

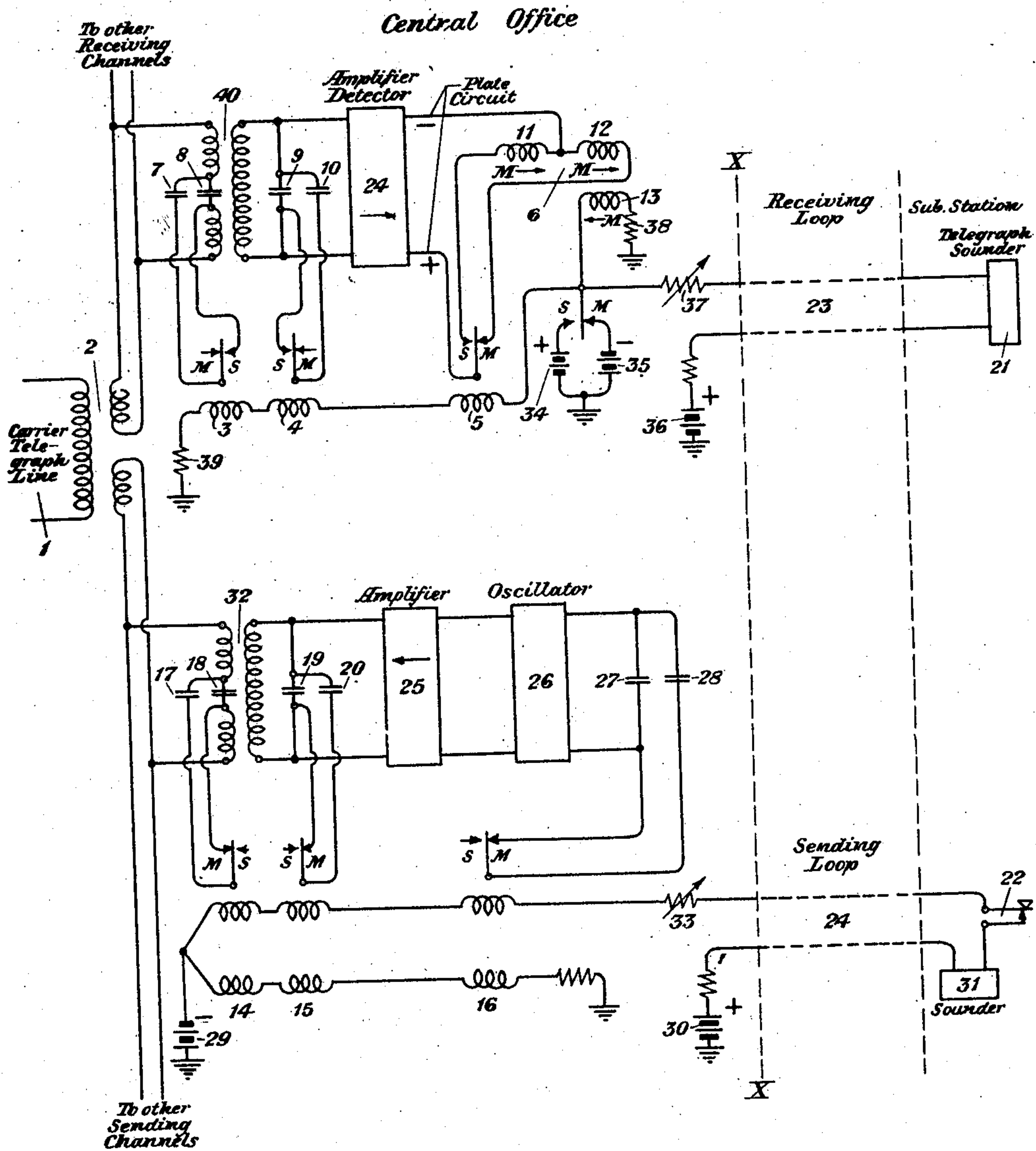
Aug. 26, 1930.

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1,773,798

CARRIER CURRENT TELEGRAPH SYSTEM

Filed Aug. 10, 1928



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CARRIER-CURRENT TELEGRAPH SYSTEM

Application filed August 10, 1928. Serial No. 298,732.

This invention relates to the art of telegraph communication and discloses a carrier current telegraph system in which distinct frequencies are utilized for the transmission of the marking and spacing frequencies.

At the present time, it is the general practice in carrier current telegraphy to transmit signals by the so-called "open-and-close" method, i. e., carrier current is transmitted over the line during the marking interval whereas no current is transmitted during the spacing interval. At the receiving terminus of the carrier line the rectified carrier signals constitute pulses of direct current succeeded by intervals of no current. Signals of this type may be used to operate a sensitive polar relay which is biased toward the spacing contact by means of a current through an auxiliary winding.

The "open-and-close" method of operation discussed immediately above, has a serious disadvantage in that changes in line attenuation cause the signals to become biased. For example, if the constant biasing current through the auxiliary winding of the polar relay is so adjusted that there is no signal bias for a given condition of line attenuation, it of course, follows that any change in line attenuation will immediately introduce some signal bias, the magnitude of which will be dependent upon the amount of such change. In operating practice, there are many factors which cause variations in line attenuation such, for example, as the effect of temperature variations on the conductor resistance, or in the case of open wire lines the enormous variation in line leakage with humidity conditions. With the above method of open and close operation, each change of line attenuation of any considerable magnitude would require a readjustment of the constant biasing current or readjustment of the gain of the receiving amplifier.

The present invention has been developed

with the view toward providing what is in effect a polar method of operation, and one which is not open to the drawbacks encountered in connection with the method of open and close operation discussed above.

The circuit operation is best understood by reference to the drawing which shows in schematic form for a single carrier channel the transmitting and receiving apparatus embodying the invention which is located at one terminus of the carrier line. The circuit, as shown, is arranged for full duplex operation, though it is understood, of course, that by means of simple circuit transformations well known to the art, the circuit could be arranged for half duplex operation.

Referring to the drawing, the apparatus to the left of XX is located in the central office at one terminus of the carrier line 1. The sending circuit includes sending key 22 and telegraph sounder 31 located at a subscriber's station and connected over loop 24 to the carrier sending means which includes polar relays 14 to 16, inclusive, a source of carrier current 26, amplifier 25, and a connection through certain tuned circuits to carrier line 1 through transformer 2. The receiving circuit shown in the upper portion of the drawing is also connected to the carrier line 1 through transformer 2, and comprises certain other tuned circuits, amplifier-detector 24, polar relays 3 to 6, inclusive, receiving loop 23, and telegraph sounder 21 located at a subscriber's station.

The substation equipment shown is adapted for transmission in accordance with the Morse code but it is to be understood, of course, that other substation equipment such as printing telegraph sets might be used without affecting the novel features of the invention.

Referring to the sending circuit, it will be noted that with key 22 down as shown, current flows from grounded plus battery 30, over the lower conductor of loop 24, through

sounder 31, key 22, back over the upper conductor of loop 24, through resistance 33 and through the line or upper windings of polar relays 14 to 16, inclusive, in series, through minus battery 29 to ground. This current holds the polar relays in question operated against their respective marking contacts M. In addition, current flows from grounded negative battery 29 through the lower or auxiliary windings of relays 14 to 16, inclusive, in series. This current tends to operate the relays in question against their respective spacing contacts S but being of smaller magnitude than the current in the line windings will not so operate the relays while the above-described current flows in the line windings. If, however, the current in the line windings of the relays is interrupted as by opening key 22, the current through the auxiliary windings immediately operates the relays against their respective spacing contacts.

It will thus be seen that polar relays 14 to 16, inclusive, follow the operations of the sending key 22. With relay 16 operated against its marking contact M, condensers 27 and 28 in parallel are shunted across the tuning inductance associated with oscillator 26, thus causing the oscillator to oscillate at a definite frequency f_1 . With relays 14 and 15 likewise operated against their marking contacts M, condensers 17 and 18 in parallel are in series with the left winding of transformer 32 and condensers 19 and 20 in parallel are shunted across the right winding of transformer 32. These capacities associated with the inductance of the transformer windings in the manner shown constitute a pair of tuned circuits adapted to transmit the marking frequency f_1 generated by oscillator 26. The result is that frequency f_1 generated by oscillator 26 flows through amplifier 25, through transformer 32, and out over carrier line 1 through transformer 2 to the distant station.

If, now, the sending key 22 be opened, relays 14 to 16, inclusive, will move against their respective spacing contacts S, as explained above. The operation of relay 16 against its spacing contact will open the circuit containing condenser 28 and will thus leave only condenser 27 connected to the tuning inductance associated with the oscillator 26. This will cause generated frequency of the oscillator to change from the marking frequency f_1 to the spacing frequency f_2 . The operation of relay 15 against its spacing contact will disconnect condenser 20 from its shunt relation with condenser 19. Likewise the operation of relay 14 against its spacing contact will disconnect condenser 17 from its shunt relation with condenser 18. This will leave only condensers 18 and 19 associated with transformer 32 and will thus constitute a pair of tuned circuits adapted to transmit

the spacing frequency f_2 instead of the marking frequency f_1 . Thus, while key 22 is held open, the spacing frequency f_2 generated by oscillator 26 passes through amplifier 25, transformer 32 and through transformer 2 to the distant point over carrier line 1. The subsequent closure of key 22 will reoperate relays 14 to 16, inclusive, against their respective marking contacts thus reconnecting condensers 17, 20 and 26 in their respective circuits to again transmit the marking frequency f_1 to the distant point.

Considering the operation of the receiving circuit, normally a marking frequency f_3 is transmitted from the distant point over carrier line 1 and through transformer 2 to the receiving circuit. For this condition, the receiving circuit is operated as shown on the drawing. Current flows from plus battery 36 over the lower conductor of loop 23, through telegraph sounder 21, back over the upper conductor of loop 23 through resistance 37 and through the marking contact of polar relay 6, through minus battery 35 to ground. This current holds sounder 21 operated against its marking contact. Assuming the conventional direction of current flow, i. e., from plus to minus battery, current also flows from ground through resistance 38, holding winding 13, armature and marking contact of polar relay 6 and through negative battery 35 to ground. This current holds the armature of relay 6 operated against its marking contact. Current likewise flows from ground through resistance 39, through the windings of polar relays 3 to 5, inclusive, in series through the marking contact of relay 6 and through negative battery 35 to ground. The latter current likewise operates relays 3 to 5 against their respective marking contacts M.

With relay 3 operated against its marking contact, only condenser 8 is in series with the left winding of transformer 40. Likewise, with relay 4 operated against its marking contact, only condenser 9 shunts the right winding of transformer 40. These capacities associated with the inductances of the transformer windings constitute a pair of tuned circuits adapted to transmit the spacing frequency f_4 from the distant point. Since, however, under present assumption, the marking frequency f_3 is being transmitted from the distant point, the received signaling current is thus prevented, by the tuned circuit referred to, from entering the receiving amplifier and detector 24.

Assume, now, that the spacing frequency f_4 is transmitted from the distant point. This current upon arriving at the central office flows from the carrier line 1, through transformer 2 and through transformer 40 to the amplifier-detector 24 where the signal current is rectified. Assuming the conventional current flow, that is from plus to

minus, the rectified current in the plate circuit of the detector flows from the detector over the plus lead, through the marking contact of relay 5, winding 12 of relay 6 and back over the minus lead to the detector. This current acting through winding 12 of relay 6 is of sufficient magnitude to operate the armature of relay 6 against its spacing contact, against the effect of the holding current through winding 13.

As soon as the armature of relay 6 is thus operated against the spacing contact S, plus battery 34 is substituted for minus battery 35. This reverses the direction of current flow through winding 13 of relay 6 and is thus adapted to hold relay 6 operated against its spacing contact. The positive battery 34 now supplied through the spacing contact of relay 6 opposes positive battery 36 through telegraph sounder 21. These opposed batteries thus prevent further current flow through sounder 21 which is thereupon operated to its spacing contact by means of the usual spring tension.

The positive battery 34 supplied through the spacing contact of relay 6 furthermore reverses the direction of current flow through the windings of polar relays 3 to 5, inclusive, causing all of these relays to be operated against their respective spacing contacts S. The operation of relay 3 connects condenser 7 in parallel with condenser 8, both of said condensers now being in series with the left winding of transformer 40. Likewise the operation of relay 4 against its spacing contact connects condenser 10 in parallel with condenser 9, both of said condensers now shunting the right winding of transformer 40. This changes the tuning of the transformer circuit to receive the marking frequency f_3 instead of the spacing frequency f_4 . The result is that even though the spacing frequency f_4 continues to be transmitted, it can no longer flow into the amplifier-detector 24, since the circuit is now prepared to receive the next marking frequency f_3 .

The operation of relay 5 against its spacing contact disconnects winding 12 of relay 6 from the plate circuit of detector 24 and substitutes therefor winding 11 of relay 6. This substitution adapts polar relay 6 to be operated against its marking contact when the next marking frequency is received from the distant point.

Assume, now, that the next marking frequency is transmitted from the distant point and flows through transformer 2 to the receiving channel. Since transformer 40 in conjunction with condensers 7, 8, 9 and 10 is now arranged to pass the marking frequency f_3 , the received signaling current will flow through transformer 40 into amplifier-detector 24. The rectified current thus flowing in the plate circuit through winding 11 reoperates relay 6 against its marking con-

tact M, despite the holding current flowing through winding 13 which tends to hold the relay against its spacing contact. The operation of relay 6 against its marking contact replaces plus battery 34 by minus battery 35. Current from minus battery 35 again reverses the direction of current flow through winding 13 and thus holds the armature of relay 6 against its marking contact. Also current now flows from plus battery 36 through the sounder 21 to minus battery 35 and reoperates the sounder against its marking contact. And, again the minus battery 35 reverses the direction of current flow through polar relays 3 to 5, inclusive, operating the same against their respective marking contacts. The operation of relays 3 and 4 in this manner disconnects condensers 7 and 10 from their shunt relation with condensers 8 and 9, respectively, thus preparing the circuit for reception of the next succeeding spacing frequency f_4 . The operation of relay 5 against its marking contact substitutes winding 12 for winding 11 in the plate circuit of detector 24, thus preparing for the operation of polar relay 6 against its spacing contact when the next succeeding spacing frequency is received.

It will be observed from the description of the circuit operation given above that the arrangement is somewhat similar to certain impulse or "kick" methods of operation in that the operating current in the receiving relay 6 is reduced to zero after the armature has moved to its opposite contact, the armature being held in its new position by the current in a holding winding. However, this difference should be noted, that in case interference, such as lightning, operates the relay armature from the marking to the spacing contact, or vice versa, the steady carrier current transmitted from the distant end would cause the armature to move back to the position in which it was prior to the occurrence of the interference.

It will be furthermore noted from a study of the arrangement described that the shaped of the marking and spacing waves should be very nearly identical, giving in effect polar operation as contrasted with the usual open-and-close method of operation of existing carrier systems. The system has the further advantage pointed out above of attenuating the marking and spacing frequencies at all times by a like amount, since both frequencies are transmitted from the distant end over the carrier line. Thus, signal bias is eliminated.

It should be further pointed out here that in general there need be relatively little separation between the marking and spacing frequencies transmitted from a given station, since the effect of a small amount of spacing current passing through the filters at the receiving end while the filters are tuned to transmit the marking frequency or vice versa, may

be compensated for by properly adjusting the current through the holding winding of the receiving relay 6. In fact, it is advantageous to have these frequencies as closely the same as practicable, since this will insure like attenuation of both frequencies in transmission over the carrier line and thus insure that no signal bias will be introduced.

What is claimed is:

1. Carrier current telegraph means comprising in combination, a telegraph line terminating at a certain point, transmitting means associated therewith at said point for applying to said line alternate pulses of two distinct single frequency currents, and receiving means, including a single tuned circuit, associated with said line at said point for receiving alternate pulses of two distinct single frequency currents and being operative in one sense by current of one said frequency and operative in a different sense by current of the other frequency.

2. Carrier current telegraph means comprising in combination, a telegraph line extending from a first to a second point, transmitting means associated with the line at the first point for applying to said line alternate pulses of two distinct single frequency currents, and receiving means, including a single tuned circuit and polar relay means, associated with said line at the second point for receiving said transmitted pulses, said relay means being operated in one sense by current of one frequency and in a different sense by current of the other frequency.

3. Carrier current telegraph means comprising in combination, a telegraph line terminating at a central office, a source of oscillation at said office, a tuned circuit interposed between said line and the output of said oscillator, a subscriber's loop extending from said office to a subscriber's station, sending means associated with the loop thereat, relay means associated with the loop at the central office and operable in accordance with said sending means, means controlled by said relay means for causing said oscillator to generate one frequency while said relay means is operated in one sense, and a different frequency while operated in the other sense, means controlled by said relay means for adjusting said tuned circuit to transmit the particular frequency being generated by said oscillator at a given instant.

4. In a carrier current telegraph system in combination, a tuned circuit for transmitting one of two frequencies, means for applying thereto current of such frequency, detector means associated therewith for rectifying the same, a receiving relay responsive to said rectified current and operable to a first position thereby, means effective upon such operation for adjusting said tuned circuit to transmit the second frequency, and to prepare said receiving relay for operation to a second posi-

tion by rectified current, means for applying to the tuned circuit current of the second frequency to so operate the receiving relay, means effective upon such operation to adjust the tuned circuit to transmit current of the first frequency, and to prepare the receiving relay for operation to the first position by rectified current, means thereafter for applying current of the first frequency and then of the second frequency alternately to cause the cycle of operations described to be indefinitely repeated while such alternate pulses are applied, biasing means effective upon operation of the receiving relay to a given position to hold the same thus operated until current of the succeeding frequency is applied, D. C. telegraph receiving means associated with said receiving relay and operable in accordance therewith.

5. In a carrier current telegraph system in combination, a tuned circuit for transmitting one of two frequencies, means for applying thereto current of the transmitted frequency, detector means associated therewith for rectifying said current, a receiving relay associated with the detector output and operable to a first position by said rectified current, a circuit completed by such operation to operate additional relay means to a first position, means controlled through the latter operation to adjust said tuned circuit to transmit the second frequency and to prepare said receiving relay for operation to a second position by rectified current, means to apply current of the second frequency to the tuned circuit for so operating the receiving relay, a circuit effective thereupon for operating said additional relay means to a second position, means controlled through the latter operation to adjust the tuned circuit to again transmit the first frequency and to prepare the receiving relay for operation to the first position, means thereafter to apply the first frequency and then the second frequency alternately to cause the cycle of operations described to be repeated indefinitely, biasing means associated with the receiving relay to hold the same operated in a given position until acted upon by rectified current of the succeeding frequency, D. C. telegraph receiving means associated with said receiving relay and operable in accordance therewith.

6. In a carrier current telegraph system in combination, a tuned circuit for transmitting one of two predetermined frequencies, means for applying thereto current of said frequency, detector means associated therewith for rectifying the same, a polar relay, an operating winding therefor connected in said detector output for operating the armature thereof against a first contact by said rectified current, a potential source of predetermined polarity associated with said first contact, additional relay means associated with said armature and operable to a first posi-

tion by said potential source, means with said additional relay means thus operated for adjusting said tuned circuit to transmit the second of said predetermined frequencies, and for reversing the connection of said polar relay operating winding, means for applying to said tuned circuit current of said second frequency whereby rectified current in said reversed polar relay winding operates said armature against a second contact, a potential source of polarity opposite to that first mentioned associated with said second contact, whereby said additional relay means is operated to a second position, means effective upon such operation for adjusting said tuned circuit to transmit the first frequency and for again reversing the connection of said polar relay operating winding, said receiving means being operable thereafter to repeat the cycle of operations while currents of said first and second frequencies are alternately applied thereto, a holding winding for said polar relay associated with the armature thereof responsive to current from either potential source to bias the armature against either contact after contact therewith, telegraph receiving means associated with said armature responsive uniquely to each potential source.

7. A carrier current telegraph system comprising in combination a telegraph line extending from a first to a second office, a subscriber's station with telegraph sending means thereat adjacent the first office, a loop circuit connecting the subscriber's station to said office, relay means associated with the loop at said office responsive to the operation of said sending means, a source of oscillation associated with the telegraph line at the first office, means controlled by said relay means for causing said oscillator to transmit over said line alternate pulses of two distinct single frequency signaling currents in accordance with the operation of said subscriber's sending means, a tuned circuit associated with said line at the second office adjusted to transmit said signaling frequencies received from the first office, detector means connected to said tuned circuit for rectifying said received signaling current, relay means connected in said detector output operable to a first position by said rectified current upon reception of said frequency, means effective upon such operation for adjusting the tuned circuit to transmit the second frequency and for preparing said relay means for operation to a second position by rectified current upon reception of said second frequency, means effective upon such operation for adjusting said tuned circuit to again transmit the first frequency and for preparing said relay means for operation to the first position, said means at the second office being adapted thereafter to repeat the cycle of operations described while said alternate frequency pulses of current are received, a subscriber's loop associated with

said relay means at the second office and extending to a local subscriber's station, telegraph receiving means thereat connected to said loop responsive to the operation of said relay means at the second office.

8. In the art of telegraphy, the method of signaling, which consists in transmitting alternately currents of two distinct frequencies through a circuit resonant to current only of that frequency being transmitted at a given instant, and utilizing the current of said frequency to cause the operation of telegraph signaling means and to cause the tuning of said resonant circuit to transmit current of the other frequency.

9. In the art of telegraphy, the method of signaling, which consists in transmitting alternately currents of two distinct frequencies through a circuit resonant to current only of that frequency being transmitted at a given instant, utilizing the current of said frequency to cause the operation of telegraph signaling means and to cause the tuning of said resonant circuit to transmit current of the other frequency, and utilizing at another given instant current of said other frequency to cause the operation of telegraph signaling means and to cause the tuning of said resonant circuit to transmit current of the first frequency.

10. The method of carrier current telegraphy, which consists in transmitting alternately currents of two distinct frequencies through a circuit resonant to current only of that frequency being transmitted at a given instant, utilizing the current of said frequency for operating polar relay means in a certain sense to cause the operation of telegraph signal means and to cause the tuning of said resonant circuit to transmit current of the other frequencies, and utilizing at another given instant current of said other frequency for operating polar relay means in the opposite sense to cause the operation of telegraph signal means and to cause the tuning of said resonant circuit to transmit current of the first frequency.

11. The method of carrier current telegraphy, which consists in transmitting an alternating current pulse of a predetermined frequency for the marking signal, receiving said pulse at a distant station through a circuit resonant only to said frequency, rectifying said pulse, utilizing said rectified pulse to cause the operation of a telegraph receiver to its marking contact and to cause the tuning of said resonant circuit to another distinct frequency, transmitting an alternating current pulse of said other distinct frequency for a spacing signal, rectifying said spacing signal pulse, and utilizing said rectified spacing signal pulse to cause the operation of said telegraph receiver to its spacing contact and to cause the tuning of said resonant circuit to the frequency of said marking signal pulse.

12. In a telegraph system comprising a receiver and a receiving circuit including a resonant circuit, a rectifier and relay means, the method of signaling, which consists in transmitting an alternating current pulse of a predetermined frequency through said resonant circuit, rectifying said pulse, operating said relay means with said rectified pulse to operate said receiver to its marking contact and to tune said resonant circuit to another distinct frequency, transmitting an alternating current pulse of said other distinct frequency through said resonant circuit, rectifying the pulse of said other frequency, and operating said relay means with the rectified pulse of said other frequency to operate said receiver to its spacing contact and to retune said resonant circuit to the first frequency.

13. In a telegraph system comprising a receiver and a receiving circuit including a rectifier, polar relay means and a resonant circuit tuned to transmit current only of a predetermined frequency, the method of signaling, which consists in transmitting an alternating current pulse of said predetermined frequency through said tuned circuit, rectifying said pulse, utilizing said rectified pulse for operating said polar relay means in a predetermined sense to cause the operation of said receiver to its marking contact and to tune said resonant circuit to a current of another distinct frequency, transmitting an alternating current pulse of said other distinct frequency through said tuned circuit, rectifying the pulse of said other frequency, and utilizing said latter rectified pulse for operating said polar relay means in the opposite sense to cause the operation of said receiver to its spacing contact and to tune said resonant circuit to a current of said first predetermined frequency.

14. In combination, a source of oscillation, a tuned circuit associated with the output of said oscillator, a circuit including relay means, a key adapted to control the operation of said relay means, means controlled by said relay means for causing said oscillator to generate one frequency while said key is operated in one position and a different frequency while said key is operated in another position, and means controlled by said relay means for adjusting said tuned circuit to transmit the particular frequency being generated by said oscillator at a given instant.

15. In a carrier current telegraph system including a source of oscillation, polar relay means and a tuned circuit associated with the output of said oscillator, the method of signaling, which consists in operating said relay means in one sense to cause said oscillator to generate one frequency and simultaneously to adjust said tuned circuit to transmit said frequency, and operating said relay means in the other sense to cause said oscil-

lator to generate another distinct frequency and simultaneously to adjust said tuned circuit to transmit said other frequency.

16. In a carrier current telegraph system, in combination, a telegraph circuit extending from a first point to a second point, a sending key and a source of oscillation associated with said telegraph circuit at said first point, a tuned circuit associated with the output of said oscillator, means controlled by the operation of said sending key for causing said oscillator to generate alternately pulses of two distinct frequencies and for adjusting said tuned circuit to transmit pulses of the frequency being generated by said oscillator at a given instant, a circuit at said second point resonant only to the frequency being transmitted at a given instant, and means associated with said resonant circuit for causing the operation of telegraph receiving means at said second point and for causing said resonant circuit to be adjusted to transmit pulses of said other frequency at another given instant.

17. The method of controlling the operation of polar relays with alternating currents of two frequencies, which consists in transmitting current of one frequency through a tuned circuit resonant only to the frequency being transmitted, rectifying said current, transmitting said rectified current through a first winding of said polar relay to operate said relay in a predetermined sense, causing the operation of said relay in said predetermined sense to render said tuned circuit resonant only to another frequency and to connect a second winding of said polar relay in place of said first winding, transmitting current of said other frequency through said tuned circuit, rectifying said current, transmitting said rectified current through said second winding to operate said polar relay in the opposite sense and causing the operation of said relay in said opposite sense to again render said tuned circuit resonant only to said first frequency and to reconnect said first winding of said polar relay in place of said second winding.

18. Means for controlling polar relays with alternating current of two frequencies, comprising means for generating alternately currents of two distinct frequencies, a tuned circuit associated with said generating means and resonant only to one of said frequencies at a given instant, a rectifier adapted to rectify the current transmitted through said tuned circuit, a polar relay including a first winding and a second winding, means for transmitting said rectified current through said first winding at a given instant to operate said relay in a predetermined sense, means controlled by the operation of said relay in said predetermined sense for adjusting said tuned circuit to transmit only the other of said frequencies, means controlled by

the operation of said relay in said predetermined sense for transmitting the rectified current resulting from said other frequency through said second winding to operate said relay in the opposite sense, and means controlled by the operation of said relay in said
5 opposite sense for readjusting said tuned circuit to transmit only said first frequency.

In testimony whereof, I have signed my
10 name to this specification this 8th day of August, 1928.

VAUGHN P. THORP.

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