of battery is shown in Fig. 3. Here the operating and holding windings are so connected as to reverse the two poles of the battery 30 with each operation of the contacts. The remaining functions of the circuit are as in Fig. 1.

An alternative arrangement for a low frequency oscillator embodying the essential features of Fig. 1 is shown in Fig. 4. The same elements are employed as are shown at the left of the line Y—Y in Fig. 1. The arrangement at the right of line Y—Y differs in that the two gaseous arc discharge tubes 14 and 15, along with the transformer 13, are inserted between the amplifier K and the relays for the purpose of insuring greater constancy in the operating characteristics of the relays A and B. Biasing batteries 16 and 17 are included in series with the grids of the tubes 14 and 15, respectively, for the purpose of determining the operating point of these tubes. When the plate-cathode potential of these tubes exceeds a selected positive value, as determined by the biasing batteries 16 and 17, the tubes become conducting and allow a current to flow in the windings P₁ or P₂ of the transformer 13 to thereby produce a relay operating current in the secondary circuit of this transformer. Since the tubes 14 and 15 are oppositely connected, these actions occur in cyclic order.

The functioning of the tubes and relays in this circuit may be followed by referring to Fig. 6. Assume a closure of the contact M of relay B at time $t=0$. A transient voltage will then appear at the output of the network N, as indicated by the solid portion c of the curve Fig. 6, and a like voltage will be applied across the resistances 11 and 12. At time t_1 this voltage is positive with respect to the plate of tube 14 and exceeds its breakdown potential. The tube allows a current I₁ to flow through primary winding P₁ of transformer 13 to induce a current I₃ in the secondary winding S and relay windings a, b. The amplitude is instantaneously sufficient to operate relays A and B against the restraining force of the holding current in windings a'', b'' so that the armatures of these relays move from their M contacts to their S contacts, thereby reversing the holding current in windings a'', b'' and the potential applied to the network N, to produce a reversal of the potential across the plate resistances 11, 12. At time t_2 , the positive voltage responsible for the breakdown of tube 14 has declined to a value insufficient to support ionization and the current I₁ and likewise I₃ return to zero, but by this time the current in windings a'', b'' has been established as shown so that the relay armatures are held on their S contacts. At time t_3 the voltage built up across plate resistors 11, 12 is negative with respect to the plate of tube 14. It is positive with respect to the plate of tube 15 and of sufficient amplitude to start a current I₂ flowing through this tube and transformer primary winding P₂. The induced current I₃ in secondary winding S and relay windings a, b is sufficient to move the relay armatures from their S contacts to their M contacts. After several cycles of this process, the transient effects subside and the oscillator vibrates at a constant frequency.

It should be noted that two relays are not necessary to the operation of the circuits shown in Figs. 1 and 4. Relay A serves to provide a rectangular output, and the holding current for winding a'', b'', but these functions could be performed by relay B if the batteries 1, 2 were of sufficient capacity.

The efficiency of the relay system as regards constancy of frequency is primarily dependent upon the degree of constancy or uniformity which can be obtained in the starting of the relay. In the system of Figs. 1 and 3 this is dependent upon the value of the slope of a sine wave. In the system of Fig. 4, however, the relay is operated by the current I₃ of Fig. 6. This sharply rising current serves to produce a more constant and positive operation of the relay, thus improving the frequency stability of the system.

Resistance-capacity networks have been shown for the purpose of producing an output wave whose slope determines the operating period of the reversing relays. It is possible to use instead of the resistance-capacity networks, other networks comprising series inductance and shunt capacity or resistance. These may or may not be of a distortionless type. In this case the output of the network would be in the form of a repeated transient having a sharp rise, in counter-distinction to the sine wave output of the resistance-capacity network. The frequency of the system would then be determined very largely by the delay imposed by the inductive network rather than by the passage of a sloping wave through a given value, such as occurs in Figs. 2 and 6.

The relays have been provided with a holding current through the windings a'' and b''. The purpose of this current is primarily to provide a complete electrical control of the relays and, while a holding current is preferred, an opposing current may also be employed with but slight change in the functioning of the system. In fact the windings a'' and b'' may be omitted altogether, but in this case the relays will be somewhat unstable during the period when the operating currents are passing through low values.

Agencies other than relays may be used for accomplishing the reversal of polarity. For instance, as shown in Fig. 5, the secondary of the transformer 13 is connected to a pair of gaseous arc discharge tubes arranged to perform the reversing function. Here the two gaseous arc discharge tubes 20 and 21 replace the relays A and B of the other figures. The functioning of these tubes to reverse the polarity of their output current is as described in Patent 1,881,458 to A. E. Frost. Since the frequency is limited only by the speed at which the reversing device can operate, a relatively high frequency may be obtained if desired. Thus if the relays A and B shown in the arrangement of Figs. 1, 3 and 4, are replaced by gaseous arc discharge tubes, as in Fig. 5, the maximum frequency approaches the frequency determined by the deionization time of the tubes. Accordingly it is to be understood that the scope of my invention is defined by the appended claims.

I claim:

1. An oscillation generator, comprising a thermionic amplifier having input and output circuits, a polar relay having an operating winding connected to the output circuit, a holding winding, and an armature adapted to rest upon either of two contacts connected to opposite potentials, means whereby when the armature rests

upon either of the contacts a steady current flows through the holding winding, a wave shaping network and means for feeding back energy alternately from said opposite potentials to said input circuit through said network.

2. An oscillation generator comprising an amplifier having a pair of thermionic tubes in push-pull arrangement, a polar relay having operating windings operatively connected to the output circuit of said tubes, a holding winding and an armature adapted to rest upon either of two contacts connected to opposite potentials, means whereby when the armature rests upon either of the contacts a steady current flows through the holding winding, a transformer interposed in the circuit between said tubes and said relay having its secondary coil connected to said operating windings and two primary coils connected to said output circuit, means for alternately energizing said primary coils in synchronism with the operation of said tubes, a retarding network and means for feeding energy alternately from said opposite potentials to the input of said tubes through said retarding network.

3. An oscillation generator comprising an amplifier having a pair of thermionic tubes in push-pull arrangement, a transformer connected to the output of said amplifier having a pair of parallel connected primary windings, gaseous arc discharge tubes reversely arranged and connected in series with each winding, a second pair of gaseous arc discharge tubes in balanced arrangement and having their input circuits connected to the secondary winding of said transformer, a wave shaping current retarding network and means for feeding back energy from the output of said last named tubes through said network to the input of said amplifier.

4. An oscillation generator, comprising a thermionic amplifier having an input circuit and an output circuit, a polar relay having an operating winding connected to the output circuit, a biasing winding and an armature adapted to rest upon either of two contacts connected to opposite potentials, means whereby when the armature rests upon either of the contacts a steady current flows through the biasing winding, a retarding network and means for feeding energy alternately from said opposite potentials to the input of said tubes through said retarding network.

5. An oscillation generator, comprising a thermionic amplifier having input and output circuits, a polar relay having an operating winding connected to the output circuit, a biasing winding and an armature adapted to rest upon either of two contacts connected to opposite potentials, means whereby when the armature rests upon either of the contacts a steady current flows through the biasing winding, a delay network and means for feeding back energy alternately from said opposite potentials to said input circuit through said network.

6. An oscillation generator comprising an amplifier having a pair of thermionic tubes in push-pull arrangement, a polar relay having an armature adapted to rest upon either of two contacts connected to opposite potentials, a delay network, means for feeding back energy from said opposite potentials through said network to the input circuits of said tubes, and means interposed between the output circuits of said tubes and the operating windings of said relay, to alternately supply sharply rising current to said operating windings.

ALFRED E. MICHON.