

Feb. 10, 1931.

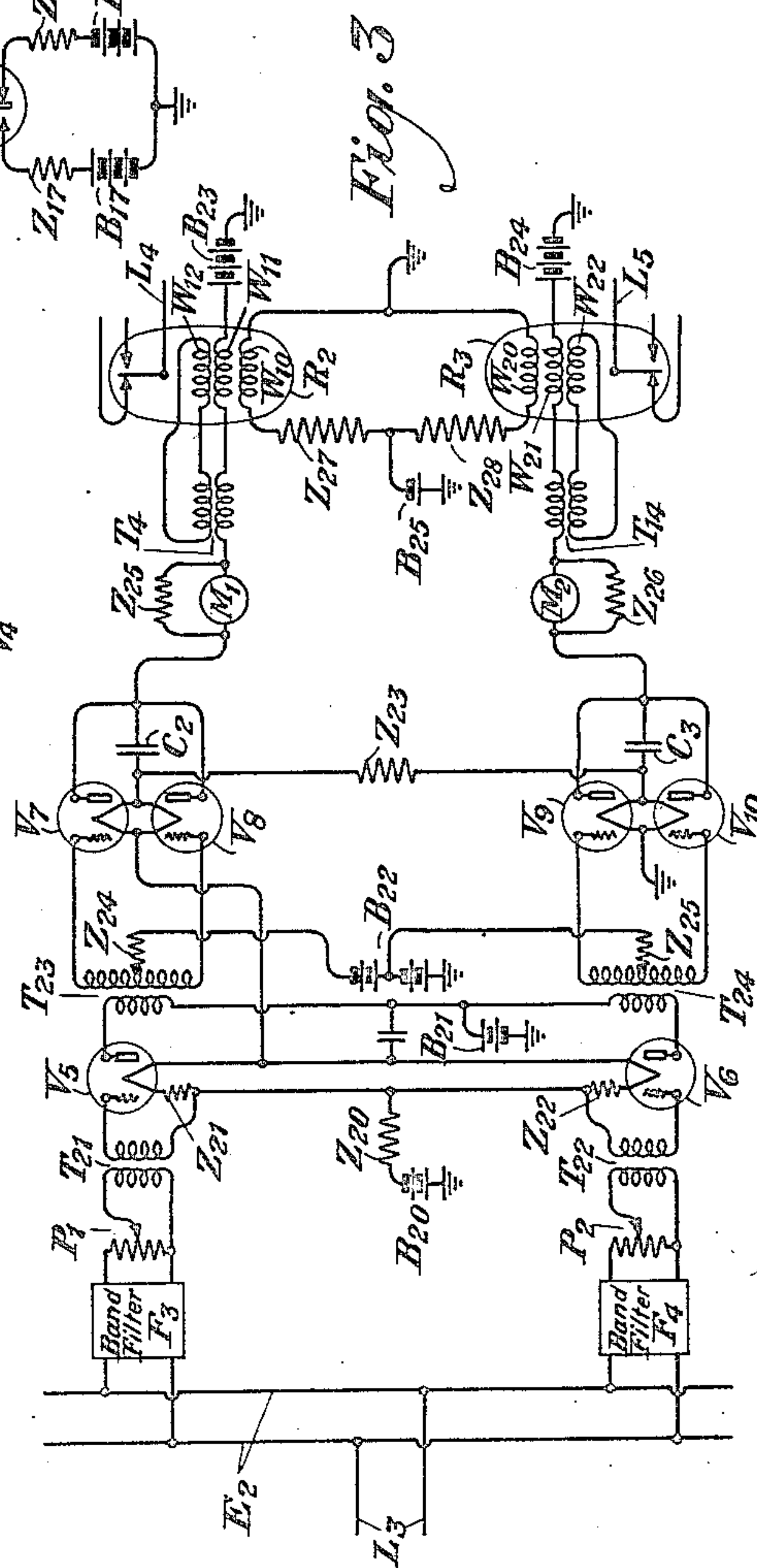
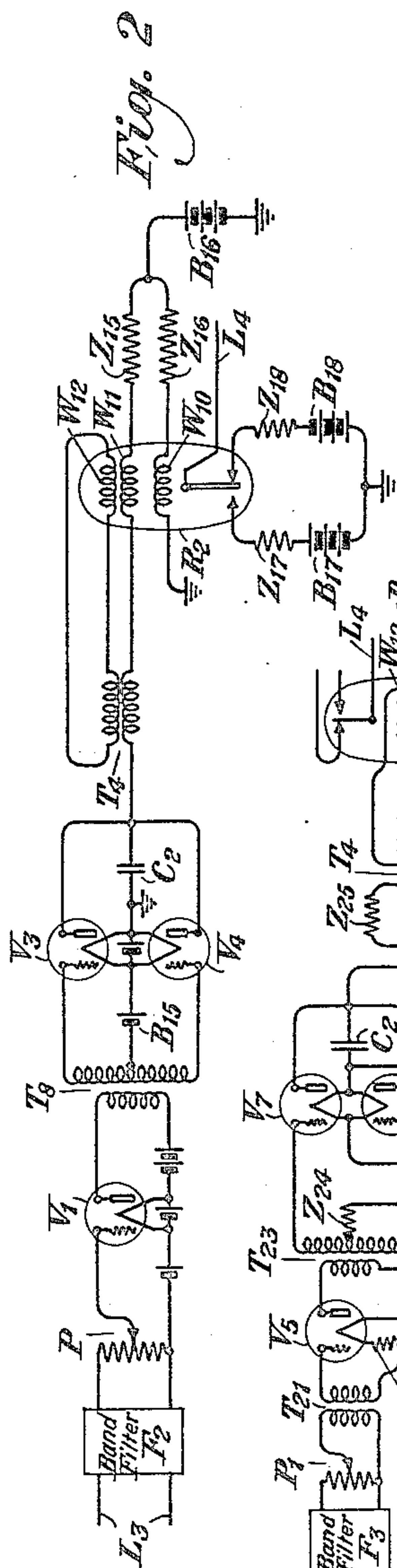
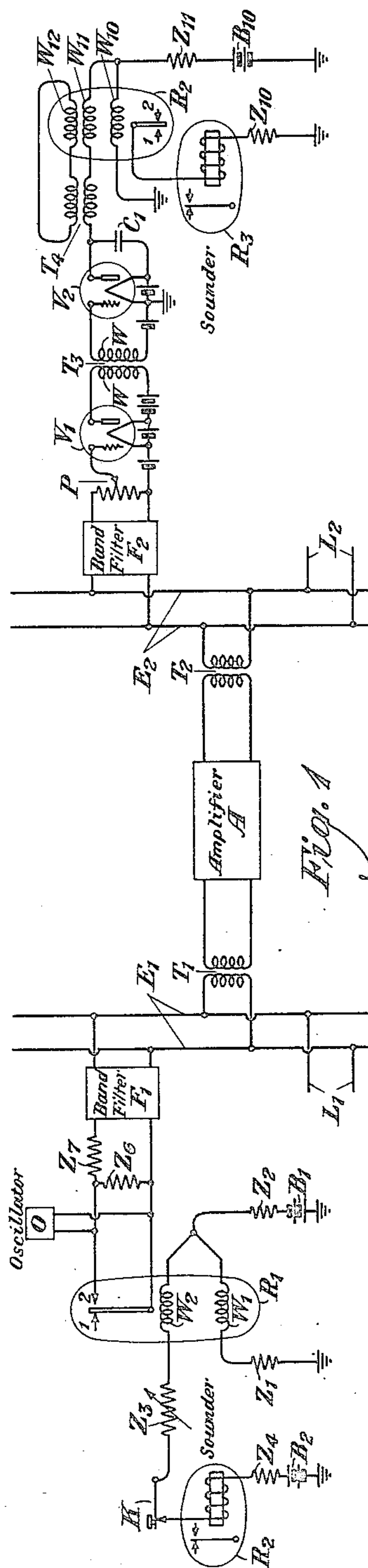
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1,791,579

TELEGRAPH SIGNALING SYSTEM

Filed March 20, 1929

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

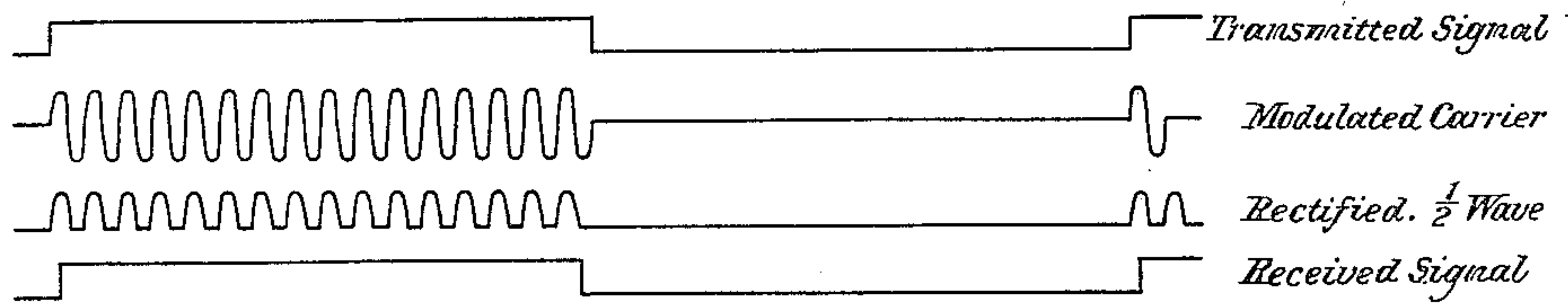


Fig. 4a

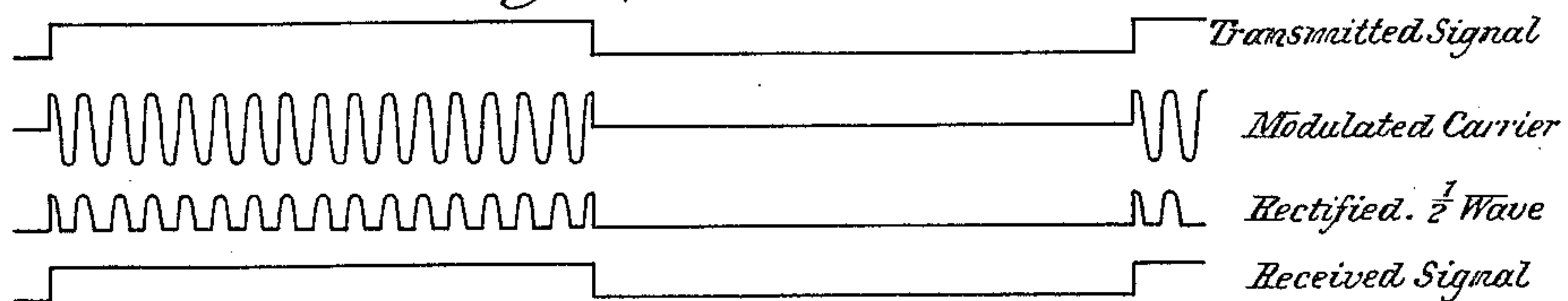


Fig. 4b

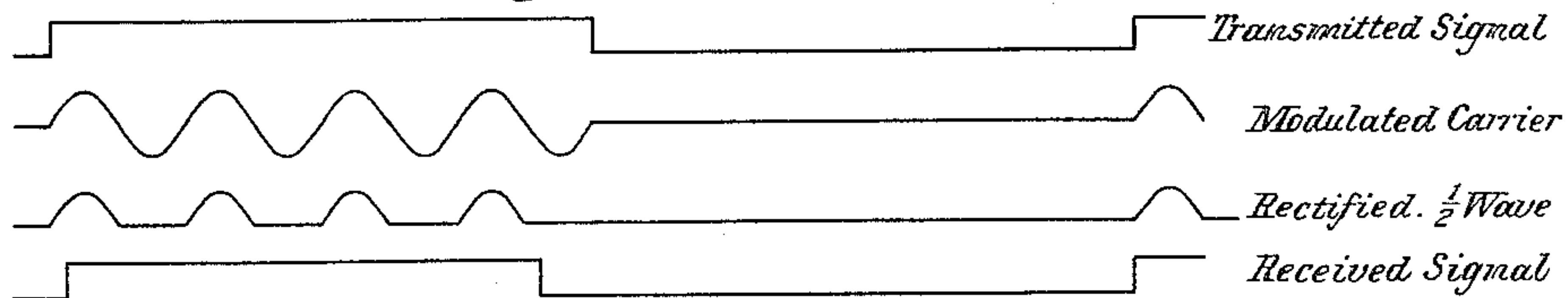


Fig. 4c

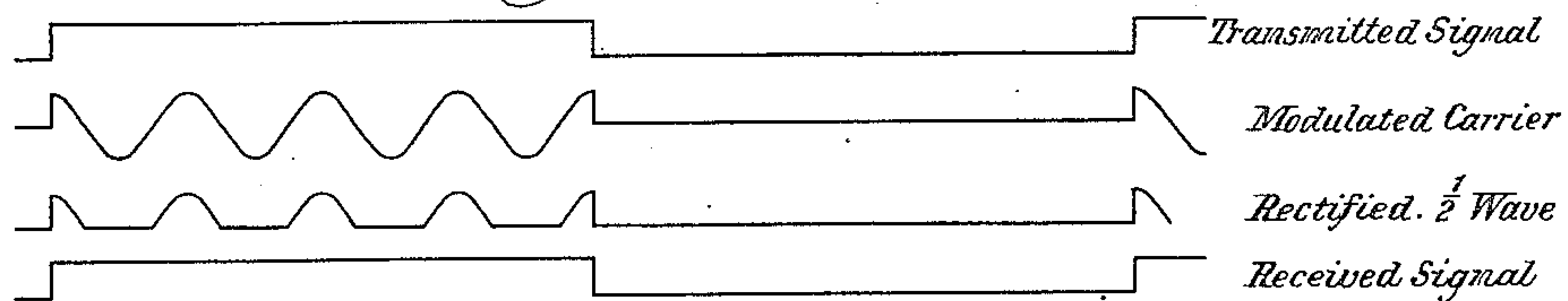


Fig. 4d

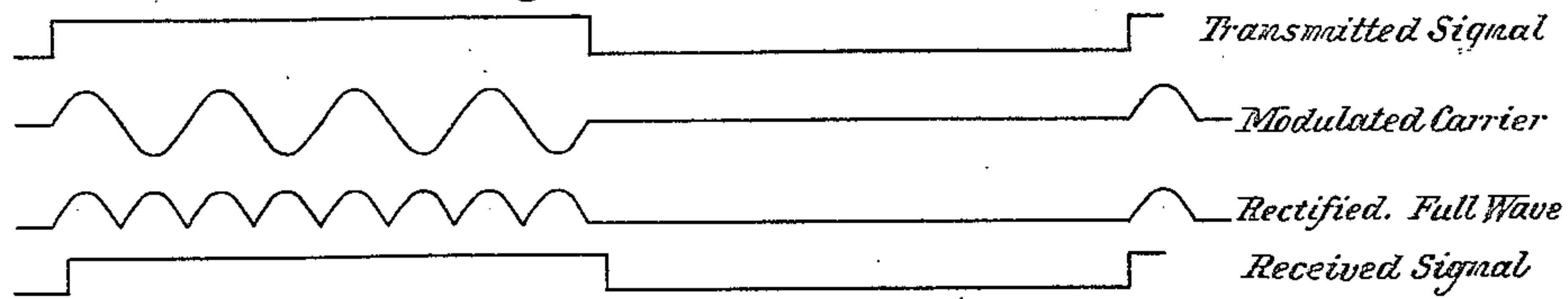


Fig. 4e

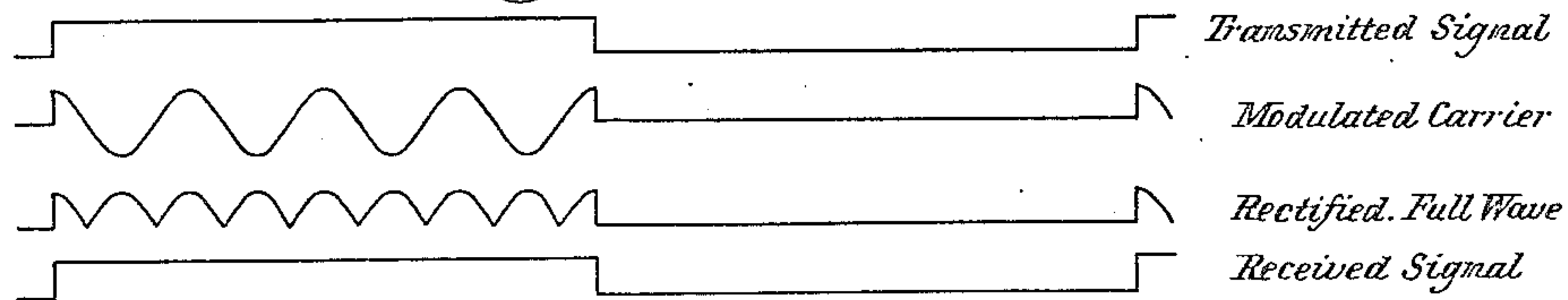


Fig. 4f

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TELEGRAPH SIGNALING SYSTEM

Application filed March 20, 1929. Serial No. 348,500.

This invention relates to signaling systems generally, and particularly to signaling systems employing carrier waves of very low frequencies. More particularly, this invention relates to receiving systems suitable for receiving pulses of alternating current representing signals characteristic of carrier telegraphy, the alternating pulses being derived from waves of low frequency.

10 In this application, a carrier telegraph system is disclosed, in which the carrier wave or waves employed are of a frequency only several times the dot frequency of the transmitted signals. Pulses of low frequency current are produced in accordance with the signals. These pulses are transmitted over a wire circuit and subsequently converted into direct current pulses, each pulse of direct current corresponding to each received alternating current pulse.

One of the objects of this invention is to provide a telegraph system for signaling with carrier waves of very low frequency with small or negligible distortion.

25 Another of the objects of this invention is to provide an arrangement for producing alternating current pulses from direct current pulses representing signals, and for converting these alternating current pulses into the corresponding direct current pulses, with small or negligible distortion, in which the lengths of the direct current pulses derived from the alternating current pulses correspond closely to the lengths of the direct current pulses employed at the sending end in producing the alternating current pulses.

Another of the objects of this invention is to provide an arrangement for interconnecting a line circuit over which alternating current of some definite frequency or frequencies between the limits of a predetermined band may flow and a direct current relay so that the direct current relay may be continuously operated throughout the period during which current of the proper frequency or frequencies is present in the line circuit.

And it is a further object of this invention to interconnect a line circuit over which alternating current may flow and a direct current relay through a pair of three-element vacuum

tube rectifying devices which, respectively, rectify the opposite halves of each alternating current cycle and provide the current necessary to operate the direct current relay.

While this invention will be pointed out with particularity in the appended claims, the invention itself, both as to its further objects and features, will be better understood from the detailed description hereinafter following, when read in connection with the accompanying drawing in which Figure 1 represents a telegraph system employing a three-electrode vacuum tube rectifying element for half-wave rectification; Fig. 2 represents a modification of the receiving system shown in Fig. 1, providing two three-electrode vacuum tube rectifying elements for full-wave rectification; Fig. 3 represents a receiving system suitable to replace the receiving system shown in Fig. 1, this receiving system including means for receiving two alternating current pulses or bands of signals, and Figs. 4a, 4b, 4c, 4d, 4e and 4f representing curves disclosing certain of the features of the invention.

Referring to Fig. 1 of the drawing, the transmitting end of a telegraph system is shown at the left, and the receiving end at the right, both connected by a wire circuit. At the transmitting end, there is a transmitting relay R_1 having two windings W_1 and W_2 and an armature which may vibrate between contacts designated 1 and 2. Winding W_1 is connected in series with a resistance Z_1 and another resistance Z_2 , a battery B_1 and ground. The right-hand terminal of the winding W_2 is also connected in series with resistance Z_2 , battery B_1 and ground, the left-hand terminal of this winding being connected in series with a variable resistance Z_3 , a key K , the winding of a sounder R_2 , resistance Z_4 , battery B_2 and ground.

An oscillator O provides current of the carrier frequency to be employed throughout the system. This oscillator may be of any well-known type, preferably one capable of producing alternating current of comparatively low frequency. This oscillator transmits signaling current to bus-bars E_1 through a pair of resistances, one designated Z_5 con-

connected in shunt with the oscillator, and the other designated Z_7 in series with the oscillator and through a band filter F_1 .

When key K is opened, current will flow from battery B_1 through winding W_1 , causing the armature of relay R_1 to close contact 2 and oscillator O will be rendered practically ineffective. When key K is closed, current will flow from batteries B_1 and B_2 through the winding of the sounder R_2 and through the winding W_2 of the transmitting relay R_1 . The current through winding W_2 may be controlled in its magnitude by adjustment of the resistance Z_3 , and, ordinarily, the current through winding W_2 may be approximately twice as great as that through winding W_1 . Consequently, the armature of relay R_1 will close contact 1, and current will then flow from oscillator O over resistance Z_7 and through the band filter F_1 to the bus-bars E_1 . Thus, by operating key K , current derived from oscillator O will be modulated and transmitted to bus-bars E_1 in accordance with signals.

Current impressed upon bus-bars E_1 will ordinarily be more than just a simple alternating current wave. The current derived from oscillator O may include all frequencies within the spectrum, and the band filter F_1 is provided for the purpose of limiting the width of the band impressed upon bus-bars E_1 . Thus, if oscillator O produces current of a frequency of, for example, 255 cycles, the band filter F_1 may transmit only those frequencies lying between the limits of, for example, 170 cycles and 340 cycles.

It is to be clearly understood that a transmitting set similar to the one just described may also be connected to the line L_1 in order to impress upon bus-bars E_1 another band of frequencies representing another set of signals. It is to be understood that still other transmitting sets similar to the one described may be added, as required, within the scope of this invention. For the sake of clarity, however, the description of the arrangement shown in Fig. 1 will be limited to the transmission of that band of frequencies derived from oscillator O and filter F_1 .

Current flowing over bus-bars E_1 is transmitted through a transformer T_1 , an amplifier A , another transformer T_2 to bus-bars E_2 . The amplifier A may be of any well-known type, preferably one employing vacuum tubes.

Pulses received by bus-bars E_2 represent marking and spacing signals characteristic of telegraphy. As already stated hereinabove, these pulses are composed of a plurality of frequencies constituting a band, and it will be clearly understood that these frequencies may be on either side of the carrier produced by the oscillator O . The band filter F_2 may be of the same general type as filter F_1 , freely transmitting the component fre-

quencies lying between the same predetermined limits as those of filter F_1 and substantially suppressing all other frequencies.

The output of the filter F_2 is impressed, through a potentiometer P , upon a vacuum tube system including a three-element vacuum tube V_1 . The potentiometer is employed for the purpose of controlling the magnitude of the voltage of the current to be impressed upon the input circuit of vacuum tube V_1 . The output circuit of vacuum tube V_1 is coupled by means of a transformer T_3 to the input circuit of another vacuum tube system including a three-element vacuum tube V_2 employed as a rectifying element. While the vacuum tube V_1 is employed herein merely for the purpose of amplifying the band of frequencies transmitted by filter F_2 through potentiometer P , it will be understood that any other amplifying device or means may equally well be employed instead thereof, within the scope of this invention. Moreover, if the current transmitted by filter F_2 through potentiometer P has considerable energy, the vacuum tube amplifying system may perhaps be omitted, in which event the potentiometer P may be terminated by the primary winding of transformer T_3 .

The grid electrode of vacuum tube V_2 is maintained suitably negative with respect to its filament electrode. The plate electrode is connected to the filament electrode through a condenser C_1 of large capacity in order that alternating current components in the output circuit of the vacuum tube may be freely shunted thereby and so that the variations in the amplitude of the current flowing through winding W_{11} of relay R_2 may be reduced to a minimum. The direct current relay R_2 has three coupled windings W_{10} , W_{11} and W_{12} . This relay also includes an armature which may vibrate between contacts designated 1 and 2. The axis of rotation of the armature of this relay is connected in series with a winding of a sounder R_3 , a resistance Z_{10} and ground. Winding W_{10} of relay R_2 is connected in series relationship with resistance Z_{11} , battery B_{10} and ground. The plate electrode of vacuum tube V_2 is connected to ground through the primary winding of a transformer T_4 , winding W_{11} of relay R_2 , resistance Z_{11} and battery B_{10} . Winding W_{12} of relay R_2 is connected in a local circuit with the secondary winding of the transformer T_4 .

Winding W_{10} is permanently connected in a local circuit with resistance Z_{11} and battery B_{10} and is employed to normally bias the armature of relay R_2 against contact 2. It will be understood that a similar biasing effect may be obtained by connecting the armature to a spring, not shown, or by placing the armature nearer one pole than the other, not shown, or by any other means.

When a pulse of alternating current, such

as may be produced by oscillator O, is impressed upon the input circuit of vacuum tube V_2 , the positive half of each of the various cycles in the pulse will be effective in substantially diminishing the negativity of the grid electrode with respect to the filament electrode, so that substantial current may flow from battery B_{10} through resistance Z_{11} , winding W_{11} , the primary winding of transformer T_1 and the plate and filament electrodes of vacuum tube V_2 and ground. During the negative half of each of the various cycles, however, the negativity of the grid electrode will be substantially increased so that the impedance to the flow of current from battery B_{10} through the circuit just described will be greatly increased, and practically no current will then flow through the plate circuit of vacuum tube V_2 . There will be a current flow through winding W_{11} , however, because a charging current will flow from battery B_{10} into condenser C_1 . Accordingly, the armature of relay R_2 will move toward contact 1 a short time after the beginning of the pulse and will remain on contact 1 until a short time after the end of the pulse, when it will return to contact 2, under the influence of current through winding W_{10} .

Reference character T_4 designates a so-called "kick" transformer. Since the secondary winding of this transformer is serially connected with winding W_{12} of relay R_2 , this transformer tends to further couple windings W_{11} and W_{12} . Accordingly, when current increasing at a rapid rate, as at the beginning of a pulse, flows through winding W_{11} , and the primary winding of transformer T_4 , the transformer will act to build up a substantial electromagnetic effect about winding W_{12} , to cause the armature of relay R_2 to move to contact 1 more quickly. On the other hand, at the termination of an alternating current or pulse, this transformer will tend to set up a current in its secondary which will cause winding W_{12} to assist winding W_{11} in retracting the armature of relay R_2 . In effect, then, this transformer causes the direct current relay R_2 to become more accurately responsive to the current transmitted to the input circuit of vacuum tube V_2 .

It is apparent that the rectifying system shown in Fig. 1 rectifies only one-half of each alternating current wave. During the positive half of each cycle, current will be rectified, and during the negative half of each cycle, there will be no rectification. With currents of exceedingly low frequencies, this will cause distortion, as will be apparent from the description hereinafter following. To overcome this distortion, it is necessary to provide a receiving system which is suitable for rectifying both halves of each cycle. A full-wave rectifying system is shown in

Fig. 2, and this system may be employed to replace the one shown in Fig. 1 which is connected to the bus-bars E_2 .

In Fig. 2, the reference character L_3 designates the pair of conductors connected to the bus-bars E_2 . The band filter F_2 , potentiometer P and vacuum tube V_1 may be similar in all respects to those elements shown in Fig. 1 and designated by the same reference characters.

The output circuit of vacuum tube V_1 is coupled, through transformer T_3 , to the input circuits of two three-element vacuum tubes V_3 and V_4 employed to act as rectifying devices. The grid electrodes of these devices are maintained at suitable negative potentials with respect to the corresponding filament electrodes by means of a common battery B_{15} , this battery being connected to the grid electrodes through the upper and lower halves of the secondary winding of transformer T_3 . The plate electrodes of these devices are tied together, and, as such, are connected to the corresponding filament electrodes through a stabilizing condenser C_2 which is of comparatively large capacity. Battery B_{16} is grounded at its negative terminal and its positive terminal is connected to the plate electrodes of devices V_3 and V_4 through a resistance Z_{15} , winding W_{11} of relay R_2 and the primary winding of transformer T_4 . Winding W_{10} of relay R_2 is connected in series with another resistance Z_{16} , battery B_{16} and ground.

A line which is suitable for transmitting direct current pulses characteristic of telegraphy is designated L_4 , and this line is directly connected to the axis of rotation of the armature of relay R_2 . The contacts 1 and 2, between which the armature of relay R_2 may vibrate, are serially connected with resistances Z_{17} and Z_{18} and batteries B_{17} and B_{18} , respectively, the point common to these batteries being grounded. When the armature of relay R_2 closes contact 1, current flows from battery B_{17} , through resistance Z_{17} and over line L_4 . Later, when this armature closes contact 2, current flows from battery B_{18} through resistance Z_{18} and also over line L_4 .

When no current flows over line L_3 , or when current flows over line L_3 having a frequency beyond the predetermined limits of filter F_2 , the vacuum tube V_1 will not be effective and the grid electrodes of vacuum tubes V_3 and V_4 will be so negative as to greatly impede the electronic emissions between the corresponding plate and filament electrodes. Accordingly, no current, or a practically negligible current, will be derived from battery B_{16} . The armature of relay R_2 will be held against contact 2 by the current flowing from battery B_{16} through resistance Z_{16} and winding W_{10} , and current will flow from battery B_{18} over line L_4 . Moreover, condenser C_2

will become charged to the voltage of battery B_{16} .

When a pulse of alternating current of the proper frequency is impressed upon line L_3 , or, in general, when current of any frequency or frequencies between the predetermined limits of filter F_2 are transmitted over the line L_3 , that current will be impressed upon the input circuit of vacuum tube V_1 through potentiometer P and the potentiometer may be manipulated to adjust the voltage of the impressed current. Vacuum tube V_1 will amplify the transmitted current and impress that current through transformer T_3 upon the input circuits of the three-element rectifying devices V_3 and V_4 . During the positive half of each alternating current cycle, the grid electrode of one of the vacuum tubes, for example, V_3 , will be rendered less negative with respect to its filament electrode, while the grid electrode of the other of the vacuum tubes V_4 will be rendered more negative with respect to its filament electrode. Accordingly, direct current will flow from battery B_{16} over the circuit which includes resistance Z_{15} , winding W_{11} of relay R_2 , primary winding of transformer T_4 , the plate and filament electrodes of vacuum tube V_3 and ground. Since the grid electrode of the vacuum tube V_4 is rendered more negative with respect to its filament electrode, practically no current will flow in the circuit which includes the plate and filament electrodes of that tube.

During the negative half of each alternating current cycle, the voltages impressed upon the input circuits of vacuum tubes V_3 and V_4 will be in the opposite direction, and therefore the grid electrode of vacuum tube V_3 will be rendered more negative with respect to its filament electrode than is normally the case, and the grid electrode of vacuum tube V_4 will be rendered less negative with respect to its filament electrode. Consequently, direct current will flow from battery B_{16} through the circuit which includes resistance Z_{15} , winding W_{11} of relay R_2 , the primary winding of transformer T_4 , the plate and filament electrodes of vacuum tube V_4 and ground. Since the grid electrode of vacuum tube V_3 is rendered highly negative with respect to its filament electrode, practically no current will flow in the circuit which includes the plate and filament electrodes of the latter tube.

It is to be particularly noted that during the impression of current of proper frequency upon the grid electrodes of the rectifying devices V_3 and V_4 , pulsating current flows through the winding W_{11} of relay R_2 , and that this current is uni-directional. Thus, during the positive half cycle of each alternating current, current flows through the plate filament circuit of vacuum tube V_3 and during the negative half of each cycle

through the plate filament circuit of vacuum tube V_4 . Shortly after the beginning of an alternating current pulse, the current through winding W_{11} is substantially greater than the continuous current through winding W_{10} and therefore the armature of relay R_2 is moved away from contact 2 and toward contact 1. After contact 1 is closed, current will flow from battery B_{17} through resistance Z_{17} and over line L_4 . Likewise, shortly after the end of an alternating current pulse, the current through winding W_{11} will be reduced to zero and therefore the armature of relay R_2 is moved away from contact 2 toward contact 1 under the influence of current through winding W_{10} . After contact 2 is closed, current will again flow from battery B_{18} through resistance Z_{18} , and over line L_4 .

The action of condensers C_2 , as well as that of "kick" transformer T_4 , tends to stabilize the current through winding W_{11} and to prevent the current from falling to zero when the current which is impressed upon the grid electrodes of devices V_3 and V_4 passes through a zero value.

When no current is impressed upon the grid electrodes of vacuum tubes V_3 and V_4 , condenser C_2 is charged to the voltage of battery B_{16} . However, when proper current is impressed upon the grid electrodes of vacuum tubes V_3 and V_4 , current will flow through a circuit which includes the plate and filament electrodes of one of these tubes, for example, the plate and filament electrodes of vacuum tube V_3 , whereupon condenser C_2 will partly discharge through a local circuit which includes the plate and filament electrodes of vacuum tube V_3 . The discharge of condenser C_2 will be a maximum when the impressed wave reaches the point of maximum amplitude in its cycle. Thereafter, condenser C_2 will become almost fully recharged to the voltage of battery B_{16} . It will be apparent that when current flows through the plate and filament electrodes of the other vacuum tube, i. e., tube V_4 , condenser C_2 will again partly discharge in a local circuit which includes the plate and filament electrodes of tube V_4 , the discharge reaching its maximum value at a point in the cycle where the current is a maximum, this condenser thereafter becoming recharged to the voltage of battery B_{16} .

As in the case of the half-wave rectifying circuit described hereinabove, the "kick" transformer T_4 accelerates the movement of the armature of relay R_2 from contact 2 to contact 1 at the beginning of a pulse, and accelerates the movement of the armature back to contact 2 at the end of a pulse.

Fig. 3 shows line L_3 connected to bus-bars E_2 . Band filters F_3 and F_4 are connected in parallel to bus-bars E_2 , each of these filters freely transmitting current of a definite frequency or a band having predetermined limits.

The filter F_3 may, for example, transmit currents having frequencies between zero and 170 cycles, and filter F_4 may transmit other currents having frequencies between the limits of 170 and 340 cycles. These currents are transmitted through potentiometers P_1 and P_2 , transformers T_{21} and T_{22} , three-electrode amplifying devices V_5 and V_6 , transformers T_{23} and T_{24} to the input circuits of the three-electrode vacuum tube rectifying devices V_7 and V_8 and V_9 and V_{10} , respectively.

Battery B_{20} is employed for heating the filament electrodes of all of the vacuum tubes just referred to, this battery being connected in a circuit which includes resistance Z_{20} , resistances Z_{21} and Z_{22} and the filament electrodes of vacuum tubes V_5 and V_6 in parallel, the filament electrodes of vacuum tubes V_7 and V_8 in parallel, resistance Z_{23} , the filament electrodes of vacuum tubes V_9 and V_{10} in parallel and ground. The current which flows through resistances Z_{21} and Z_{22} causes the production of voltages sufficient to render the grid electrodes of vacuum tubes V_5 and V_6 suitably negative with respect to the filament electrodes of the respective tubes.

Battery B_{21} is connected in parallel to the primary windings of transformers T_{23} and T_{24} and with the plate electrodes of vacuum tubes V_5 and V_6 , this battery providing the proper operating positive potential for these plate electrodes. A battery B_{22} is connected through a resistance Z_{24} and the secondary windings of transformer T_{23} to the grid electrodes of vacuum tubes V_7 and V_8 . Part of the voltage of battery B_{22} is applied through resistance Z_{25} and the secondary windings of transformer T_{24} to the grid electrodes of vacuum tubes V_9 and V_{10} . It is to be noted that only part of the voltage of battery B_{22} is necessary to properly render the grid electrodes of vacuum tubes V_9 and V_{10} negative with respect to the corresponding filament electrodes because the filament electrodes of vacuum tubes V_7 and V_8 are at comparatively higher potentials than the filament electrodes of vacuum tubes V_9 and V_{10} .

Battery B_{23} is connected to the plate electrodes of vacuum tubes V_7 and V_8 through winding W_{11} of relay R_2 , the primary winding of transformer T_4 and a meter M_1 and resistance Z_{25} in parallel. A battery B_{24} is connected to the plate electrodes of vacuum tubes V_9 and V_{10} through winding W_{21} of relay R_3 , the primary winding of transformer T_{14} and meter M_2 and resistance Z_{26} in parallel. The battery B_{25} supplies continuous current to windings W_{10} and W_{20} of relays R_2 and R_3 , respectively, through resistances Z_{27} and Z_{28} in parallel and ground. Condenser C_2 is connected between the plate electrodes of vacuum tubes V_7 and V_8 and the corresponding filament electrodes, and a condenser C_3 is connected between the plate elec-

trodes of vacuum tubes V_9 and V_{10} and the corresponding filament electrodes.

It is to be noted that the two receiving paths provided by the arrangement of Fig. 3 are each similar in many respects to the receiving path shown in Fig. 2 and each operates in a similar manner. Further description of the arrangements of Fig. 3 seems unnecessary.

Fig. 4a shows a progression of signal pulses over a circuit of the type shown in Fig. 1. The marking and spacing pulses correspond to those produced by key K in modulating the current flowing from batteries B_1 and B_2 . The modulated carrier represents the wave produced by oscillator O. For simplicity in explanation, it is to be noted that the changes from a marking signal to a spacing signal are assumed in this figure to occur exactly at the time when the carrier passes through zero. It is to be further noted in this and in Figs. 4b, 4c, 4d, 4e and 4f that no account is taken of the effect of filters, etc., in changing the envelope of the modulated carrier. While these effects are present, their introduction into Fig. 4 would complicate the explanations of half-wave and full-wave rectification. The reduction in distortion by using full-wave rectification rather than half-wave rectification, will still be obtained, however, even though the envelope of the modulated carrier may be changed by the filter and line networks between the oscillator at the transmitting station, and the rectifiers at the receiving station. It will also be apparent in this figure that the stabilizing effect of condensers C_1 , C_2 and C_3 , shown in Figs. 1, 2 and 3, are not shown for simplicity. In Fig. 4a, only one-half of the received wave is rectified, and the received signal is almost a duplicate of the transmitted signal. It is to be understood that the carrier wave has a frequency somewhat higher than contemplated for the arrangements shown in Figs. 2 and 3, and still it seems that each received marking pulse is somewhat shorter than the corresponding marking pulse transmitted to the extent of one-half of an alternating current cycle.

Fig. 4b shows the corresponding progression when the changes from marking to spacing and back again to spacing occur exactly at the point where the carrier passes through its maximum value. Here, the received signal, though derived from a half-wave rectifier, more closely resembles the transmitted signal. It is to be noted from Figs. 4a and 4b that in the general case where the carrier pulse does not necessarily begin nor end at the zero or the maximum point in a particular cycle, it is possible to have the received signal shorter than the transmitted signal by as much as one-half cycle of carrier current for each marking pulse due to the employment of half wave rectification.

Since the carrier frequency may be considered high with respect to the signal dot frequency in Figs. 4a and 4b, (one ratio may be 425 cycles to 24 dots), the marking signal at the receiving end is shortened only an inappreciable amount and the distortion is not very great.

If half-wave rectification is employed and the signals are modulated on a carrier wave of considerably lower frequency, then the progression of signal pulses is shown in Fig. 4c. Here changes from a spacing signal to a marking signal and back again to a spacing signal are shown for illustration to occur exactly as the carrier passes through zero. In Fig. 4d, a similar progression of pulses is shown, but in this case the changes from a marking signal to a spacing signal, and so on, are selected to occur exactly as the carrier passes through its maximum value. In the case shown by Fig. 4d, the received signal wave is not shortened nor distorted very much, whereas in the arrangement having the characteristics shown by Fig. 4c the received signal wave is considerably shorter than the transmitted signal. From these illustrations, it will be apparent in the general case that the likelihood of obtaining a large distortion, as is disclosed in Fig. 4c, is as great as the likelihood of obtaining only a small or inappreciable distortion, as is shown in Fig. 4d and the most probable value may still be objectionably large.

To overcome the effects tending to produce distortion, as is illustrated by Figs. 4c and 4d, a full-wave rectification circuit is necessary, and such a rectification circuit is shown in Figs. 2 and 3. It will be apparent that a full-wave rectification circuit will not introduce the distortion resulting from the loss of part of a cycle of the carrier during rectification. The advantages of full-wave rectification are shown by the curves of Figs. 4e and 4f. During rectification, both the positive and negative halves of each cycle are acted upon with the result that a pulsating current is produced which changes from zero to a maximum and back again to zero throughout each half-cycle in the alternating current pulse. When the stabilizing condensers are connected, as shown, the magnitude of the pulsations are considerably reduced, with the result that a fairly constant rectified current flows through the corresponding winding of relay R₂. Inasmuch as time is required to overcome the biasing current of each receiving relay, it will be apparent that the received signal, as produced by the receiving relay, begins somewhat after the beginning of the transmitted signal and ends a corresponding interval of time after the end of the transmitted signal.

While this invention has been disclosed in certain particular embodiments, merely for the purpose of illustration, it will be understood that the general principles of this in-

vention may be disclosed in other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. An arrangement for operating a direct current relay when current is present having a frequency lying within the limits of a predetermined band, comprising a pair of vacuum tube rectifying elements the plate electrodes of which are directly tied together and the filament electrodes of which are similarly tied together, and a source of electromotive force, said source of electromotive force being connected in a series circuit between a point common to said plate electrodes and a point common to said filament electrodes, said series circuit including the winding of the direct current relay.
2. A full wave rectifying system for receiving signals transmitted as alternating current pulses, including two three-element vacuum tube rectifiers, means to bias the grid electrodes of said rectifiers negatively with respect to the corresponding filament electrodes, means for alternately operating said rectifiers during each transmitted pulse of alternating current, and a relay the winding of which is connected between a point common to both plate electrodes of said rectifiers and a point common to the corresponding filament electrodes and through which current may continuously flow unidirectionally as obtained alternately from the rectifiers.
3. In a carrier telegraph system, the combination of two rectifiers each having an electron discharge path, said paths being arranged in parallel relationship, an electromagnetic winding, means for coupling said rectifiers with said winding, and means for alternately and periodically establishing electronic discharges in said paths in order to continuously transmit current unidirectionally through said winding.
4. In a carrier telegraph system in which pulses of alternating current represent signals, the combination of two electron discharge circuits in parallel relationship, a direct current relay, a source of direct current potential connected to said circuits through the winding of said direct current relay, and means for alternately establishing electronic discharges in said circuits continuously during each received pulse of alternating current so that the winding of said direct current relay may be supplied continuously with unidirectional current during the impression of each pulse of alternating current.
5. The combination of two electron discharge paths, a condenser of large capacity, an electro-magnetic winding connected in series with said condenser, means for coupling said discharge paths in parallel relationship with said condenser, and means for

alternately energizing said discharge paths in order to continuously energize the electromagnetic winding.

6. The combination of two vacuum tube rectifying devices each including a plate electrode and a filament electrode, the plate electrodes being tied together, and the filament electrodes being similarly tied together, a relay, a source of direct current potential connected between both filament electrodes and both plate electrodes through the winding of said relay, and a condenser of large capacity connected between both filament electrodes and both plate electrodes.

7. In a carrier telegraph system in which pulses of alternating current represent signals, the combination of a direct current relay, two space discharge paths, said paths being connected in parallel with each other and in series with the winding of said relay, means to alternately provide electronic discharges through said paths continuously during the impression of each pulse of alternating current, and means for continuously energizing the winding of said relay in accordance with the integrated effect provided by the discharges through said paths.

8. In a carrier telegraph system, the combination of a source of current having a frequency which may vary between the limits of a band of definite width, two thermionic devices, means whereby said devices may alternately respond to and rectify the current of said source, an element coupled to said thermionic devices and supplied with unidirectional current derived alternately from said thermionic devices, and means for rendering the current flow through said element substantially constant.

9. The combination of two thermionic devices, means to alternately and periodically operate said devices as rectifiers, an element coupled to said devices and continuously supplied with unidirectional current as a result of rectification, and a condenser of large capacity the electrical charge of which varies so as to equalize the flow of current through said element.

10. In a carrier telegraph system, means for producing pulses of alternating current in accordance with signals, means for independently and alternately rectifying the opposite halves of each alternating current cycle, and a direct current relay coupled to the rectifying means and continuously energized during each pulse by the current derived from said rectifying means.

11. In a carrier telegraph system, means for producing pulses of alternating current corresponding to signals, a full-wave rectifier for completely rectifying each alternating current cycle, a direct current relay continuously operated by the rectified current throughout the duration of each pulse, and

means for stabilizing the operation of said relay.

12. In a telegraph system, the method of signaling with a very low frequency wave, which consists in producing a pulse of low frequency current in accordance with a marking signal and omitting such a pulse in accordance with a spacing signal, independently rectifying the positive and negative halves of each transmitted cycle, and combining the independently rectified currents so as to form a continuous current.

13. The method of signaling, which consists in generating a very low frequency wave, independently and alternately rectifying opposite halves of each cycle, and integrating the rectified waves so as to form a unidirectional wave of substantial amplitude.

In testimony whereof, I have signed my name to this specification this 18th day of March, 1929.

FRED J. SINGER.

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