March 25, 1941. K. H. THUNELL ET AL 2,236,225

SIGNALING SYSTEM FOR COMMUNICATION CHANNELS WITH PULSATING CURRENTS OVER TUBE REPEATING AMPLIFIERS

Filed Aug. 17, 1939 2 Sheets-Sheet 1

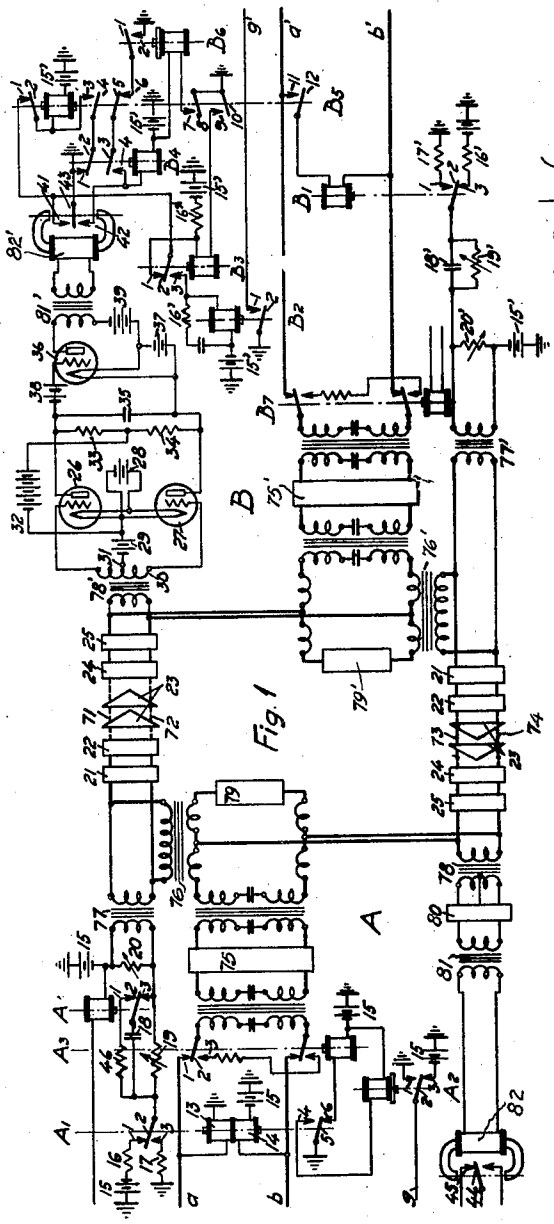


Fig. 1

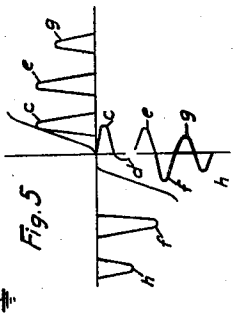


Fig. 5

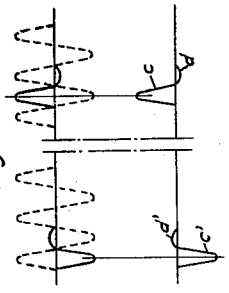


Fig. 4

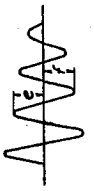


Fig. 3



Fig. 2

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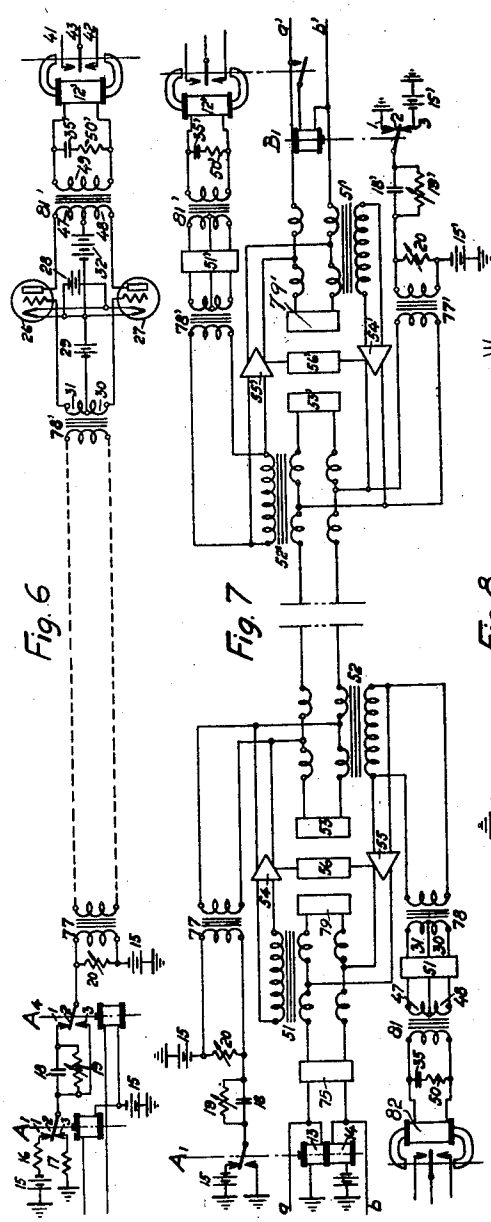


Fig. 6

Fig. 7

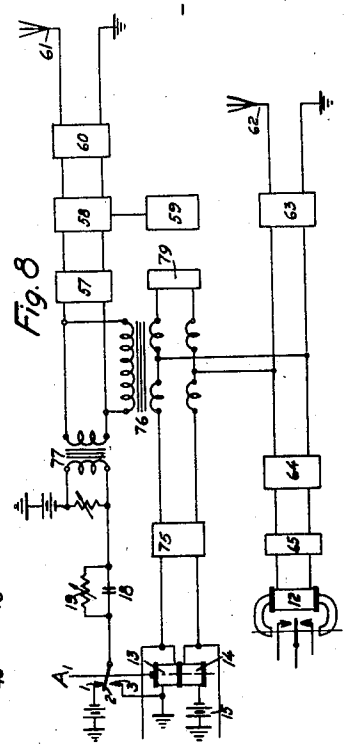


Fig. 8

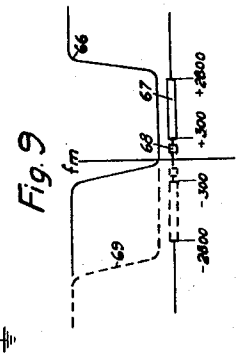


Fig. 9

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UNITED STATES PATENT OFFICE

2,236,225

SIGNALING SYSTEM FOR COMMUNICATION CHANNELS WITH PULSATING CURRENTS OVER TUBE REPEATING AMPLIFIERS

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Application August 17, 1939, Serial No. 290,570

10 Claims. (Cl. 179—4)

The present invention relates to new and useful improvements in the transmission of pulsating direct currents in one or both directions over (inductively connected) electric circuits or channels comprising vacuum or other tube repeating amplifiers through which the signals must pass.

The invention refers particularly to circuits and channels in telephone, telegraph, carrier and radio signaling systems, preferably of the type needing trunk facilities for two-way traffic between exchanges or stations, although the invention can be used also for transmission in one direction only.

The invention is particularly suitable for the transmission of signals over long distance lines of two or four wires with or without carrier channels, over radio carrier channels and the like. The signaling system enables a station or an operator of a certain telephone exchange to dial the number desired of an automatic exchange of a distant city and on the same time receiving all necessary traffic signals in the proper exchange or station, such as busy, clearing, time-measuring, debiting and like signals.

The present invention will greatly facilitate the inter-city and long distance traffic in a simple and cheap way, whereby the distant and eventually the originating long distance operators can be eliminated.

Also on channels where the long distance operators are still maintained, the new signal system can be used for calling, clearing and other signals.

The invention is also suitable for telegraph and other signals which can be transmitted over special carriers by wire or radio channels.

Heretofore different signal systems have been used for the transmission of signals over communication circuits, depending upon the distance between the two stations.

Signals based upon the use of direct currents are generally used in cases where it is desired to have the signals continue to indicate the condition of a connection throughout the conversation, for example, since the direct current can continue to flow over a continuous wire circuit simultaneously with the voice currents during conversation without interference. The most extensive use of this type of signaling has been made for the short local circuits.

In the early days the method of operation of long toll circuits was generally such that no signal was required over the toll circuit during the conversation period but only before and after the conversation and for such signals alternating currents of, for example, 16, 20, 50, 60 and 135 cycles were used.

With the further development of long toll circuits with many vacuum tube repeaters at intermediate points and also with the development of carrier telephone systems, the low frequencies of 16, 20, 50 and 60 cycles could not pass the repeaters and the satisfactory transmission of 135 cycle current from one end of the circuit to the other became more difficult.

Later on interrupted voice frequency currents of 500 cycles in Europe and 1000 cycles in U. S. A. were introduced as signaling means. With such a system the signaling current uses the same transmission path as the voice currents, but the system is designed to discriminate between the voice and signaling currents at the beginning and at the end of the circuit by means of complicated equipments. The 500-cycle and the 1000-cycle systems are now in use for the majority of circuits over 200 to 300 kilometers of length.

With the recent development of automatic telephony it became desirable to reach a station in a distant automatic exchange by causing the originating operator to dial the called number directly over a long toll line without the assistance of an inward operator at the called place. For said purpose interrupted voice frequency currents of different frequencies or of different lengths have been used for different signals. If different frequencies are used, different voice frequency transmitters and receivers have to be used for each kind of signal and if the same frequency is used, but of different length, complicated relay-sets are resorted to. Both methods are expensive and not entirely satisfactory.

The present invention eliminates all the above mentioned difficulties and offers a simple solution of transmitting pulsating half-cycle currents of, for example, 10 cycles or of the same kind as those emitted by the dial of an automatic telephone station over communication channels of any length provided with ordinary voice and/or carrier repeaters.

Our copending U. S. application Ser. No. 239,158, filed November 5, 1938, described a signaling system for the simultaneous transmission of signals in both directions over a trunk line by means of pulsating currents of any desired sequence of polarity between two stations, each thereof comprising a direct current source, transmitting and receiving means, connecting means permanently and inductively connecting said stations and said transmitting and receiving means to said trunk line, balancing means associated with said transmitting, receiving and connecting means, said balancing and connecting means being of such a magnetic constitution and electricity so connected that their magnetic and electrical characteristics remain substantially constant at any normally transmitted current magnitude at any of the stations.

Said invention, however, refers only to lines inductively connected and provided with means,

whereby it is possible to transmit heavy pulsating currents of great voltage and amplitude over the line without changing the magnetic and electrical characteristics of the special signal transformers needed according to the invention, covered in said application, as otherwise the balance between sending and receiving side on the same station would be disturbed.

The present invention refers generally to a transmitting system for the transmission of pulsating half-cycle direct signal currents of any sequence of polarity and of about the same magnitude as that of voice frequency currents to be transmitted over a communication channel between two stations, transmitting means connected to the transmitting channel at one station and at the other station receiving means connected to said channel, said receiving means comprising repeating and amplifying electron tubes in series with said channel, means for separating said pulsating half-cycle signal currents from dampened or continuous wave currents or voice frequency currents transmitted over said channel, and an operating device responsive to any polarity of said half-cycle signal currents.

The present invention refers particularly to a transmitting system comprising the transmission of signals in both directions over a two-way communication channel system, provided with tube repeating amplifiers by means of pulsating half-cycle signal currents of any desired sequence of polarity, in which there are two stations, each thereof comprising a direct current source, signal transmitting and receiving means, connecting means permanently and inductively connecting said stations to said communication system, balancing means associated with said transmitting, receiving and connection means, said receiving means comprising a tube repeating amplifier and means for separating said pulsating half-cycle signal currents from voice frequency currents, and an operating device responsive to any sequence of polarity of said half-cycle signal currents.

No specially constructed transformers are needed and the signal impulses can be repeated and/or amplified in vacuum tube repeaters or similar devices which are needed according to this invention, particularly at the receiving end to discriminate the half-cycle pulsating currents from voice frequency currents and to amplify said impulses in order to operate a polarized relay or other current-direction discriminating device.

The invention can be used for transmitting and receiving in one direction only, when there is a need of transmitting orders, reports or the like to one or a plurality of places, where messages are received only, for example in the transmission of telegraph or code signals over telegraph, telephone, carrier or radio net-works, such as used from police headquarters to police stations and radio-patrol cars, the transmission of stock-exchange rates and the like.

According to a preferred feature of the invention the half-cycle signal currents, of for example dial-impulses, are limited to about the same duration as half a cycle within the lower part of a voice-frequency range to be transmitted over the said communication channel system, in which case no change is needed in filters or in other equipment of existing communication channels.

According to another feature of the invention and particularly when carrier and radio channels are used, half-cycle signal currents of fairly great duration, for example of about 10 cycles per second from a dial, can be modulated directly on the carrier. In this case the modulation filter curve must be steeper and broader than now generally used for only letting through the voice frequency band.

The invention is further described and explained in connection with the accompanying drawings of which:

Fig. 1 represents a simplified diagram of two exchanges or stations inductively interconnected by a four-wire two-way circuit using two one-way transmission channels, eventually provided with carriers and tube repeating amplifiers.

Fig. 2 represents a positive half-cycle signal current to be transmitted over the system.

Fig. 3 represents a dampened wave train of impulses.

Fig. 4 represents a negative and a positive half-cycle of signal currents, each one of about the same duration as half a cycle within the lower part of a voice frequency range to be transmitted over a communication channel.

Fig. 5 is a diagram showing a positive half-cycle signal current as that one shown in Fig. 2 and a dampened wave train similar to that shown in Fig. 3 arriving close together to discriminating means to discriminate between the two kinds of impulses.

Fig. 6 represents in a simplified diagram the simplest form of transmitting and receiving means according to the invention.

Fig. 7 represents a simplified diagram of two stations or exchanges inductively interconnected by a two-wire two-way circuit, eventually provided with two-way tube repeaters on the line.

Fig. 8 represents a simplified diagram of a terminal exchange or station of a two-way radio communication, using two one-way carrier channels, eventually with low-pass filters for the transmission of low-frequency half-cycles of long duration modulated on a carrier wave.

Fig. 9 represents a filter for the upper side band which apart from the voice frequency band allows half-cycles of long duration and low frequencies to be modulated on a carrier wave.

The inventive idea can, of course, be varied in a great number of ways, depending upon the transmission system in which the invention shall be used and also depending upon the type of signals that shall be transmitted.

In Fig. 1 A and B are two terminal telephone exchanges united by a four-wire long distance toll line with or without carrier and/or repeaters on the line proper. The talking circuit *a—b* in the exchange A is inductively connected to the line channel circuit **71—72** and **73—74** by means of the filter network **75** and the hybrid coil **76**. The signal transmitting means is inductively connected to the one-way line channel **71—72** by means of the signal transformer **77**, while the receiving means are inductively connected to the other one-way line channel **73—74** by means of the signal transformer **78**. The object of network **75** is to act as an amplitude limiting device of the talking currents and also to transform any individual, undesirable half cycles that might arrive over the talking circuit during a conversation from the exchange side into dampened waves, before being transmitted to the line circuit. **79** is a balancing network. A1 is the impulse transmitting relay with windings **13** and **14**, directly or indirectly controlled by a subscriber's dial or by a similar device. **80** is a discriminating storage and receiving device for the pulsating currents shown in detail on station B. **81** is a transformer

for amplifying the received pulsating half-cycle currents. 82 is a biased polarized relay with armature 44 and break contact 45. 15 is a battery source on station A. 16 and 17 are resistances, 18 is a condenser. 19 is a preferably variable resistance to cause heavily dampened oscillations, when the condenser 18 is discharged. 20 is a potentiometer to serve as an amplitude limiting device for the half-cycle currents to be transmitted over the line 71—72. 21 is a modulating device, 22 a band filter, 23 repeaters on the line. 24 is a band filter and 25 a demodulating device on station B for the communication channel from A to B.

On station B 26 and 27 are tube amplifiers, connected in push-pull. 28 is a filament battery, 29 a grid battery and 32 a plate battery. 30 and 31 are half-windings of secondary winding of transformers 78'. 33—34 is a potentiometer, the mid-point of which is connected to the plate battery 32. 35 is a storage device in the form of a condenser for the half-cycle signal currents. 36 is an amplifier with filament battery 37, grid battery 38 and plate battery 39. 82' is a polarized relay with a doubly biased armature 43 and make contacts 41 and 42. Other parts on station B are similarly marked as on station A.

On station A the following relays are used for the transmission of the signal impulses: A1 to A4 inclusive.

On station B the following relays are used for receiving signals from A and for transmitting signals from B to A: B1 to B6 inclusive. The relay contacts on each relay are numbered progressively with the same numbers for the sake of simplicity. To distinguish, for example, contact spring 5 on relay A1, said spring is designated 5A1.

In Fig. 2 is shown a signal positive half-cycle *c* and a heavily dampened negative half-cycle *d*. As is well known it is very difficult to obtain just one single half-cycle, when opening or closing a signal circuit, as several impulses more or less dampened are obtained like those shown in Fig. 3. The signal half-cycle currents are heavily dampened in the sending circuit so that the difference in amplitude, for instance, between the first positive and the second negative half-cycle is very great.

A less dampened wave train is shown in Fig. 3 in which the differences in amplitude between a positive *e* and a negative consecutive *f* half-cycle is very small.

Figs. 4 and 5 explain one of the basic ideas of the invention and particularly how the signal receiving device can discriminate between the half-cycle signal currents proper and a dampened or continuous wave train as shown by the dotted line in Fig. 4 or in Fig. 3.

If the amplitude of a signal operating half-cycle is more or less the same as the amplitude of ordinary voice currents as shown in Fig. 4, the principle of the discriminating device according to the invention is shown in Fig. 5.

Fig. 5 represents the grid-plate-current characteristic curves of tubes 26 and 27 of the push-pull amplifier, shown in Fig. 1. A wave train arriving over the transformer 78' is shown on the negative ordinate shown in Fig. 5 and is composed of a positive half-cycle signal current *c* and a heavily dampened tail-half-cycle *d*. Immediately following is a semi-dampened train of impulses *e—f—g—h* of the kind shown in Fig. 3.

Upon the arrival of positive and negative half-cycles the condenser 35 (Fig. 1) is alternatively charged and discharged over the potentiometer 33—34, and simultaneously increases or decreases the grid potential of the amplifying tube 36 which controls the polarized relay 82'.

Fig. 5 thus shows that if about positive and negative half-cycles of equal or slightly varying amplitude arrive, the rest charge of the condenser 35 will be zero and accordingly will not cause any change in the grid voltage of amplifying tube 36 or to the polarized relay 82'. It can thus be observed from Fig. 5 that the amplified negative half-cycles *f* and *h* will neutralize the amplified positive half-cycles *e* and *g*.

It is preferred that the negative grid voltage of the push-pull device is sufficiently great so that the plate current ordinarily remains zero, because in such a case the positive and negative operating half-cycles will be amplified on the straight parts of the grid-plate-current characteristic curve. Due to the low amplitude of the tail negative half-cycle *d* following upon an operating half-cycle *c* said tail-half-cycle will hardly be amplified at all because corresponding to the lowest part of the amplifying characteristic curve. The same is the case with the rest charges of the condenser 35 which are due to small differences of amplitude of consecutive half-cycles of continuous wave trains. If the consecutive half-cycles of, for example, an undampened wave train are all alike, no charge will be stored in the condenser 35. From Fig. 5 we find that of the six half-cycles *c–h* only the operating signal-half-cycle *c* is stored in condenser 35.

The general operation of the transmission of signal half-cycles over the four-wire carrier channel system shown in Fig. 1 is the following: A calling station connected to exchange A, desiring connection over a long distance toll line to exchange B, obtains after certain connecting operations over known circuit arrangements, not shown in the drawing, connection to the repeating relay A1, which is energized when the receiver is off the hook. Relay A2 is thereby energized and its contacts 1 and 2 are closed, whereby ground is connected to the busy-signal-wire *g*. When contact 2—3A1 is closed, the condenser 18 is charged in series with primary winding of signal transformer 77 over the following circuit: Ground, resistance 17, contact 3—2A1, contact 2—3A4, primary winding of transformer 77 and battery 15. By means of variable resistances 19 and 20 can the duration and amplitude of the half-cycle signal currents be varied at will.

In the secondary of transformer 77 is hereby induced a voltage, causing a signal current impulse in series with the line 71—72. If a carrier is used, the signal currents are modulated together with the voice frequency currents coming over the hybrid coil 76 in modulator 21. If the signal half-cycle currents have about the same duration as half a cycle of the lower part of the voice frequency, ordinary band filter 22 is used to eliminate the upper or lower side band of the carrier wave.

If the half-cycles transmitted are of long duration, for example of the kind produced in an ordinary dial of about 10 complete cycles or 20 half-cycles per second after having passed the signal transformer 77, the band filters 22 and 24 must be made wider and sharper than those ordinarily used so that the signal impulses can be modulated on the carrier wave in the same way as the voice frequency currents. Such a band filter characteristic curve is shown in Fig.

9. In said way the low frequency signal impulses modulated on the carrier will pass the ordinary line repeaters 23 in the same way as the voice frequency currents do. The signal currents pass on station B in series with the primary winding of signal transformer 78'. If the arriving half-cycle signal current is positive, a current impulse is induced in, for example, the upper half-winding 31 of the secondary of transformer 78'. This half-cycle current is amplified in amplifier 26 over resistance 33, whereby the condenser 35 is simultaneously charged in series with resistance 34. By choosing the magnitude of the resistances of potentiometer 33—34 the condenser 35 can be made to be charged or discharged more or less slowly over either of said resistances, thereby increasing the duration of the posterior discharge of the signal half-cycle energy stored in the condenser 35.

The object of the amplifier 36 is to increase the amplitude of the half-cycle signal current stored in condenser 35 when afterwards being discharged over the grid circuit of amplifier 36. If the condenser 35 is positively or negatively charged the grid voltage of amplifier 36 is influenced in one or the other direction causing positive or negative current impulses in the primary and secondary of transformer 81' and the armature 43 of the polarized doubly biased relay 82' is moved to make momentary contact with contact 41 or contact 42.

Instead of a polarized relay other devices responding to positive or negative currents can be used, for example two ordinary relays, connected in parallel, each one with a rectifier in series and connected in opposite directions.

If a negative half-cycle is received at line signal transformer 78', it is passing through its lower secondary winding 30 and is amplified in amplifier 27 and in the same way as previously described the negative half-cycle is amplified and received at relay 82'.

If, for example, a positive half-cycle has been received by polarized relay 82', the armature 43 makes contact with contact 41, closing the following circuit: Ground, armature 43, contact 41, 1—2B5, relay B5, battery 15'. Relay B5 is energized closing contacts 3—4, 7—8, 9—10, 11—12 and breaking contacts 1—2, 5—6. Relay B5 received holding current over the following circuit: Battery 15', winding of relay B5, 3—4B5, 2—1B4, ground. On account of this holding circuit relay B5 remains energized also after the armature 43 of polarized relay 82' returns to normal position. When relay B5 was energized relays B6 and B3 were energized. B6 was energized over the following circuit: Ground, 8—7B5, winding of slow acting relay B6, battery 15'. B3 was energized over the following circuit: Ground, 10—9B5, winding of relay B3, resistance 16', battery 15', as soon as armature 43 of polarized relay 82' returns to normal position. When relay B3 is energized it closes its contacts 2—3 and prepares the circuit for relay B2, if the next half-cycle received also should be positive.

If now a negative half-cycle, however, is transmitted at A by releasing relay A1, contacts 1—2A1 are closed. Condenser 18 is thereby charged with a potential opposite to the previous charge. In similar manner as above described this negative half-cycle is transmitted at A and received and stored at B by condenser 35, which now obtains a charge of a potential opposite to that previously obtained. When condenser 35 discharges through potentiometer 33—34 the impulse magnified by amplifier 36 and transformer 81' is received by polarized relay 82', whereby armature 43 makes contact with contact 42. Relay B4 is thereby energized according to the following circuit: Ground, contact 43—42, winding of relay B4, battery 15'. Contact 1—2B4 is opened, interrupting holding current of relay B5, which is de-energized and opens its contacts 11—12B5.

If contact 11—12B5 is connected to a selector controlling circuit on station B, a positive and a negative half-cycle signal current transmitted at station A is received at station B and transformed into selecting impulses by closing and opening a contact such as 11—12B5.

If instead of transmitting positive and negative half-cycles as above described, two consecutive positive half-cycles shall be transmitted, such a transmission takes place in the following way: Previously condenser 18 had been positively charged, when 2—3A1 was closed upon A1 energizing its armature and a positive half-cycle current was transmitted over the line. Current is then continuing to flow over the following circuit: Battery 15, primary winding of transformer 77, resistance 19, 2—3A1, resistance 17, ground. The condenser 18 is thereby kept charged over the following circuit: Battery 15, primary winding of transformer 77, 3—2A4, condenser 18, 3—2A1, resistance 17, ground.

If now a second positive half-cycle current shall be transmitted, relay A4 is caused to be energized in known way, thereby breaking contact 3—2A4 and closing contact 1—2A4. Condenser 18 is then discharged through resistance 46.

When relay A4 is de-energized, contact 2—3A4 is again closed and condenser 18 is again positively charged according to the following circuit: Ground, 3—2A1, condenser 18, 3—2A4, primary winding of transformer 77, battery 15. The current previously flowing through the same winding is increased as soon as the condenser 18 is again connected in the circuit, parallel to the variable resistance 19, which, of course, is of fairly great magnitude. A half-cycle current of the same direction as the previous one is then generated in the secondary winding of transformer 77. It is understood that the closing of contacts 1—2A4 takes place before contacts 2—3A4 are opened so that no change in the current passing through the primary winding of transformer 77, takes place, when A4 is energized.

When such a second consecutive positive half-cycle signal current arrives at station B, armature 43 is again caused to make contact with contact 41, now closing the following circuit: Ground, contacts 43—41 of polarized relay 82', 2—3B3 which was energized before, relay B2, battery 15'. Relay B2 closes its contact 1—2 and connects ground to a wire g' which can be used for eventually breaking a local connection of a party for which a long-distance toll call may be waiting.

Signals in the direction from B to A can be sent in similar manner to that above described. Thus can on station A a signal be received indicating when station B answers, or when the conversation is finished, a connection counter and time measuring device can be made to operate. When, for example, a subscriber on station B answers relay B1 is energized over a circuit not shown on the drawings, closing contact 1—2B1, whereby a positive half-cycle is transmitted from B to A over line 73—74 and is re-

ceived at A by polarized relay 82, the biased armature of which temporarily breaks the contact 44—45 of a control circuit on station A.

Relays A3 and B7 are used to eventually disconnect the talking circuits from the signaling circuits, while signals are being transmitted.

In Fig. 6 the transmission and reception of half-cycle signals over amplifiers is shown in the simplest form. To the left is shown transmitting means, equal to those shown in Fig. 1. The line can be direct or provided with amplifiers. To the right is shown a simplified signal receiving device similar to that shown in Fig. 1, but instead of potentiometer 33—34, the primary 47—48 of transformer 81' is used. The plate battery 32 is connected to the center point of said primary. The energy storing device or the condenser 35' is connected in series with a resistance 50' in parallel to the secondary 49 and in parallel to the polarized relay 82'. The extra amplification tube 36 shown in Fig. 1 is omitted here.

The transmission and reception of signals in Fig. 6 is very similar to that described in Fig. 1.

Fig. 7 shows a two-wire connection between two exchanges, provided with amplifiers and echo-suppressers on each station. The line can be direct or provided with two-way repeaters in known manner. Transmission and reception can be made in both directions. Reference numbers in Fig. 7 refer to same devices as shown in Fig. 6 or Fig. 1. 51 and 52, 51' and 52' are hybrid coils in respective station amplifiers. 53 and 53' are line balancing net-works. 79 and 79' are station balancing net-works. 54 and 55, 54' and 55' are sending and receiving voice frequency amplifiers respectively. 56 and 56' are echo-suppressers which might be needed on long two-wire circuits with many two-way repeaters in series.

In Fig. 8 is shown a sending and receiving device on a station for a two-way radio communication channel. Sending and receiving devices are similar to those previously shown. Instead of a physical line a radio channel system is used in which 57 is an amplifier, 58 a modulator, 59 oscillator and amplifier, 60 an amplifier and 61 the sending antenna. 62 is the receiving antenna, 63 is the radio receiving and demodulating devices, 64 is a low-pass filter, which is used if the half-cycle signal impulses are of low frequency and long duration. 65 is an amplifying device and 12 a polarized relay to receive the demodulated half-cycle signals.

The distant station shall, of course, be similarly equipped if a two-way communication is desired.

The invention is not limited to the described figures which only show a few applications of the general and special forms of the invention and it is clearly understood that the general inventive ideas can be used in any combination, where signal half-cycle currents can be transmitted through an amplifier with or without a filtering net-work, be it that the half-cycles are of a duration equal to those within the voice frequency range or below or above said range.

In Fig. 9 is shown a filtering curve 66, which can be used in carrier channel systems over line wires. The curve 66 indicates that the upper side band is passed through the filter which is wide enough to let through both the carrier frequency f_m with the upper parts of the voice and signal frequency bands, 67 and 68 respectively.

If frequency modulation is used or in radio communication both the lower (dotted parts in the figure) and the upper side bands are passed through the filter, 66 and 69 respectively.

What we claim is:

1. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity in both directions and of about the same magnitude as that of voice frequency currents to be transmitted over a two-way communication channel, repeating electron tubes connected in series with said channel, two stations each thereof comprising a direct current source, signal transmitting and receiving means, connecting means permanently and inductively connecting said stations to said communication channel, balancing means associated with said transmitting, receiving and connecting means, said receiving means comprising means for separating said pulsating half-cycle signal currents from voice frequency currents, and an operating device responsive to any polarity of said half-cycle signal currents.

2. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity in both directions and of about the same magnitude as that of voice frequency currents to be transmitted over a two-way communication channel, repeating electron tubes connected in series with said channel, two stations, each thereof comprising a direct current source, signal transmitting and receiving means, connecting means permanently and inductively connecting said stations to said communication channel, balancing means associated with said transmitting, receiving and connecting means, said repeating electron tubes associated with said receiving means, the latter comprising means for separating said pulsating half-cycle signal currents from voice frequency currents, said separating means comprising a condenser for storing the energy of said pulsating half-cycle signal currents, and an operating device responsive to any polarity of said half-cycle signal currents.

3. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity in both directions and of about the same magnitude as that of voice frequency currents to be transmitted over a four-wire circuit comprising two one-way communication channels, repeating electron tubes connected in series with each one-way communication channel, two stations, each thereof comprising a direct current source, signal transmitting and receiving means, connecting means permanently and inductively connecting said stations to said communication channel, balancing means associated with said transmitting, receiving and connecting means, said receiving means comprising an electron tube amplifier and means for separating said pulsating half-cycle signal currents from voice frequency currents, said separating means comprising a condenser for storing the energy of said pulsating half-cycle signal currents and an operating device responsive to any polarity of said half-cycle signal currents.

4. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity in both directions and of about the same magnitude as that of voice frequency currents to be transmitted over a physical circuit comprising equipment for two carrier communication channels to be operated in opposite directions, repeating elec-

tron tubes connected in series with said physical circuits, two stations, each thereof comprising a direct current source, transmitting and receiving means, connecting means permanently and inductively connecting said stations to said circuit and channels, balancing means associated with said transmitting, receiving and connecting means, a carrier current generating source, modulating, demodulating and filtering means associated with said carrier channels to modulate and demodulate the half-cycle signal and voice frequency currents with respect to carrier waves to be transmitted over said channels, said receiving means comprising means for separating said demodulated pulsating half-signal currents from voice frequency currents, said separating means comprising a condenser for storing the energy of said pulsating half-cycle signal currents and an operating device responsive to any polarity of said half-cycle signal currents.

5. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity in both directions and of about the same magnitude as that of voice frequency currents to be transmitted over two radio communication carrier channels to be operated in opposite directions, two stations, each thereof comprising a direct current source, a carrier generating source, transmitting and receiving means, connecting means permanently and inductively connecting said transmitting and receiving means to the two radio communication carrier channels, balancing means associated with said transmitting, receiving and connecting means, modulating demodulating and filtering means to modulate and demodulate the half-cycle signal currents with respect to the respective radio carriers to be transmitted, said receiving means comprising means for separating said demodulated pulsating half-cycle signal currents from voice frequency currents, said separating means comprising a condenser for storing the energy of said pulsating half-cycle signal currents, and an operating device responsive to any polarity of said half-cycle signal currents.

6. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity and of about the same magnitude as that of voice frequency currents to be transmitted over a communication channel, two stations, a direct current source at each station, at one station transmitting means connected to the transmitting channel and at the other station receiving means connected to said channel, said receiving means comprising repeating and amplifying electron tubes in series with said channel, means for separating said pulsating half-cycle signal currents from voice frequency currents and an operating device responsive to any polarity of said half-cycle signal currents.

7. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity and of about the same magnitude as that of voice frequency currents to be transmitted over a communication channel, two stations, a direct current source at each station, at one station transmitting means connected to the communication channel and at the other station receiving means connected to said channel, said receiving means comprising two push-pull repeating and amplifying electron tubes connected in series with said channel, the plates of said tubes being connected to each end of the primary of a transformer, the secondary of which is connected parallel to a condenser and to an operating device responsive to any polarity of said half-cycle signal currents.

8. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity and of about the same magnitude as that of voice frequency currents to be transmitted over a communication channel, two stations, a direct current source at each station, at one station transmitting means connected to the communication channel and at the other station receiving means connected to said channel, said receiving means comprising two push-pull repeating and amplifying tubes connected in series with said channel, the plates of said tubes being connected in series with a potentiometer, the center of which is connected to a plate voltage battery source, a condenser connected in parallel to said potentiometer, a third electron tube, the filament and grid of which are connected in series with said condenser, the plate and plate battery source of said third amplifier being connected in series with the primary of a transformer, and a polarized relay being connected to the secondary of said transformer to receive the said half-cycle signal currents of any polarity from said condenser.

9. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity, each of said half-cycle currents of about the same duration as a half-cycle of currents within the lower part of the voice frequency range to be transmitted over a communication channel, two stations, a direct current source at each station, at one station transmitting means connected to the transmitting channel and at the other station receiving means connected to said channel, said receiving means comprising repeating and amplifying electron tubes in series with said channel, means for separating said pulsating half-cycle signal currents from voice frequency currents, and an operating device responsive to any polarity of said half-cycle signal currents.

10. In a transmitting system comprising the transmission of pulsating half-cycle direct signal currents of any sequence of polarity over a communication carrier channel, two stations each thereof comprising a direct current source, a carrier current generating source, transmitting and receiving means connected to said carrier channel, modulating filtering and demodulating means associated with said carrier channel to modulate and demodulate the said half-cycle signal currents with respect to carrier waves to be transmitted over said channel, said receiving means comprising an electron tube amplifier and means for separating said pulsating half-cycle signal currents from any other dampened or continuous wave currents to be transmitted over the channel and a device responsive to any polarity of said half-cycle signal currents.

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