Feb. 10, 1931. F. J. SINGER 1,791,578

TELEGRAPH RECEIVING SYSTEM

Filed March 20, 1929

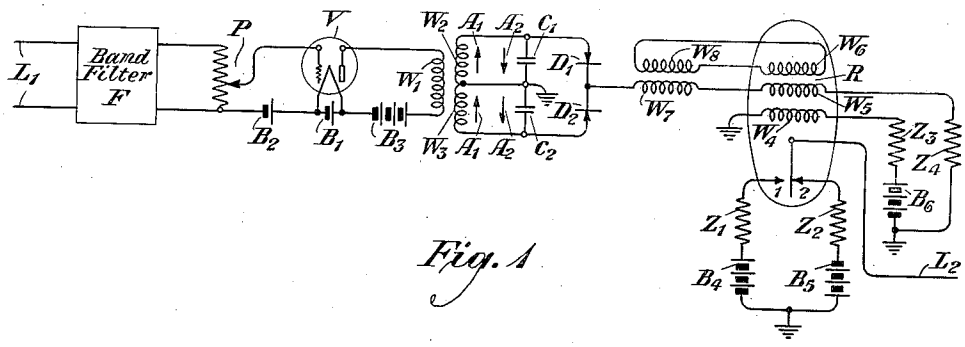


Fig. 1

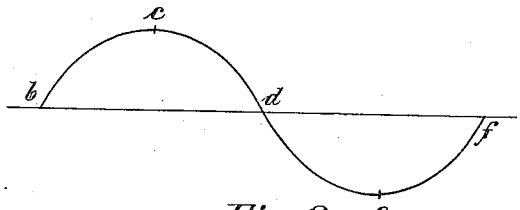


Fig. 2

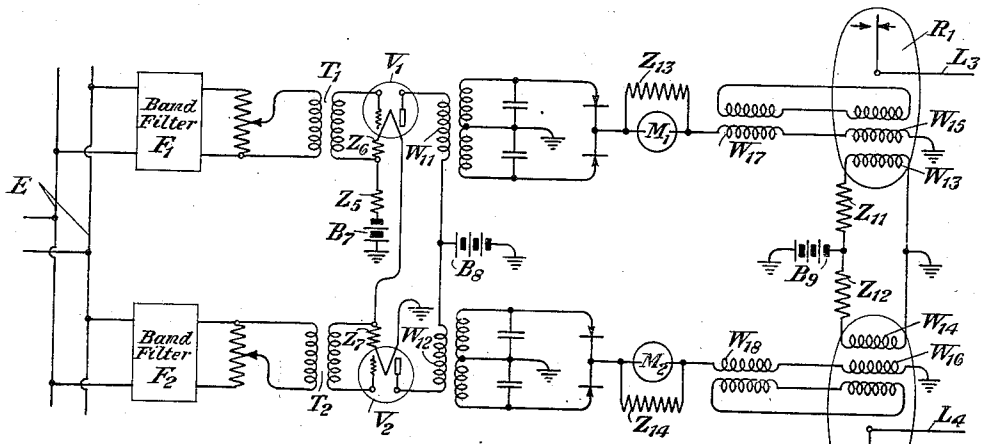


Fig. 3

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UNITED STATES PATENT OFFICE

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TELEGRAPH RECEIVING SYSTEM

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This invention relates to signaling systems and particularly to receiving systems suitable for receiving pulses of alternating current, such as may be characteristic of carrier telegraphy.

The receiving system to be described hereinafter is particularly adaptable for receiving alternating currents of especially low frequency. In accordance with the invention, pulses of such current are readily convertible into pulses of direct current, each pulse of direct current corresponding to its received pulse of alternating current.

One of the objects of this invention is to provide an improved arrangement for receiving signals such as are characteristic of carrier telegraphy.

Another of the objects of this invention is to provide an arrangement for receiving alternating current pulses and for converting these pulses into corresponding direct current pulses with small 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 which are employed at the sending end in producing said 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 of 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 rectifying elements 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 one embodiment of the invention employing a pair of rectifying elements for rectifying the current of a single source; Fig. 2 represents both halves of an alternating current cycle disclosing the points at which the apparatus of Fig. 1 is particularly responsive, and Fig. 3 represents another embodiment of the invention for receiving the current derived from two sources.

Referring to Fig. 1 of the drawing, a line or line circuit L_1 is shown over which pulses of alternating or carrier current may be transmitted in accordance with marking and spacing signals. The current transmitted over line L_1 may have a definite frequency, or it may be composed of a plurality of frequencies constituting a band on either side of some definite carrier. A band filter F receives such current as flows over line L_1, freely transmitting these component frequencies lying between its predetermined limits and substantially suppressing all other frequencies. While this band filter may be of any well known type, it is preferably of the type disclosed in the patent to G. A. Campbell, No. 1,227,113, dated May 22, 1917.

The output of the filter is impressed upon a vacuum tube system, through a potentiometer P. This potentiometer is employed to control the magnitude of the voltage of the current to be impressed upon the vacuum tube system.

The vacuum tube system includes a three-electrode space discharge device V having grid, filament and plate electrodes. The filament electrode is heated to incandescence by the current derived from a battery B_1. The grid electrode is connected to the filament electrode through the potentiometer P and a battery B_2, the battery B_2 biasing the grid electrode suitably negative with respect to the filament electrode. The plate electrode is connected to the filament electrode through a winding W_1 and a battery B_3, the battery B_3 rendering the plate electrode at a suitably high positive potential with respect to the filament electrode. While this vacuum tube

system is employed herein merely for the purpose of amplifying the alternating current transmitted by filter F through potentiometer P, 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 and potentiometer P has considerable energy, the vacuum tube system may, perhaps, be omitted, in which event the potentiometer P will be terminated by winding W_1.

A rectifying circuit is coupled to winding W_1 through windings W_2 and W_3. This rectifying circuit includes the latter windings and the oppositely directed rectifiers D_1 and D_2, all arranged in series relationship. The windings W_2 and W_3 are shunted by condensers C_1 and C_2, respectively. The point common to windings W_2 and W_3, and the point common to condensers C_1 and C_2, are tied together and both are grounded.

The direct current relay having three coupled windings, W_4, W_5 and W_6, is designated by the reference character R. The armature of this relay may vibrate between contacts 1 and 2 on either side thereof, and contact 1 may be closed in accordance with a marking signal and contact 2 in accordance with a spacing signal.

A line which is suitable for transmitting direct current pulses characteristic of telegraphy is designated L_2. This line is directly connected to the axis of rotation of the armature of relay R. The contacts 1 and 2, between which the armature of relay R may vibrate, are serially connected with resistances Z_1 and Z_2 and batteries B_4 and B_5, respectively, the point common to these batteries being grounded. When the armature of relay R closes contact 1, current flows from battery B_4, through resistance Z_1, over line L_2, yet when this armature closes contact 2, current flows from battery B_5, through resistance Z_2, over line L_2.

A so-called "kick" transformer having windings W_7 and W_8, is placed between the rectifying circuit, above mentioned, and the direct current relay R. The primary winding of this transformer, i. e., W_7, is connected serially between the point common to the rectifiers D_1 and D_2 and the winding W_5 of relay R. The secondary winding of this transformer, i. e., W_8, is connected in a local circuit in series with winding W_6 of relay R.

Winding W_4 of relay R is permanently connected in a local circuit in series with a resistance Z_3, a battery B_6 and ground, resistance Z_3 controlling the magnitude of the continuous current. Winding W_4 is employed to normally bias the relay armature of relay R against contact 2. It will be understood that to produce a similar biasing effect, this winding may be replaced by a spring (not shown), or by positioning the armature nearer one pole of the relay than the other (not shown) or by any other means.

Winding W_5 of relay R is connected to ground through the resistance Z_4.

When no current flows over line L_1, or when current flows over line L_1 having a frequency beyond the predetermined limits of filter F, the vacuum tube system will not be energized, the windings W_2 and W_3 will not be impressed with any current from winding W_1, the rectifiers D_1 and D_2 will rectify no current and will be otherwise ineffective, and the condensers C_1 and C_2 will be discharged. Moreover, the continuous current from battery B_6 through the winding W_4 of relay R will cause the closure of contact 2 by the armature of relay R, and, moreover, current will flow from battery B_5 over line L_2. There will be substantially no current through either of the windings W_5 or W_6 of relay R.

When a pulse of alternating current of the proper frequency, or in general, when current of any frequency or frequencies between predetermined limits of filter F are transmitted over line L_1, this current will be freely transmitted by filter F, through potentiometer P, to the vacuum tube system. The potentiometer P may be manipulated to adjust the voltage of the impressed current and, moreover, the vacuum tube system will amplify this current to any desired degree. Such current will be effective in energizing winding W_1. Certain changes will be brought about in the condition of the rectifying circuit and in the condition of the circuits associated with the windings of relay R, causing the armature of this relay to move to its contact 1, and these will be considered in more detail in connection with Fig. 2 of the drawing which shows the positive and negative halves of a complete alternating current cycle.

With the impression on line L_1 of current of proper frequency, and therefore upon the vacuum tube system, it has already been suggested that the winding W_1 becomes effectively energized, and accordingly, windings W_2 and W_3 become similarly energized. During the positive half of the first alternating current cycle, in other words, between points *b* and *d* of Fig. 2, the voltage impressed upon these windings will rise from a zero value, as indicated by point *b* to a maximum value, as indicated by point *c*, and then decrease to the zero value, as indicated by point *d*. Throughout the entire positive portion of the cycle, the impressed voltages are in a particular direction, as indicated by the arrows A_1.

On the other hand, with the impression of current of proper frequency upon the vacuum tube system, windings W_2 and W_3 will become effectively energized, and during the negative half of each alternating current cycle, as between points *d* and *f* of Fig. 2, the voltage impressed upon these windings will again rise from zero, as indicated by point *d*,

to a maximum value, as indicated by point *e*, and then decrease to zero, as indicated by point *f*. Throughout the entire negative portion of the cycle, the impressed voltages are in the opposite direction, this direction being indicated by the arrows A_2.

As the current impressed upon windings W_2 and W_3 rises from the minimum value *b* to the maximum value *c*, the voltages which are in the direction A_1 cause current to flow through the rectifier D_1 and the circuit through which this current flows may be traced from ground through winding W_2, rectifier D_1, winding W_7, winding W_5, resistance Z_4 and ground. As the current increases in amplitude, soon the electromagnetic effect of winding W_5 will exceed that of winding W_4, causing the armature of relay R to open contact 2, and move toward contact 1. Also, condenser C_1 will become charged to the entire voltage of the impressed current. In fact, condenser C_2 will become similarly charged, but the latter condenser will be ineffective in providing any current flow in rectifier D_1, and therefore through winding W_5 of relay R. It is shortly after the current magnitude departs from the point of zero amplitude *b* that the armature of relay R strikes contact 1. The length of the delay will depend, among other things, upon the strength of the biasing electromagnetic effect of winding W_4, the reactance in the circuit of winding W_5, and the relative stiffness of the armature of relay R.

Between points *c* and *d*, the current impressed upon windings W_2 and W_3 will cause voltages in the same direction, i. e., A_1, but these voltages will decrease and shortly become of zero or negligible magnitude. Throughout this portion of the cycle, current continues to flow through rectifier D_1 and windings W_7 and W_5, and the armature of relay R will remain closed against contact 1. However, condenser C_1 will begin to discharge through the circuit including rectifier D_1, winding W_7, winding W_5, resistance C_4 and ground, and the discharge current will aid that derived from winding W_2 in maintaining winding W_5 sufficiently electromagnetic to overcome the biasing electromagnetic effect of winding W_4. Therefore, during the balance of this half-cycle between points *c* and *d*, the armature of relay R will remain closed against contact 1.

Between that portion of the negative half of the cycle determined by points *d* and *e*, the current impressed on windings W_2 and W_3 will cause the production of voltages in the direction indicated by the arrows A_2 and these voltages will rise from a zero or minimum value to a maximum value. The current impressed upon winding W_3 will cause a current flow through D_2 in the circuit including winding W_3, rectifier D_2, winding W_7, winding W_5, resistance Z_4 and ground. Winding W_5 will receive direct current which flows in the same direction as heretofore. Moreover, condensers C_1 and C_2 will become fully charged to the voltage of the impressed current, but it will be apparent that condenser C_1 is practically ineffective in producing a current flow through detector D_2 and winding W_5 of relay R.

Between points *e* and *f* of the negative half of the alternating current cycle, the voltage of the current impressed upon windings W_2 and W_3 will still be in the direction of arrow A_2 but will be of decreasing order. This voltage will still be effective in producing a flow of current through detector D_2 and winding W_5 of relay R. However, condenser C_2 will discharge and assist winding W_3 in maintaining a constant flow of current through detector D_2 and winding W_5 of relay R, the discharging circuit including condenser C_2, rectifier D_2, winding W_7, winding W_5, resistance Z_4 and ground. Throughout the balance of this negative half of the cycle, the electromagnetic effect of the winding W_5 will be substantially greater than the biasing electromagnetic effect of winding W_4, and consequently the armature of relay R will maintain contact 1 closed. It will be understood, moreover, that the armature of relay R will continue to remain closed against contact 1 throughout the remaining cycles of the alternating current pulse impressed upon winding W_1. It will be apparent also that the length of the delay or lag in the motion of the armature of relay R in departing from contact 1 after the completion of an alternating current pulse, will be practically the same as the length of the delay or lag of this armature in opening contact 2 and moving toward the contact 1 at the beginning of the first cycle of this alternating current pulse.

As has been stated hereinabove, the primary winding of the "kick" transformer is connected serially between the common rectifiers D_1 and D_2 and winding W_5 of the direct current relay. Since the secondary winding W_8 of this transformer is serially connected to winding W_6 of relay R, this transformer tends to further couple winding W_5 and winding W_6 of relay R. When a current increasing at a rapid rate flows through winding W_5 as at the beginning of a pulse, the transformer will act to build up a substantial electromagnetic effect about winding W_6 and therefore the armature of relay R will move from contact 2 to contact 1 more promptly and more positively. On the other hand, at the termination of the alternating current or signaling pulse, this transformer will tend to set up a current in its secondary which will cause winding W_6 to assist winding W_4 in retracting the armature of relay R. In effect then, the transformer causes the direct current relay R to become closely responsive to the envelope of the signals transmitted in the form of alternating current pulses.

Fig. 3 shows two systems each similar to the one shown in Fig. 1, both receiving currents from a bus E. In this embodiment, however, filters F_1 and F_2 may transmit currents of different frequencies or simple alternating currents having frequencies of, for example, 85 and 255 cycles, respectively, or bands of frequencies such as are popular in carrier telegraphy, these bands having limits of, for example, zero to 170 cycles, and 170 to 340 cycles, respectively. It will be understood, however, that the values of these frequencies are given merely for the sake of illustration, and other frequencies or bands of frequencies may equally well be employed within the scope and spirit of this invention. It will also be understood that these filters or the filter F of Fig. 1 may each be replaced by any other device or means responsive to current of a definite frequency, or to currents having frequencies between predetermined limits, within the scope of this invention. It will be further understood that each of these filters may be omitted if desired, or replaced by a tuned circuit arrangement of any well-known type which may include, for example, a pair of coupled inductances either or both of which are shunted by a condenser of variable capacity. In the latter event, one of these windings may be connected to line L_1, the other connected to the terminals of the potentiometer P, and the condenser of variable capacity shunting the latter winding, or if preferred, the former winding.

In the arrangement of Fig. 3, the filament electrode of the vacuum tubes V_1 and V_2 are heated to incandescence by a common battery B_7, the interconnected circuit including battery B_7, resistance Z_5, resistance Z_6, the filament electrode of tube V_1, resistance Z_7, the filament electrode of tube V_2 and ground. The flow of current through resistances Z_6 and Z_7 causes a drop in potential across the respective terminals of these resistances, the drop in potential across Z_6 biasing the grid electrode of tube V_1 suitably negative with respect to filament electrode through the secondary of a transformer T_1 and the drop in potential across Z_7 being ample to suitably bias the grid electrode of tube V_2 with respect to the filament of that tube through the secondary winding of transformer T_2. In connection with the vacuum tube systems shown, it is to be noted that the battery B_8 renders the plate electrodes of tubes V_1 and V_2 suitably positive with respect to the corresponding filament electrodes, through windings W_{11} and W_{12}, respectively.

The relays R_1 and R_2 control the transmission of direct current pulses over lines L_3 and L_4, respectively. It will be apparent that relays R_1 and R_2 operate in the manner already described. It is to be particularly noted that the biasing windings W_{13} and W_{14}, respectively, of these relays are continuously supplied by the current derived from the same source, i. e., battery B_9, the current of this battery flowing over resistances Z_{11} and Z_{12} and windings W_{13} and W_{14} in parallel, respectively, and over ground. Windings W_{15} and W_{16} of relays R_1 and R_2, respectively, are connected in series relationship with primary windings W_{17} and W_{18}, respectively, and with meters M_1 and M_2. Meters M_1 and M_2 may be ammeters or any devices of low resistance, and these meters may, if desired, be shunted by resistances Z_{13} and Z_{14}, respectively.

It will be apparent that each vacuum tube system, each rectifying circuit, and all of the circuits associated with each direct current relay in the arrangement of Fig. 3 operate in a manner substantially the same as already described hereinabove in connection with Fig. 1, and therefore this description need not be repeated.

It will be understood that each of the rectifying devices employed herein may be any dry disc rectifying device as, for example, a copper oxide rectifier which includes a metallic element, such as copper, in intimate contact with an oxide of the metallic element, such as copper oxide, or each may be a gas-filled tube of any well-known type, or a two-element space discharge device which includes an incandescent filament electrode and a suitably positive plate electrode, or any other rectifying means.

While this invention has been described in certain particular embodiments merely for the sake of illustration, it will be understood that the general principles of this invention may be applied to other widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a signaling system, the combination of a source of current the frequency of which may vary within the limits of a band, a pair of copper oxide rectifiers connected in series with each other and coupled to said source, said rectifiers being oppositely directed and respectively rectifying opposite halves of each alternating current cycle, and a circuit including a direct current relay coupled to said copper oxide rectifiers through which only unidirectional current may flow.

2. In a signaling system, the combination of a winding through which alternating current flows, a pair of oppositely directed contact rectifiers connected to said winding in series relationship, each rectifier by-passing one-half the wave of each alternating current cycle, and a relay having a winding coupled to said rectifiers through which direct current derived from said rectifiers continuously flows.

3. In a signaling system, the combination

of a series circuit including a first winding and a pair of oppositely directed contact rectifying elements, and a relay having a second winding connected in series between the midpoint of the first winding and the point common to said rectifying elements.

4. In a signaling system, the combination of a series circuit including a first winding and a pair of oppositely directed contact rectifying elements, a second winding connected in series between the point common to said rectifying elements and the midpoint of said first winding, and a pair of condensers of large capacity connected across each half of said first winding.

5. In a signaling system, the combination of two windings, two contact rectifiers, two condensers each of large capacity, and a direct current relay, said two windings being connected in series relationship with said rectifiers which are directed in opposition, each condenser shunting one of said windings, the winding of the direct current relay connecting the point common to said rectifiers with the point common to said first mentioned windings.

6. In a signaling system, the combination of a source of low frequency alternating current the frequency of which may vary between the limits of a band of predetermined width, means for rectifying both halves of each alternating current cycle, and a direct current relay through the winding of which the rectified current flows unidirectionally.

7. In a carrier telegraph system, means for periodically establishing a flow of alternating current in accordance with signals, and means responsive to said signals including a pair of rectifiers connected in opposition, one of the rectifiers rectifying the positive half of each alternating current cycle and the other of the rectifiers the negative half of each cycle, and a direct current relay through the winding of which the rectified current flows unidirectionally, the direct current relay being energized only during the intervals when alternating current is being transmitted.

8. A system for receiving pulses of alternating current representing telegraphic signals, including a rectifying current having a pair of oppositely directed rectifying elements which become alternately responsive at the beginning of a received alternating current pulse, a direct current relay having three windings the first of which is continuously energized, means whereby the second of the windings may be energized only when the said rectifying elements become responsive to a received pulse, and a transformer for coupling the second and third windings of the direct current relay to accelerate the motion of its armature at the beginning and at the end of each pulse.

9. In a telegraph receiving system, the combination of a direct current relay having three windings, a source of direct current potential, the first of the direct current windings being continuously energized with current from said source, a rectifying circuit having a pair of oppositely directed rectifying elements which become alternately responsive to an impressed alternating current pulse and remain responsive throughout its impression, the second of the windings of said direct current relay being energized with current derived from said rectifying circuit, and a transformer for coupling the second and third windings of said direct current relay to accelerate the motion of its armature at the beginning and at the end of each pulse.

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

FRED J. SINGER.